Consumer acceptance of red meat from alternative animal species

by

Ibironke Olayinka Popoola

A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

FOOD SCIENCE AND TECHNOLOGY

Department of Agricultural, Food and Nutritional Science
University of Alberta

ABSTRACT

There is a declining trend in meat consumption in most developed countries including Canada due to environmental, animal welfare and food safety concerns. The trend is more pronounced for red meat due to its association with negative health outcomes. Red meats from alternative animal species such as bison, horse, and elk offer some nutritional benefits and are locally produced in Western Canada, but their consumption is still confined to niche markets. Although Canada is a global player in the horse meat export industry, profitability can be increased by reducing input cost from carcass chilling, but this has the tendency to negatively impact quality. The objective of this research was to provide information that will contribute to the profitability and advancement of the alternative red meats industry.

Impact of reduced carcass chilling duration from 30 h to 17 h prior to harvesting on consumer acceptance of horse meat was investigated among existing horse meat consumers in Quebec. Consumers evaluated cooked *Semimembranosus* muscle roasts in a Central Location Test (CLT) and Home Use Test (HUT) using hedonic and Just-About-Right (JAR) evaluations. Color and juiciness of samples from carcasses chilled for 30 h was liked significantly more than those from carcasses chilled 17 h in the CLT while no differences were observed in the HUT. Overall acceptance was significantly greater in the HUT than CLT for samples of both chilling times. Although a higher proportion of consumers in the CLT perceived the color of 17 h samples to be lighter, this did not significantly decrease overall liking.

Sensory attributes and drivers of liking and disliking of beef, horse, bison and elk meats were identified by 25 and 63 consumers in a taste panel using Preferred Attributes Elicitation (PAE) and Check-All-That-Apply (CATA), respectively. Both methods provided similar description of the sensory attributes and drivers of liking for the meats. Based on penalty analysis on the CATA

data, juiciness, mild meaty/beefy flavor and aroma and tender texture are attributes with a significantly positive impact on overall liking while dryness, tough texture, livery flavor and aftertaste had a significantly negative impact on overall liking. The latter attributes were associated with horse and elk meats and are considered drivers of disliking for these meats. Cluster analysis identified a small group of consumers that showed high overall liking for horse and elk meats which may present a target market for these meats.

An online survey was conducted among 145 participants to identify consumer perception of and liking or willingness to try beef, horse and bison meats. Although beef was associated with the live animal (cow, cattle, livestock), it was also associated with consumption related activities including “yummy”, “burger and barbecue”. Consumers did not have a mental representation of horse meat as suitable for food and it was associated with “aversion” and “cruelty. Four consumer clusters were identified based on their variety seeking tendencies and level of involvement with food. The low variety seeking and low involvement consumers showed significantly higher liking for beef than the high variety seeking and high involvement consumers while willingness to try horse and bison meats was low regardless of the cluster. Also, the presence of salient negative perceptions for horse and bison meats resulted in significantly negative willingness to try scores.

This research contributes to the body of knowledge about consumer acceptance of the sensory attributes of red meats from alternative species as well as their perception and response to these meat types. Information obtained from this research will guide potential policy changes that will increase profitability of the Canadian horse meat export market and give direction on the potential for the expansion of the alternative red meat industry beyond niche markets.

PREFACE

This thesis is an original research work by Ibironke Olayinka Popoola under the supervision of Dr. Wendy Wismer with funding from Alberta Agriculture and Forestry Strategic Research and Development Program, and the NSERC CREATE for Assuring Meat Safety and Quality (MEaTnet).

Chapter four of this thesis has been published as Popoola, I.O., Bruce, H.L., McMullen, L.M. and Wismer, W.V. (2019). Consumer sensory comparisons among beef, horse, elk and bison using preferred attributes elicitation and check-all-that-apply methods, *Journal of Food Science,* 84(10*),* 3009-3017. I designed the experiment, collected and analyzed data, interpreted the results and drafted the manuscript. Olalekan Laguda, Simona Fernandes, Xiaoquin Feng and Susan Gibson assisted with sample preparation, Dr. Wendy Wismer contributed to the study design and critical review of the manuscript while Dr. Lynn McMullen and Dr. Heather Bruce contributed to the study design and provided editorial comments to the final manuscript.

A version of chapter three of this thesis will be submitted to *Journal of the Science of Food and Agriculture* for publication as Ibironke O. Popoola, Brian D. Walker, Heather L. Bruce, Lynn M. McMullen and Wendy V. Wismer. Consumer acceptance of horse meat with reduced carcass chilling time. I designed the experiment, contributed to collection of data, analyzed the data, interpreted the results, and drafted the manuscript. Brian Walker and members of staff of Cintech Agroalimentaire, Saint-Hyacinthe, Quebec collected the data, Dr. Wendy Wismer contributed to the study design and critical review of the manuscript while Dr. Lynn McMullen and Dr. Heather Bruce contributed to the study design and provided editorial comments to the final manuscript.

Chapter two of this thesis has been submitted to *Food Reviews International* for publication as Ibironke O. Popoola, Philip O. Soladoye, Nicole Gaudette and Wendy V. Wismer. Red meats from alternative species: A review of sensory attributes, consumer acceptance and consumer factors influencing acceptance. I conducted the database search, selected the studies, and drafted the manuscript, Philip Soladoye contributed to the selection of studies and drafting of manuscript while Dr. Nicole Gaudette and Dr. Wendy Wismer critically reviewed the manuscript.

Chapter five of this thesis will be submitted to *Food Research International* for publication as Ibironke O. Popoola, Sven Anders, Michelle Feuereisen, Mariarosaria Savarese and Wendy V. Wismer. Consumer response to familiar and unfamiliar meats: the role of perception, variety seeking and food involvement. I contributed to the study design, collected, and analyzed data, interpreted results, and drafted the manuscript. Dr. Anders contributed to the study design, data analysis and critical review of the manuscript, Michelle Feuereisen and Mariarosaria Savarese contributed to the study design while Dr. Wismer contributed to the study design, data analysis and critical review of the manuscript.

DEDICATION

To the most High, the one who makes all things work together for my good and makes all things beautiful in His own time.

ACKNOWLEDGEMENTS

Firstly, I would like to thank God Almighty for the privilege I was given to commence and complete this program I am eternally grateful for the strength and knowledge bestowed on me all through my PhD and the grace to broaden my knowledge. I would like to express my sincere gratitude my supervisor, Dr. Wendy Wismer for her guidance, patience, and support all through my PhD. It is a dream come true for me to partake of her wealth of knowledge in Sensory and Consumer Science field. My sincere appreciation also goes to my supervisory committee members – Dr. Heather Bruce and Dr. Lynn McMullen, for their contributions at every stage of my PhD. Words alone cannot convey my gratitude to them for the financial support provided through their research projects. I would like to appreciate Dr. Sven Anders for his immense contributions to the final stage of my research.

My sincere appreciation goes to Susan Gibson for her support. I would also like to appreciate my lab mates both present and graduated - Blanca, Ha, Gaam, Xiaoqin, and Minhui for their support and insightful comments whenever I give presentations about my research. I would like to thank Olalekan Laguda, Simona Fernandes, Susan Gibson and Xiaoqin Feng for their assistance during the data collection stage of my second study and Minhui Li for contributing to the design of my last study.

I would like to thank my dad, Prof. Tope Popoola for his love and prayers, all my uncles and aunts and my sweet grandparents who have gone to be with the Lord. I am grateful to God for the gift of awesome friends who provided unwavering love and moral support all through my PhD - Bimbo, Nurudeen, Mosun, Oluwaseun, Martins, Omolola, Samson, Philip, Michael, Ope, Raphael, Eyitayo, Jolaade, Niyi, Chibyki, Doyin, Bidemi, Toyin and John. I am also grateful to my former supervisor at International Institute of Tropical Agriculture - Dr. Busie Maziya-Dixon who encouraged me to still pursue my PhD dreams when I decided to relocate to Canada.

Finally, my heartfelt gratitude goes to Alberta Agriculture and Forestry Strategic Research and Development Program, and the NSERC CREATE for Assuring Meat Safety and Quality (MEaTnet) for the financial support provided for my PhD research without which I would not have been able to undertake the program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AMSA: American Meat Science Association

ANOVA: Analysis of Variance

ATP: Adenosine Triphosphate

BSE: Bovine Spongiform Encephalopathy

CATA: Check-All-That-Apply

CFIA: Canadian Food Inspection Agency

CLT: Central Location Test

DNA: Deoxyribonucleic Acid

FWA: Free Word Association

GPA: Generalized Procrustes Analysis

HFI: High Food Involvement

HUT: Home Use Test

HVS: High Variety Seeking

JAR: Just About Right

LFI: Low Food Involvement

LVS: Low Variety Seeking

MFA: Multiple Factor Analysis

MVS: Medium Variety Seeking

PAE: Preferred Attributes Elicitation

PUFA: Poly Unsaturated Fatty Acid

RATA: Rate-All-That-Apply

SFA: Saturated Fatty Acid

SM: *Semimembranosus*

WHO: World Health Organization

WTT: Willingness to Try

Chapter 1. Introduction and objectives

1.1. Introduction

Global meat consumption patterns have changed significantly over the past few decades, both in quantity and type of meat consumed. Aggregate global meat consumption increased by over 90% between 1990 and 2019 (OECD, 2020) mainly due to growing world population, increasing globalization of food systems and rising incomes in developing countries (Graça, 2016; Henchion, McCarthy, Resconi, & Troy, 2014; Maheswarappa & Kiran, 2014). However, in most developed countries including Canada, there is both a declining trend in the quantity of meat consumed, with consumers showing interest in plant-based protein sources (Food Navigator-USA, 2020; National Research Council of Canada, 2019) and a shift in the type of meat consumed (Statista, 2019b). Although per capita consumption of sheep and pig meat in Canada has not changed significantly between 1990 and 2019, per capita consumption of beef decreased from 38.8 kg to 25.4 kg between 1980 and 2018 while chicken increased from 26.2 kg to 34.6 kg between 1998 and 2018 (OECD, 2020; Statista, 2019a; Statista, 2019b). These changes are largely driven by increased health consciousness and consumer interest in health-promoting foods, increasing environmental awareness and consumer interest in organic or naturally produced meat with low input systems, animal welfare concerns and concerns about meat safety due to meat-related disease outbreaks such as foot-and-mouth disease (Cheah, Sadat Shimul, Liang, & Phau, 2020; Hartmann & Siegrist, 2017; Hoffman & Wiklund, 2006). The socio-economic and demographic factors contributing to changing meat consumption include the high cost of beef relative to chicken, differences in meat preference across different demographics with younger consumers and women tending towards consumption of a lesser amount of red meat; together with increasing immigration and its accompanying cultural changes (Cranfield, 2013; Hoffman & Wiklund, 2006; Statista, 2016).

In addition, consumers have high expectations regarding the nutritional value, wholesomeness, freshness, leanness and sensory attributes (flavor, tenderness, juiciness, color) of meat (Cranfield, 2013; Dransfield, 2001). Failure to meet these expectations will have an adverse impact on demand and consumption. The changing meat consumption pattern may provide market opportunity for red meat from alternative animal species such as bison, elk or horse among consumers who wish to add variety to their meat choice. These meats are also suitable for diets that encourages consumption of

lean meat such as the paleolithic diet (Barone et al., 2019) . Red meats from alternative animal species are meats derived from game or non-domesticated animals or animals considered unusual for the purpose of consumption (Maheswarappa & Kiran, 2014; Schupp, Gillespie, & Reed, 1998). Most of these meats possess quality attributes that compare favorably with conventional red meats (Hoffman & Wiklund, 2006; Steiner, Gao Fei, & Unterschultz, 2010). Nutritionally, bison, horse and elk meats are leaner and contain lower cholesterol and good proportion of polyunsaturated to saturated fatty acids when compared to beef (Polawska, Cooper, Jozwik, & Pomianowski, 2013; Rule, Broughton, Shellito, & Maiorano, 2002).

Farmers in Western Canada are diversifying into specialized livestock industries and production of these red meats from alternative animal species (Sanderson, Hobbs, Shand, & Kerr, 2002). As of January 2017, there were 145,000 bison farmed in 975 farms in Canada; 80% of which are in Alberta and Saskatchewan (Agriculture and Agri-Food Canada, 2019; Canadian Bison Association, 2020). There were about 38,000 farm raised elk and deer in Canada with a large proportion farmed in Alberta (Agriculture and Agri-Food Canada, 2019). Between 2009 and 2018, annual exports from Canada fell from 356,229 kg and 1,699,441 kg to 116,779 kg and 943,270 kg for elk and bison meats, respectively (Government of Canada, 2019a). Canada is also a major player in the global horse meat industry. Annual global production of horse meat was about 700,000 tonnes per annum as of 2016 and Canada ranks third largest exporter in the world after Belgium and Argentina (Belaunzaran et al., 2015; Jastrzębska, Daszkiewicz, Górecka-Bruzda, & Feliś, 2019). While the amount of horse meat exported from Canada represents about 85% of production, the remaining horse meat is sold mainly in the province of Quebec (Canadian Meat Council, 2013) where consumption of horse meat is common. Only federally inspected abattoirs can export horse meat outside of Canada; two of these are located in the province of Alberta while the other two are located in the province of Quebec (Canadian Meat Council, 2013). Canadian horse meat is mainly exported to United States, Japan, Germany, Italy, United Kingdom, Greece, France, Norway Malaysia and Switzerland while the quantity of horse meat exported to Belgium fell drastically between 2012 and 2015 (Government of Alberta, 2017; Government of Canada, 2019b).

The Canadian horse meat export industry generates about CAN$ 83 million annually (Canadian Meat Council, 2013). Increasing profitability will require reduced input cost without impact on quality. This may be achieved by reducing input cost from refrigeration as this accounts for between 60 and

70% of total energy consumed in slaughter houses (DEFRA, 2010). As it is necessary to maintain dressed carcass at temperatures less than 10ºC after harvesting, it is impossible to save cost via this means. Another option is to reduce the initial carcass chilling duration which accounts for 30% of the total energy needed to run a slaughterhouse (McGinnis, Aalhus, Chabot, Gariepy, & Jones, 1994) thereby maximizing slaughterhouse capacity, reducing energy inputs and ultimately increasing profitability. However, as carcass chilling impacts biochemical changes taking place in the carcass within 24 h of slaughter (Aalhus, Robertson, Dugan, & Best, 2002; Savell, Mueller, & Baird, 2005), reducing the duration of chilling can adversely affect the quality of Canadian horse meat, making it less competitive in the global market. The goal is to reduce horse carcass chilling duration without significant impact on quality. While the effect of reduced horse meat carcass chilling duration on technological and microbial quality of horse meat has been established (Rahman, Walker, Roy, McMullen, & Bruce, 2017; Walker, 2017), its effect on sensory quality is yet to be investigated.

Moreover, the alternative red meat industry generally is a niche market with production and consumption representing a low share of the global meat market. The global per capita consumption of 'other meats' including wild game, horse and rabbit was 0.84 kg while bovine, mutton and goat meat, poultry and pig meat were 9, 1.86, 15.08, and 15.68 kg, respectively (FAOSTAT, 2020; Ritchie & Roser, 2019). Compared to meats from conventional animal species, horse meat represents 0.25% of the total worldwide meat production with average per capital consumption of 0.1kg (Belaunzaran et al., 2015). Production of horse meat is mainly for a small group of consumers in countries with traditions of consuming this meat (Jastrzębska et al., 2019).

The changing pattern of meat consumption may provide an opportunity to expand the alternative meat industry beyond a niche market through marketing these meats to consumers who wish to add variety to their meat choices (McClenahan & Driskell, 2002). To successfully achieve this, there is need to understand consumer preferences, behavioral patterns and their contributing factors so that production efforts and marketing decisions can be designed to meet consumers needs (Font-i-Furnols & Guerrero, 2014; Sanderson et al., 2002). Increasing revenue from export of Canadian horse meat to countries where it is traditionally consumed entails reducing input cost without compromising quality. The next sections provide an overview of factors motivating food choice and the role of post-mortem carcass chilling on sensory quality, an important driver of consumer meat choice.

1.2. Factors motivating food choice

Food choice is a complex interplay of preferences for sensory (appearance, taste, texture, aroma) characteristics of the food together with the influence of other non-sensory factors including food related expectations and attitudes, nutritional quality, interest in health, ethical concerns, price, convenience, familiarity, social, economic, cultural and political factors (Johansen, Naes, & Hersleth, 2011; Prescott, Young, O'Neill, Yau, & Stevens, 2002). These food choice motives have been shown to be related to consumers' personality and lifestyle and can be further explained by underlying factors relating to age, gender, social class, and income (Johansen et al., 2011). Ultimately, these factors result in the acceptance of some products and rejection of others (Wadolowska, Babicz-Zielinska, & Czarnocinska, 2008). In a broader context, the factors motivating food choice are a function of product-related factors (physical and chemical properties, sensory attributes, functional factors, nutrient content), person or consumer-related factors (personality traits, psychological and physiological factors) and place or environment-related factors (eating occasion/context, cultural and social factors) (Jaeger, Bava, Worch, Dawson, & Marshall, 2011; Mak, Lumbers, Eves, & Chang, 2012; Wadolowska et al., 2008). The sensory and consumer-related factors influencing food choice are the focus of this research. These factors and the measurement methods are discussed in the next sub-sections.

1.2.1. Influence of product sensory factors on food choice

Food consumption is often considered a pleasurable act and oftentimes, foods are almost entirely consumed for the pleasure provided (Johansen et al., 2011). Sensory attributes are inherent characteristics of food products (including meat) that play a major role in consumers purchase decisions and acceptance (Hartung, Nowak, & Springorum, 2009; Henchion, McCarthy, & Resconi, 2017). Product sensory quality is assessed using consumer affective tests, which provide information about consumer acceptance and preference, or characterized by descriptive profiling using trained panels (Mullen, 2002; Resurreccion, 2003). Descriptive sensory evaluation requires the use of highly trained panels to obtain detailed, consistent, reproducible results that are stable in time and within a certain sensory space (Moussaoui & Varela, 2010). It is necessary that the tests are conducted under stringent laboratory conditions. Unlike descriptive sensory tests, consumer affective tests can be conducted either in sensory laboratories, at a central location or in consumers' homes (Resurreccion,

2003). Meat sensory evaluation is often performed in sensory laboratories with samples prepared without seasoning and served as small cubes. Although this eliminates influence of extraneous factors, it does not represent the usual condition under which meat is consumed. This necessitates sensory evaluation of meat under less stringent laboratory conditions to obtain a valid evaluation of consumer perceived quality.

Red meat from alternative species are known to possess unique sensory attributes different from conventional red meat types. Past studies have characterized these sensory differences or evaluated sensory preference compared to conventional meats (Barton, Bures, Kotrba, & Sales, 2014; Koch, Crouse, & Seideman, 1988; Rodbotten, Ueland, Lea, & Kubberod, 2004). To date, no published study has linked the specific sensory attributes to acceptance scores of these meat types for the purpose of identifying sensory attributes that drive liking or disliking. Although consumer affective tests provide information about consumer liking, they do not identify specific attributes driving product liking. Conversely, trained panels are less subjective to the assessor's preference/opinion and only provide information about sensory characteristics without its impact on acceptance (Resurreccion, 2003). Recently, consumer methods that allow the identification of specific sensory attributes driving acceptance of food products by combining both descriptive sensory profiling and consumer affective tests have been developed (Resurreccion, 2003). In addition, these methods overcome the limitations associated with traditional descriptive profiling in terms of the time, cost and effort required to create and maintain a well-trained and calibrated sensory panel as they provide a rapid means of characterizing sensory attributes of food products (Varela & Ares, 2012).

An example of a consumer method that combines descriptive profiling with hedonic ratings for the purpose of identifying sensory drivers of liking is the Check-All-That-Apply (CATA) method (Adams, Williams, Lancaster, & Foley, 2007). Panelists (usually between 50 and 100) select terms that best describe the products being evaluated from a list of attributes generated by trained assessors or from previous focus groups (Ares, Tárrega, Izquierdo, & Jaeger, 2014). When combined with hedonic ratings, particularly overall liking scores, attributes driving liking are identified through penalty analysis (Ares, Dauber, Fernández, Giménez, & Varela, 2014). Rate-All-That-Apply (RATA) is a variant of CATA that allows panelists to rate the intensity of the attributes in addition to just selecting from a list the attributes that describe the product (Antunez, Machin, Ares, & Jaeger, 2019;

Vidal, Ares, & Gimenez, 2013). This method has however, been shown not to be an improvement over the CATA method. In a study to compare RATA and CATA, similarities and differences among the product evaluated were similar for both methods (Vidal et al., 2013).

Another rapid descriptive sensory method to identify sensory drivers of liking is the Preferred Attributes Elicitation (PAE) method. This is a method in which untrained consumers simultaneously agree on the attributes that describe a set of products, rate the intensity of the attributes, and rank the attributes in order of importance to liking (Grygorczyk, Lesschaeve, Corredig, & Duizer, 2013; McSweeney, Duizer, Seetharaman, & Dan Ramdath, 2016; McSweeney, Sisopha, T'ien, Rector, & Duizer, 2017; Muggah & McSweeney, 2017).The advantage of this method is that it is conducted with untrained panelists within a single session using fewer panelists compared to CATA, and most importantly, the PAE method provides insight into the importance of the sensory attributes to liking, similar to penalty analysis of CATA data. While CATA, has gained wide application in the domain of meat sensory evaluation, (Beldarrain et al., 2020; de Andrade et al., 2018; Jorge et al., 2015), application of PAE method is still limited in the food industry and has not yet been applied for meat evaluation. Its use may be broadened if it compares well with other existing rapid methods.

1.2.1.1. Carcass chilling and meat sensory quality

Sensory characteristics important for consumer meat choice include appearance/color, tenderness, juiciness and flavor (Hartung et al., 2009; Resurreccion, 2003). The ultimate sensory quality of meat is ideally predicted in the early post-mortem period i.e. within 24-48 h post-slaughter (Mullen, 2002). Carcass chilling is the major activity carried out during this time and it has impact on meat sensory quality, particularly tenderness. When carcasses are chilled rapidly, cold shortening occurs; a situation whereby meat becomes tough because the temperature drops below 10^{o}C within 10 h when ATP is still present, making the sarcoplasmic reticulum to leak calcium which stimulates irreversible contraction of the sarcomere (Rubio, Vieira, Martinez, & Fernandez, 2013).

Carcass chilling is strictly guided by government policy to ensure food safety. Regardless of the animal species, the Canadian Food Inspection Agency (2017) requires that warmest part of meat animal carcasses be chilled to 7°C or less, with alternative chilling processes only permitted after lengthy review by Health Canada, supported by scientific review. Under conventional chilling i.e.

chiller temperature of 0 - 4°C and air velocity of 0.5m/s (Zhu, Gao, & Luo, 2011), the time taken to achieve this internal temperature varies depending on the species of animal, with horse carcasses taking about 30 h (Walker, 2017), beef carcasses taking 32 h or more (Liu, Youssef, & Yang, 2016) and lamb carcasses taking 16 h (McGeehin, Sheridan, & Butler, 2002) . As the policy does not stipulate chilling duration, in order to increase product turnover thereby increasing profitability, attempts have been made to reduce the time taken to achieve this internal temperature through rapid chilling whereby carcasses are chilled to -1°C within 5 h (Joseph, 1996). However, this produces darker and tougher meats with lower marbling scores unless combined with electrical stimulation (Aalhus, Janz, Tong, Jones, & Robertson, 2001; Janz et al., 2004; Pinto Neto, Beraquet, & Cardoso, 2013). Another option is chilling using the conventional means but for a shorter duration such that carcasses are harvested at temperatures higher than the stipulated 7°C. The oxidative nature of beef and other red meat types delays pH drop, making the muscles more susceptible to cold shortening (Savell et al., 2005) so that harvesting at higher temperature may not be possible. However, horse tissue is higher in glycogen than beef (22 mg/g glycogen for horse meat; ≤10 mg/g for beef) (Gill, 2005) and although not yet proven, this may result in a faster rate of glycolysis so that a muscle pH of <5.8 is achieved before 24 h. Hence a shorter carcass chilling duration may be ideal for horse meat and may result in substantial savings for the industry.

Cost savings through reduced horse carcass chilling duration is a process innovation. Success of such innovations in the Food and Agricultural domain is often guided by sensory methods that identify the extent to which sensory attributes of products differ from consumers' ideal (Ares et al., 2017). An example of such methods is the Just-About-Right (JAR) method, which uses a 3 to 9-point bi-polar scale to determine if the intensity of an attribute is too weak, just-about-right or too strong relative to the ideal (Gere et al., 2017). Together with overall hedonic ratings, JAR provides information on sensory attributes with most impact on consumer acceptance using penalty analysis (Ares et al., 2017). For the reduced duration of horse meat carcass chilling to be a success, a large proportion of consumers should perceive sensory attributes of horse meat from the reduced chilling duration to be ideal or, deviations from ideal do not result in a significant drop in overall liking. The JAR method has found application in meat studies particularly chicken (Fanatico et al., 2007; Jarvis et al., 2012; Oloo, Mahungu, & Kahi, 2018; Saha, Lee, Meullenet, & Owens, 2009; Youngseung Lee, Rui Xiong, & Meullenet, 2014) and processed meat products (Garcia-Diez et al., 2017; Hayes, Raines,

Depasquale, & Cutter, 2014; Rodrigues et al., 2020; Sheng-Hang Chan, Moss, Farmer, Gordon, & Cuskelly, 2013; Yung Hung & Verbeke, 2018) but not for horse meat.

1.2.2. Influence of consumer-related factors on food choice

In addition to sensory acceptance, consumer-related factors also play an important role in food choice (Shan et al., 2017). To gain knowledge of these factors, various consumer behavior theories have been developed, most of which have their roots in social psychology. One of such theories is the expectancy-value theory of Ajzen & Fishbein (1980). This theory has consumers' beliefs as its building block and is based on the assumption that consumers' attitude towards an object are formed in response to beliefs about the object and these beliefs are formed based on either direct observation, information from outside sources or by inference (Holdershaw & Gendall, 2008). The model implies that consumers have both positive and negative beliefs about an object and their attitude towards the object corresponds to the total affect associated with their beliefs (Conner & Armitage, 2006; Holdershaw & Gendall, 2008).

The free word association method is rooted in the expectancy-value theory. The method is based on the assumption that the associations that first come to a consumers' mind regarding a product or concept are closely related to their behavior towards the product or concept and are the most relevant for consumers' decision and choice (Ares, Gimenez, & Gambaro, 2008). The earlier application of this method was in psychology and sociology where it was used for evaluation of conceptual structures and for studying beliefs or attitudes (Hirsh & Tree, 2001; Hovardas & Korfiatis, 2006; Schmitt, 1998). In the food domain, the early application of free word association method was in 2006 by Roininen, Arvola, & Lahteenmaki and it is now widely applied in food research. Its wide application in consumer food research has been attributed to the spontaneity of the ideas elicited by the consumers which is not subjected to the constraints imposed by interviews and close-ended questionnaires (de Andrade, Sobral, Ares, & Deliza, 2016; Guerrero et al., 2010). Free word association has been applied in the evaluation of consumer perceptions and understanding consumer behavior towards food products and concepts, including local and traditional foods (Cerjak, Haas, Brunner, & Tomic, 2014; Serrano-Cruz, Espinoza-Ortega, Sepulveda, Vizcarra-Bordi, & Thome-Ortiz, 2018), ice-cream (da Silva et al., 2014), beer (Sester, Dacremont, Deroy, & Valentin, 2013), fruits and salads (Vaca & Mesias, 2014; Vidal et al., 2013), milk, yogurt and fermented dairy

products (Ares et al., 2008; Esmerino et al., 2017; Pinto, Leticia de Paula F. et al., 2018). In addition, the free word method has been applied to package food design (Ares & Deliza, 2010; Eldesouky, Pulido, & Mesias, 2015; Masson, Delarue, Bouillot, Sieffermann, & Blumenthal, 2016; Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013; Rebollar, Lidon, Gil-Perez, & Martin, 2019).

In the domain of meat research, the free word method has been used to understand consumer perception of processed meat products with healthiness attributes (Polizer Rocha, Lapa-Guimaraes, de Noronha, Regina Lucia F., & Trindade, 2018; Viana, dos Santos Silva, Vivian Lara, & Trindade, 2014) and lamb meat (de Andrade et al., 2016). However, application of this method in understanding consumer perception of unconventional meat types, particularly how these compare with conventional meat types and its impact on consumer choice, has not yet been explored in the literature. Moreover, while the main idea behind the free word method is that the most salient associations or beliefs that consumers have regarding an attitude object (product) is the best predictor of their behavior towards the product and most relevant for their choice and purchase decisions (Roininen, Arvola, & Lahteenmaki, 2006), so far, no study has linked free word data to consumer food choice, particularly liking of familiar foods or willingness to try unfamiliar foods.

Personality traits are another consumer-related factor known to influence food choice. According to Mak, Lumbers, Eves, & Chang (2012), food-related personality traits refer to individual characteristics that exert persuasive influence on a broad range of food-related behavior. Personality traits specifically related to food choice are food neophobia, food variety seeking and food involvement (Aqueveque, 2015; Derinalp Çanakçı & Birdir, 2020; Lähteenmäki & Arvola, 2001). Food neophobia is manifested in consumers' reluctance to ingest novel or unfamiliar foods, food variety-seeking is manifested in consumers' tendency to seek variety in their food choice, while food involvement is shown in the extent to which food plays an important role in a person's life. These traits have been operationalized using validated scales (Bell & Marshall, 2003; Pliner & Hobden, 1992; van Trijp & Steenkamp, 1992). Negative correlations exist between food neophobia and variety seeking and both are thought to be opposing traits (Marshall & Bell, 2004; Meiselman, Johnson, Reeve, & Crouch, 2000). However, this may only be true when consumers are making a choice within unfamiliar alternatives, with variety-seekers more favorable towards risks and more willing to try unfamiliar foods, while neophobes are afraid of risks hence avoid new foods (Lähteenmäki & Arvola, 2001). Moreover, research by Lenglet (2018) showed that the variety seeking has better

predictive validity for willingness to try new or unfamiliar foods as the questionnaire items are more rooted in unfamiliarity and is thus more suitable for predicting willingness to try unfamiliar foods.

Generally, these traits have significant impact on the diversity of foods consumed by consumers, their willingness to make dietary changes and their general health and well-being (Knaapila et al., 2015). Food neophobes are more prone to poorer dietary quality, metabolic risk factors and increased risk factors while highly food involved consumers are more open to unfamiliar food products, and more inclined towards healthier food choices as their decisions are based on active and open-minded information processing (Darke & Chaiken, 2005; Eertmans, Victoir, Vansant, & Van den Bergh, 2005; Sarin et al., 2019). The role of these food-related personality traits in consumers' dietary and nutritional quality choices suggests they may be a factor in consumers' choice for healthier but unfamiliar or unconventional meat types; however, this is yet to be investigated.

The tendency of consumers to reject foods (both familiar and unfamiliar/novel) has been attributed to distaste for the sensory attributes of the food, fear of negative consequences that may arise from consuming the food, a sense of repulsion for the source of the food and mental classification of the appropriateness of the item as food (Derinalp Çanakçı & Birdir, 2020; Fallon & Rozin, 1983; Pliner & Hobden, 1992). The factors underlying the exhibition of food-related personality traits imply the existence of relationship among consumer perceptions, food-related personality traits and food choice. This relationship is however yet to be investigated with respect to consumer choice for unfamiliar/ unconventional meats.

1.3. Objectives

The overall objective of this research was to provide information that will contribute to the advancement and profitability of the alternative red meat industry in Canada by identifying food-related (sensory) and consumer-related (non-sensory) factors contributing to consumers acceptance to alternative red meats. A schematic representation of the studies conducted is presented in Fig. 1.1 to illustrate the relationship among them. Overall, these studies identified the influence of cost-reduction effort on sensory quality of horse meat and identified the sensory and non-sensory factors impacting acceptance and consumption of horse, bison and elk relative to beef. Based on the overall objective, a review and three studies were performed with the specific objectives below.

1.3.1. Specific objectives

Objective 1. Literature review (Chapter 2): To identify sensory attributes, consumer acceptance and consumer factors that influence the consumption of red meats from selected alternative species and identify key differences with conventional red meat to guide future research on opportunities for expansion of the alternative red meat industry.

Objective 2. Study 1 (Chapter 3): To investigate the influence of reduced horse meat carcass chilling time from 30 h to 17 h prior to muscle harvesting on sensory quality and consumer acceptance of the final cooked product under controlled a controlled laboratory condition and home preparation condition.

Hypotheses:

1. Reduced horse carcass chilling time will not significantly reduce consumer acceptance.

2. Sensory quality and acceptance will improve significantly when consumers prepare and evaluate horse meat at home compared to the same evaluation in a controlled laboratory condition at a central location.

Sub-objective 2.1. Investigate the influence of reduced horse meat carcass chilling time prior to harvesting from 30 h to 17 h on sensory quality and consumer acceptance of the final cooked product.

Sub-objective 2.2. Investigate influence of preparation and serving conditions on consumer acceptance of horse meat.

Objective 3. Study 3 (Chapter 4): To identify sensory attribute dissimilarities among beef, horse, bison and elk meats and their influence on consumer acceptance.

Hypotheses:

1. The sensory attribute dissimilarities between beef and red meats from alternative animal species (horse, bison and elk) has significant impact on consumer acceptance.

2. PAE will generate similar results to CATA for the evaluation of sensory attribute dissimilarities among the meats and identification of drivers of liking.

Sub-objective 3.1. Elicit and compare the sensory attributes of beef, horse, bison and elk meats and identify specific attributes driving acceptance or rejection.

Sub-objective 3.2. Determine the suitability of PAE for consumer descriptive meat profiling and identification of drivers of liking.

Objective 4. Study 4 (Chapter 5): To determine the influence of personality traits relating to food variety-seeking and food involvement together with consumers perception on their liking for familiar (beef) and willingness to try unfamiliar red meat types (horse and bison).

Hypotheses:

1. Personality traits of food variety seeking and food involvement will have significant impact on consumers' perception of beef, horse and bison meats.

2. Personality traits of food variety-seeking and food involvement will have significant impact on consumers' liking for beef and willingness to try bison and horse meats.

3. Consumers' most salient perception and personality traits will have significant impact on liking for beef and willingness to try bison and horse meats.

Sub-objective 4.1. Identify homogeneous consumer groups based on their variety-seeking tendencies and level of involvement with food and determine the extent to which these traits influence consumers' perception of beef, bison and horse meats.

Sub-objective 4.2. Evaluate the influence food variety seeking and food involvement on consumers' liking of beef and willingness to try bison and horse meats.

Sub-objective 4.3. Identify the most salient consumer perception of the meats and its impact on liking for beef and willingness to try bison and horse meats.

1.4. References

Aalhus, J. L., Janz, J. A. M., Tong, A. K. W., Jones, S. D. M., & Robertson, W. M. (2001). The influence of chilling rate and fat cover on beef quality. *Canadian Journal of Animal Science, 81*(3), 321-330. doi:https://doi.org/10.4141/A00-084

Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., & Best, D. R. (2002). Very fast chilling of beef carcasses. *Canadian Journal of Animal Science, 82*, 59-67. doi:https://doi.org/10.4141/A01-020

Adams, J., Williams, A., Lancaster, B., & Foley, M. (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. *Paper Presented at 7th Pangborn Sensory Science Symposium, Minneapolis, USA, 12–16 August, 2007.*

Agriculture and Agri-Food Canada. (2019). Canada's red meat and livestock industry at a glance. Retrieved from http://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/industry-profile/?id=1415860000002

Ajzen, I., & Fishbein, M. (1980). *Understanding attitude and predicting behavior.* Prentice-Hall. Inc, Engelwood Cliffs, New Jersey.

Antunez, L., Machin, L., Ares, G., & Jaeger, S. R. (2019). Visual attention to rate-all-that-apply (RATA) questions: A case study with apple images as food stimuli. *Food Quality and Preference, 72*, 136-142. doi:10.1016/j.foodqual.2018.10.007 ER

Aqueveque, C. (2015). Intention to try unfamiliar food: The role of level and type of unfamiliarity, food neophobia, and ethnocentrism. *Journal of Food Products Marketing, 21*, 244-254. doi:10.1080/10454446.2013.807414

Ares, G., de Andrade, J. C., Antunez, L., Alcaire, F., Swaney-Stueve, M., Gordon, S., & Jaeger, S. R. (2017). Hedonic product optimisation: CATA questions as alternatives to JAR scales. *Food Quality and Preference, 55*, 67-78. doi:https://doi.org/10.1016/j.foodqual.2016.08.011

Ares, G., Gimenez, A., & Gambaro, A. (2008). Understanding consumers' perception of conventional and functional yogurts using word association and hard laddering. *Food Quality and Preference, 19*, 636-643. doi:10.1016/j.foodqual.2008.05.005 ER

Ares, G., Dauber, C., Fernández, E., Giménez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. *Food Quality and Preference, 32*, 65-76. doi:https://doi.org/10.1016/j.foodqual.2013.05.014

Ares, G., & Deliza, R. (2010). Identifying important package features of milk desserts using free listing and word association. *Food Quality and Preference, 21*, 621-628. doi:10.1016/j.foodqual.2010.03.010

Ares, G., Tárrega, A., Izquierdo, L., & Jaeger, S. R. (2014). Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-that-apply (CATA) questions. *Food Quality and Preference, 31*, 135-141. doi://doi.org/10.1016/j.foodqual.2013.08.012

Barone, M., Turroni, S., Rampelli, S., Soverini, M., D'Amico, F., Biagi, E., . . . Candela, M. (2019). Gut microbiome response to a modern paleolithic diet in a western lifestyle context. *PLoS ONE, 14*, 503-514 doi:10.1371/journal.pone.0220619 ER

Barton, L., Bures, D., Kotrba, R., & Sales, J. (2014). Comparison of meat quality between eland (*Taurotragus oryx*) and cattle (*Bos taurus*) raised under similar conditions. *Meat Science, 96*, 346-352.

Belaunzaran, X., Bessa, R. J. B., Lavín, P., Mantecón, A. R., Kramer, J. K. G., & Aldai, N. (2015). Horse meat for human consumption — current research and future opportunities. *Meat Science, 108*, 74-81. doi:https://doi.org/10.1016/j.meatsci.2015.05.006

Beldarrain, L. R., Etaio, I., Moran, L., Sentandreu, M. A., Barron, L. J. R., & Aldai, N. (2020). Effect of ageing time on consumer preference and sensory description of foal meat. *Food Research International, 129* doi:10.1016/j.foodres.2019.108871 ER

Bell, R., & Marshall, D. W. (2003). The construct of food involvement in behavioral research: Scale development and validation. *Appetite, 40*, 235-244. doi:https://doi.org/10.1016/S0195-6663(03)00009-6

Canadian Bison Association. (2020). Bison history. Retrieved from https://www.canadianbison.ca/producers/about-bison/bison-history

Canadian Food Inspection Agency. (2017). Refrigeration of carcasses and carcass parts. Retrieved from http://www.inspection.gc.ca/food/meat-and-poultry-products/manual-of-procedures/chapter-17/eng/1367723343665/1367723573062?chap=12

Canadian Meat Council. (2013). Horse meat production in Canada. Retrieved from https://www.cmc-cvc.com/sites/default/files/files/Horse%20Meat%20Production%20in%20Canada%20Feb%202013.pdf

Cerjak, M., Haas, R., Brunner, F., & Tomic, M. (2014). What motivates consumers to buy traditional food products? evidence from Croatia and Austria using word association and laddering interviews. *British Food Journal, 116*, 1726-1747. doi:10.1108/BFJ-02-2014-0090

Cheah, I., Sadat Shimul, A., Liang, J., & Phau, I. (2020). Drivers and barriers toward reducing meat consumption. *Appetite, 149*, 104636.

Conner, M., & Armitage, C. J. (2006). Social psychological models of food choice. In R. Shepherd, & M. Raats (Eds.), *The psychology of food choice* (pp. 41-57). United Kingdom: Frontiers in Nutritional Science.

Cranfield, J. (2013). Impact of beef quality on Canadian beef demand. Retrieved from https://www.beefresearch.ca/factsheet.cfm/impact-of-beef-quality-on-canadian-beef-demand-166

da Silva, V. M., Rodrigues Minim, V. P., Marques Ferreira, M. A., de Paula Souza, Pedro Henrique, da Silva Moraes, Liliane Elen, & Minim, L. A. (2014). Study of the perception of consumers in relation to different ice cream concepts. *Food Quality and Preference, 36*, 161-168. doi:10.1016/j.foodqual.2014.04.008

Darke, P. R., & Chaiken, S. (2005). The pursuit of self-interest: Self-interest bias in attitude judgment and persuasion. *Journal of Personality and Social Psychology, 89*, 864-883.

de Andrade, J. C., Nalerio, E. S., Giongo, C., de Barcellos, M. D., Ares, G., & Deliza, R. (2018). Consumer sensory and hedonic perception of sheep meat coppa under blind and informed conditions. *Meat Science, 137*, 201-210. doi:10.1016/j.meatsci.2017.11.026 ER

de Andrade, J. C., Sobral, L. d. A., Ares, G., & Deliza, R. (2016). Understanding consumers' perception of lamb meat using free word association. *Meat Science, 117*, 68-74. doi:10.1016/j.meatsci.2016.02.039

DEFRA. (2010). Fostering the development of technologies and practices to reduce the energy inputs into the refrigeration of food. *Department for Environment, Food and Rural Affairs*. Retrieved from https://www.grimsby.ac.uk/documents/defra/sectrep-meatchill.pdf

Derinalp Çanakçı, S., & Birdir, K. (2020). The relation among food involvement, food variety seeking and food neophobia: A study on foreign tourists visiting Turkey. *Current Issues in Tourism, 23*, 917-928. doi:10.1080/13683500.2019.1602114

Dransfield, E. (2001). Consumer issues and acceptance of meat. *Paper Presented at 47th International Congress of Meat Science and Technology, Krakow, Poland,* 27-31 *August, 2001, 72-78.*

Eertmans, A., Victoir, A., Vansant, G., & Van den Bergh, O. (2005). Food-related personality traits, food choice motives and food intake: Mediator and moderator relationships. *Food Quality and Preference, 16*, 714-726. doi:https://doi.org/10.1016/j.foodqual.2005.04.007

Eldesouky, A., Pulido, A. F., & Mesias, F. J. (2015). The role of packaging and presentation format in consumers' preferences for food: An application of projective techniques. *Journal of Sensory Studies, 30*, 360-369. doi:10.1111/joss.12162

Esmerino, E. A., Ferraz, J. P., Tavares Filho, E. R., Pinto, L. P. F., Freitas, M. Q., Cruz, A. G., & Bolini, H. M. A. (2017). Consumers' perceptions toward 3 different fermented dairy products: Insights from focus groups, word association, and projective mapping. *Journal of Dairy Science, 100*(11), 8849-8860. doi:10.3168/jds.2016-12533

Fallon, A. E., & Rozin, P. (1983). The psychological bases of food rejections by humans. *Ecology of Food and Nutrition, 13*, 15-26. doi:10.1080/03670244.1983.9990728

Fanatico, A. C., Pillai, P. B., Emmert, J. L., Gbur, E. E., Meullenet, J. F., & Owens, C. M. (2007). Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. *Poultry Science, 86*, 2441-2449. doi:https://doi.org/10.3382/ps.2007-00092

FAOSTAT. (2020). New food balances. *Food and Agriculture Organization of the United Nations,* Retrieved from http://www.fao.org/faostat/en/#data/FBS

Font-i-Furnols, M., & Guerrero, L. (2014). Consumer preference, behavior and perception about meat and meat products: An overview. *Meat Science, 98*, 361-371.

Food Navigator-USA. (2020). Want to stay competitive in the growing protein space? look no further than consumer preferences. Retrieved from https://www.foodnavigator-usa.com/News/Promotional-Features/Discover-Insights-Into-What-Drives-Consumer-Protein-Choice?source=3&utm_source=newsletter_daily&utm_medium=email&utm_campaign=20-May-2020

Garcia-Diez, J., Alheiro, J., Pinto, A. L., Soares, L., Falco, V., Fraqueza, M. J., & Patarata, L. (2017). The impact of essential oils on consumer acceptance of chourico de vinho - a dry-cured sausage made from wine-marinated meat - assessed by the hedonic scale, JAR intensity scale and consumers' "will to consume and purchase". *Journal of Food Processing and Preservation, 41*. doi:https://doi.org/10.1111/jfpp.13056 ER

Gere, A., Szabo, Z., Pasztor-Huszar, K., Orban, C., Kokai, Z., & Sipos, L. (2017). Use of JAR-based analysis for improvement of product acceptance: A case study on flavored kefirs. *Journal of Food Science, 82*, 1200-1207. doi:https://doi.org/10.1111/1750-3841.13701 ER

Gill, C. O. (2005). Safety and storage stability of horse meat for human consumption. *Meat Science, 71*, 506-513. doi:https://doi.org/10.1016/j.meatsci.2005.04.030

Government of Alberta. (2017). Alberta horse meat exports by destination. Retrieved from https://open-alberta-ca.login.ezproxy.library.ualberta.ca/dataset/b16b47e6-33aa-4f42-86c5-c2c8f86b0003/resource/65163962-a4ff-4635-b6a6-98b2b66fc408/download/tab-68.xlsx

Government of Canada. (2019a). Annual game report by species in Canada. Retrieved from https://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/supply-sheets-by-species/annual-game-report-by-species/?id=1415860000117

Government of Canada. (2019b). Canadian total exports - horse and other equine production. Retrieved from https://www.ic.gc.ca/app/scr/tdst/tdo/crtr.html?grouped=INDIVIDUAL&searchType=BL&naArea=9999&countryList=TOP&toFromCountry=CDN&reportType=TE&customYears=2019&timePeriod=%7CCustom+Years&currency=CDN&productType=NAICS&hSelectedCodes=%7C11292&runReport=true

Graça, J. (2016). Towards an integrated approach to food behaviour: Meat consumption and substitution, from context to consumers. *Psychology, Community & Health, 5*, 152-169. doi:http://dx.doi.org/10.5964/pch.v5i2.169

Grygorczyk, A., Lesschaeve, I., Corredig, M., & Duizer, L. (2013). Extraction of consumer texture preferences for yogurt: Comparison of the preferred attribute elicitation method to conventional profiling. *Food Quality and Preference, 27*, 215-222. doi://doi.org/10.1016/j.foodqual.2012.02.017

Guerrero, L., Claret, A., Verbeke, W., Enderli, G., Zakowska-Biemans, S., Vanhonacker, F., . . . Hersleth, M. (2010). Perception of traditional food products in six European regions using free word association. *Food Quality and Preference, 21*, 225-233. doi:10.1016/j.foodqual.2009.06.003

Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science & Technology, 61*, 11-25. doi:https://doi.org/10.1016/j.tifs.2016.12.006

Hartung, J., Nowak, B., & Springorum, A. C. (2009). 27 - animal welfare and meat quality. In J. P. Kerry, & D. Ledward (Eds.), *Improving the sensory and nutritional quality of fresh meat* (pp.

628-646) Woodhead Publishing. doi:https://doi.org/10.1533/9781845695439.4.628 Retrieved from http://www.sciencedirect.com/science/article/pii/B9781845693435500273

Hayes, J. E., Raines, C. R., Depasquale, D. A., & Cutter, C. N. (2014). Consumer acceptability of high hydrostatic pressure (HHP)-treated ground beef patties. *LWT -- Food Science and Technology, 56*, 207-210.

Henchion, M. M., McCarthy, M., Resconi, V. C., & Troy, D. (2014). Meat consumption: Trends and quality matters. *Meat Science, 98*, 561-568.

Henchion, M. M., McCarthy, M., & Resconi, V. C. (2017). Beef quality attributes: A systematic review of consumer perspectives. *Meat Science, 128*, 1-7. doi://doi.org/10.1016/j.meatsci.2017.01.006

Hirsh, K. W., & Tree, J. J. (2001). Word association norms for two cohorts of British adults. *Journal of Neurolinguistics, 14*, 1-44. doi:10.1016/S0911-6044(00)00002-6

Hoffman, L. C., & Wiklund, E. (2006). Game and venison - meat for the modern consumer. *Meat Science, 74*, 197-208. doi://dx.doi.org/10.1016/j.meatsci.2006.04.005

Holdershaw, J., & Gendall, P. (2008). Understanding and predicting human behaviour. *Power and Place: Refereed Proceedings of the Australian and New Zealand Communication Association Conference, Wellington, New Zealand, July 9-11, 2008.*

Hovardas, T., & Korfiatis, K. J. (2006). Word associations as a tool for assessing conceptual change in science education. *Learning and Instruction, 16*, 416-432. doi:https://doi.org/10.1016/j.learninstruc.2006.09.003

Jaeger, S. R., Bava, C. M., Worch, T., Dawson, J., & Marshall, D. W. (2011). The food choice kaleidoscope. A framework for structured description of product, place and person as sources of variation in food choices. *Appetite, 562*, 412-423.

Janz, J. A. M., Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., Larsen, I. L., & Landry, S. (2004). The effects of modified carcass chilling on beef carcass grade and quality of several muscles. *Canadian Journal of Animal Science, 84*, 377-384. doi:https://doi.org/10.4141/A03-067

Jarvis, N., Clement, A. R., O'Bryan, C. A., Babu, D., Crandall, P. G., Owens, C. M., . . . Ricke, S. C. (2012). Dried plum products as a substitute for phosphate in chicken marinade. *Journal of Food Science, 77*, S253-S257.

Jastrzębska, E., Daszkiewicz, T., Górecka-Bruzda, A., & Feliś, D. (2019). Current situation and prospects for the horse meat market in Poland and the world. *Medycyna Weterynaryjna, 75*, 196-202.

Johansen, S. B., Naes, T., & Hersleth, M. (2011). Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. *Appetite, 56*, 15-24.

Jorge, E. d. C., Mendes, A. C. G., Auriema, B. E., Cazedey, H. P., Fontes, P. R., Ramos, A. de L. S., & Ramos, E. M. (2015). Application of a check-all-that-apply question for evaluating and characterizing meat products. *Meat Science, 100*, 124-133.

Joseph, R. L. (1996). Very fast chilling of beef and tenderness—a report from an EU concerted action. *Meat Science, 43*, 217-227. doi:https://doi.org/10.1016/0309-1740(96)00067-8

Knaapila, A. J., Sandell, M. A., Vaarno, J., Hoppu, U., Puolimatka, T., Kaljonen, A., & Lagström, H. (2015). Food neophobia associates with lower dietary quality and higher BMI in Finnish adults. *Public Health Nutrition, 18*(12), 2161-2171. doi:10.1017/S1368980014003024

Koch, R. M., Crouse, J. D., & Seideman, S. C. (1988). Bison, Hereford and Brahman growth and carcass characteristics. *Beef Research Progress Report, Roman L. Hruska US Meat Animal Research Center,* 3, 26-28.

Lähteenmäki, L., & Arvola, A. (2001). Food neophobia and variety seeking — consumer fear or demand for new food products. In L. J. Frewer, E. Risvik & H. Schifferstein (Eds.), *Food, people*

and society: A European perspective of consumers' food choices (pp. 161-175). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-662-04601-2_11

Lenglet, F. (2018). FNS or the varseek-scale? proposals for a valid operationalization of neophilia. *Food Quality and Preference, 66*, 76-84. doi:https://doi.org/10.1016/j.foodqual.2018.01.007

Liu, Y., Youssef, M. K., & Yang, X. (2016). Effects of dry chilling on the microflora on beef carcasses at a Canadian beef packing plant. *Journal of Food Protection, 79*, 538-543. doi:10.4315/0362-028X.JFP-15-476 ER

Maheswarappa, N. B., & Kiran, M. (2014). Emu meat: New source of healthier meat towards niche market. *Food Reviews International, 30*, 22-35. doi:10.1080/87559129.2013.853773

Mak, A. H. N., Lumbers, M., Eves, A., & Chang, R. C. Y. (2012). Factors influencing tourist food consumption. *International Journal of Hospitality Management, 31*, 928-936. doi:https://doi.org/10.1016/j.ijhm.2011.10.012

Marshall, D., & Bell, R. (2004). Relating the food involvement scale to demographic variables, food choice and other constructs. *Food Quality and Preference, 15*, 871-879. doi:10.1016/j.foodqual.2004.06.003

Masson, M., Delarue, J., Bouillot, S., Sieffermann, J., & Blumenthal, D. (2016). Beyond sensory characteristics, how can we identify subjective dimensions? A comparison of six qualitative methods relative to a case study on coffee cups. *Food Quality and Preference, 47*, 156-165. doi:10.1016/j.foodqual.2015.01.003

McClenahan, J. M., & Driskell, J. A. (2002). Nutrient content and sensory characteristics of bison meat: *Historical Materials from University of Nebraska-Lincoln Extension, 144.* Retrieved from http://digitalcommons.unl.edu/extensionhist/144

McGeehin, B., Sheridan, J. J., & Butler, F. (2002). Optimising a rapid chilling system for lamb carcasses. *Journal of Food Engineering, 52,* 75-81. doi:https://doi.org/10.1016/S0260-8774(01)00088-7

McGinnis, D. S., Aalhus, J. L., Chabot, B., Gariepy, C., & Jones, S. D. M. (1994). A modified hot processing strategy for beef: Reduced electrical energy consumption in carcass chilling. *Food Research International, 27*, 527-535. doi:10.1016/0963-9969(94)90138-4 ER

McSweeney, M. B., Duizer, L. M., Seetharaman, K., & Dan Ramdath, D. (2016). Assessment of important sensory attributes of millet-based snacks and biscuits. *Journal of Food Science, 81*, S1203-S1209.

McSweeney, M. B., Sisopha, A., T'ien, C., Rector, M., & Duizer, L. M. (2017). Comparing preferred attribute elicitation to trained panelists' evaluations using a novel food product. *Journal of Sensory Studies, 32* doi:10.1111/joss.12300 ER

Meiselman, H. L., Johnson, J. L., Reeve, W., & Crouch, J. E. (2000). Demonstrations of the influence of the eating environment on food acceptance. *Appetite, 35*, 231-237. doi:https://doi.org/10.1006/appe.2000.0360

Moussaoui, K. A., & Varela, P. (2010). Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis. *Food Quality and Preference, 21*, 1088-1099. doi://doi.org/10.1016/j.foodqual.2010.09.005

Muggah, E. M., & McSweeney, M. B. (2017). Using preferred attribute elicitation to determine how males and females evaluate beer. *Journal of Food Science, 82*, 1916-1923. doi:10.1111/1750-3841.13799 ER

Mullen, A. M. (2002). New techniques for analysing raw meat quality. In J. Kerry, J. Kerry & D. Ledward (Eds.), *Meat processing* (pp. 394-416) Woodhead Publishing. doi:https://doi.org/10.1533/9781855736665.3.394

National Research Council of Canada. (2019). *Plant-based protein market: Global and Canadian market analysis*. Retrieved from https://nrc.canada.ca/en/research-development/research-collaboration/programs/plant-based-protein-market-global-canadian-market-analysis

OECD. (2020). Meat consumption (indicator). Retrieved from https://data.oecd.org/agroutput/meat-consumption.htm.

Oloo, B., Mahungu, S., & Kahi, A. (2018). Descriptive sensory quality of Kenya's indigenous chicken meat from different ecotype-clusters reared under an intensive system. *African Journal of Food, Agriculture, Nutrition and Development, 18*, 13202-13225. doi:https://doi.org/10.18697/ajfand.81.16900 ER

Pinto Neto, M., Beraquet, N. J., & Cardoso, S. (2013). Effects of chilling methods and hot-boning on quality parameters of *M. Longissimus lumborum* from *Bos indicus nelore* steer. *Meat Science, 93*, 201-206. doi:https://doi/10.1016/j.meatsci.2012.08.024

Pinto, Leticia de Paula F., Silva, H. L. A., Kuriya, S. P., Macaira, P. M., Cyrino Oliveira, F. L., Cruz, A. G., . . . Freitas, M. Q. (2018). Understanding perceptions and beliefs about different types of fermented milks through the application of projective techniques: A case study using Haire's shopping list and free word association. *Journal of Sensory Studies, 33*, e12326. doi:10.1111/joss.12326

Piqueras-Fiszman, B., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars. *Food Quality and Preference, 28*, 328-338. doi:10.1016/j.foodqual.2012.10.006

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120. doi:https://doi.org/10.1016/0195-6663(92)90014-W

Polawska, E., Cooper, R. G., Jozwik, A., & Pomianowski, J. (2013). Meat from alternative species - nutritive and dietetic value, and its benefit for human health - a review. *CyTA -- Journal of Food, 11*, 37-42.

Polizer Rocha, Y. J., Lapa-Guimaraes, J., de Noronha, Regina Lucia F., & Trindade, M. A. (2018). Evaluation of consumers' perception regarding frankfurter sausages with different healthiness attributes. *Journal of Sensory Studies, 33*, e12468. doi:10.1111/joss.12468

Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference, 13*, 489-495.

Rahman, M. M., Walker, B., Roy, B. C., McMullen, L., & Bruce, H. L. (2017). Effects of chilling and ageing period on horse meat quality. *Proceedings of the 63rd International Congress of Meat Science and Technology, Cork, Ireland, 13-18, August, 2017, 212-213.*

Rebollar, R., Lidon, I., Gil-Perez, I., & Martin, J. (2019). How should I tell you this? the effects of the image used to convey that a natural yogurt is sweetened on consumer expectations and willingness to buy. *Food Research International, 126* doi:10.1016/j.foodres.2019.108721 ER

Resurreccion, A. V. A. (2003). Sensory aspects of consumer choices for meat and meat products. *Meat Science, 66*, 11-20. doi://doi.org/10.1016/S0309-1740(03)00021-4

Ritchie, H., & Roser, M. (2019). Meat and dairy production. Retrieved from https://ourworldindata.org/meat-production

Rodbotten, M., Ueland, O., Lea, P., & Kubberod, E. (2004). A sensory map of the meat universe. sensory profile of meat from 15 species. *Meat Science, 68*, 137-144.

Rodrigues, I., Goncalves, L. A., Carvalho, F. A., Pires, M., Rocha, Y. J. P., Barros, J. C., . . . Trindade, M. A. (2020). Understanding salt reduction in fat-reduced hot dog sausages: Network structure, emulsion stability and consumer acceptance. *Food Science and Technology International, 26*, 123-131. doi:10.1177/1082013219872677 ER

Roininen, K., Arvola, A., & Lahteenmaki, L. (2006). Exploring consumers' perceptions different qualitative of local food with two techniques: Laddering and word association. *Food Quality and Preference, 17*, 20-30. doi:10.1016/j.foodqual.2005.04.012

Rubio, B., Vieira, C., Martinez, B., & Fernandez, A. M. (2013). Effect of different post-mortem temperatures on carcass quality of suckling lamb. *Food Science and Technology International, 19*, 351-356.

Rule, D. C., Broughton, K. S., Shellito, S. M., & Maiorano, G. (2002). Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. *Journal of Animal Science, 80*, 1202-1211.

Saha, A., Lee, Y., Meullenet, J. F., & Owens, C. M. (2009). Consumer acceptance of broiler breast fillets marinated with varying levels of salt. *Poultry Science, 88*, 415-423. doi:10.3382/ps.2008-00230 ER

Sanderson, K., Hobbs, J. E., Shand, P., & Kerr, W. A. (2002). Consumer preferences in the emerging bison industry: Marketing implications. *Journal of International Food & Agribusiness Marketing, 14*, 57-78. doi:10.1300/J047v14n03_05 ER

Sarin, H. V., Taba, N., Fischer, K., Esko, T., Kanerva, N., Moilanen, L., . . . Perola, M. (2019). Food neophobia associates with poorer dietary quality, metabolic risk factors, and increased disease outcome risk in population-based cohorts in a metabolomics study. *American Journal of Clinical Nutrition, 110*, 233-245. doi:10.1093/ajcn/nqz100 ER

Savell, J. W., Mueller, S. L., & Baird, B. E. (2005). The chilling of carcasses. *Meat Science, 70*, 449-459. doi:https://doi.org/10.1016/j.meatsci.2004.06.027 ER

Schmitt, N. (1998). Quantifying word association responses: What is native-like? *System, 26*, 389-401. doi:https://doi.org/10.1016/S0346-251X(98)00019-0

Schupp, A., Gillespie, J., & Reed, D. (1998). Consumer choice among alternative red meats. *Journal of Food Distribution Research, 29*, 35-43.

Serrano-Cruz, M. R., Espinoza-Ortega, A., Sepulveda, W. S., Vizcarra-Bordi, I., & Thome-Ortiz, H. (2018). Factors associated with the consumption of traditional foods in Central Mexico. *British Food Journal, 120*, 2695-2709. doi:10.1108/BFJ-11-2017-0663

Sester, C., Dacremont, C., Deroy, O., & Valentin, D. (2013). Investigating consumers' representations of beers through a free association task: A comparison between packaging and blind conditions. *Food Quality and Preference, 28*, 475-483. doi:10.1016/j.foodqual.2012.11.005

Shan, L. C., Henchion, M., De Brún, A., Murrin, C., Wall, P. G., & Monahan, F. J. (2017). Factors that predict consumer acceptance of enriched processed meats. *Meat Science, 133*, 185-193. doi:https://doi.org/10.1016/j.meatsci.2017.07.006

Sheng-Hang Chan, Moss, B. W., Farmer, L. J., Gordon, A., & Cuskelly, G. J. (2013). Comparison of consumer perception and acceptability for steaks cooked to different endpoints: Validation of photographic approach. *Food Chemistry, 136*, 1597-1602. doi:10.1016/j.foodchem.2012.04.069 ER

Statista. (2016). Meat consumption habits in Canada from 2013 to 2015. Retrieved from https://www.statista.com/statistics/521135/meat-consumption-canada/

Statista. (2019a). Consumption of beef per capita in Canada from 2000 to 2020. Retrieved from https://www.statista.com/statistics/735166/consumption-of-milk-per-capita-canada/

Statista. (2019b). Per capita meat consumption in Canada from 1998 to 2018, by type. Retrieved from https://www.statista.com/statistics/442461/per-capita-meat-consumption-by-type-canada/

Steiner, B., Gao Fei, & Unterschultz, J. (2010). Alberta consumers' valuation of extrinsic and intrinsic red meat attributes: A choice experimental approach. *Canadian Journal of Agricultural Economics, 58*, 171-189. doi:10.1111/j.1744-7976.2009.01177.x ER

Vaca, S. I., & Mesias, F. J. (2014). Spanish consumer perceptions towards fruits from Ecuador: A preliminary qualitative approach with projective techniques. *Itea-Informacion Tecnica Economica Agraria, 110*, 89-101.

van Trijp, H. C. M., & Steenkamp, J. E. M. (1992). Consumers' variety seeking tendency with respect to foods: Measurement and managerial implications, *European Review of Agricultural Economics, 19*, 181-195.

Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. *Food Research International, 48*, 893-908. doi://doi.org/10.1016/j.foodres.2012.06.037

Viana, M. M., dos Santos Silva, Vivian Lara, & Trindade, M. A. (2014). Consumers' perception of beef burgers with different healthy attributes. *Lwt-Food Science and Technology, 59*(2), 1227-1232. doi:10.1016/j.lwt.2014.05.009

Vidal, L., Ares, G., & Gimenez, A. (2013). Projective techniques to uncover consumer perception: Application of three methodologies to ready-to-eat salads. *Food Quality and Preference, 28*, 1-7. doi:10.1016/j.foodqual.2012.08.005

Wadolowska, L., Babicz-Zielinska, E., & Czarnocinska, J. (2008). Food choice models and their relation with food preferences and eating frequency in the Polish population: POFPRES study. *Food Policy, 33*, 122-134. doi:10.1016/j.foodpol.2007.08.001 ER

Walker, B. (2017). *Impact of Carcass Chill Time on the Microbiology of Horse Meat.* Retrieved from https://era.library.ualberta.ca/items/502543e7-6ddc-4f59-90fb-b786ad9cfee9/view/fd5ba37d-3bca-48c0-ab81-3a4150e49074/Walker_Brian_D_201709_MSc.pdf

Youngseung Lee, Rui Xiong, & Meullenet, J. F. (2014). Prediction of sensory texture of broiler breast meat using instrumental spectral stress-strain analysis. *International Journal of Food Science & Technology, 49*, 2269-2275.

Yung Hung, & Verbeke, W. (2018). Sensory attributes shaping consumers' willingness-to-pay for newly developed processed meat products with natural compounds and a reduced level of nitrite. *Food Quality and Preference, 70*, 21-31. doi:https://doi.org/10.1016/j.foodqual.2017.02.017 ER

Zhu, L., Gao, S., & Luo, X. (2011). Rapid chilling has no detrimental effect on the tenderness of low-voltage electrically stimulated *M. longissimus* in Chinese bulls. *Meat Science, 88*, 597-601. doi:https://doi.org/10.1016/j.meatsci.2011.02.005

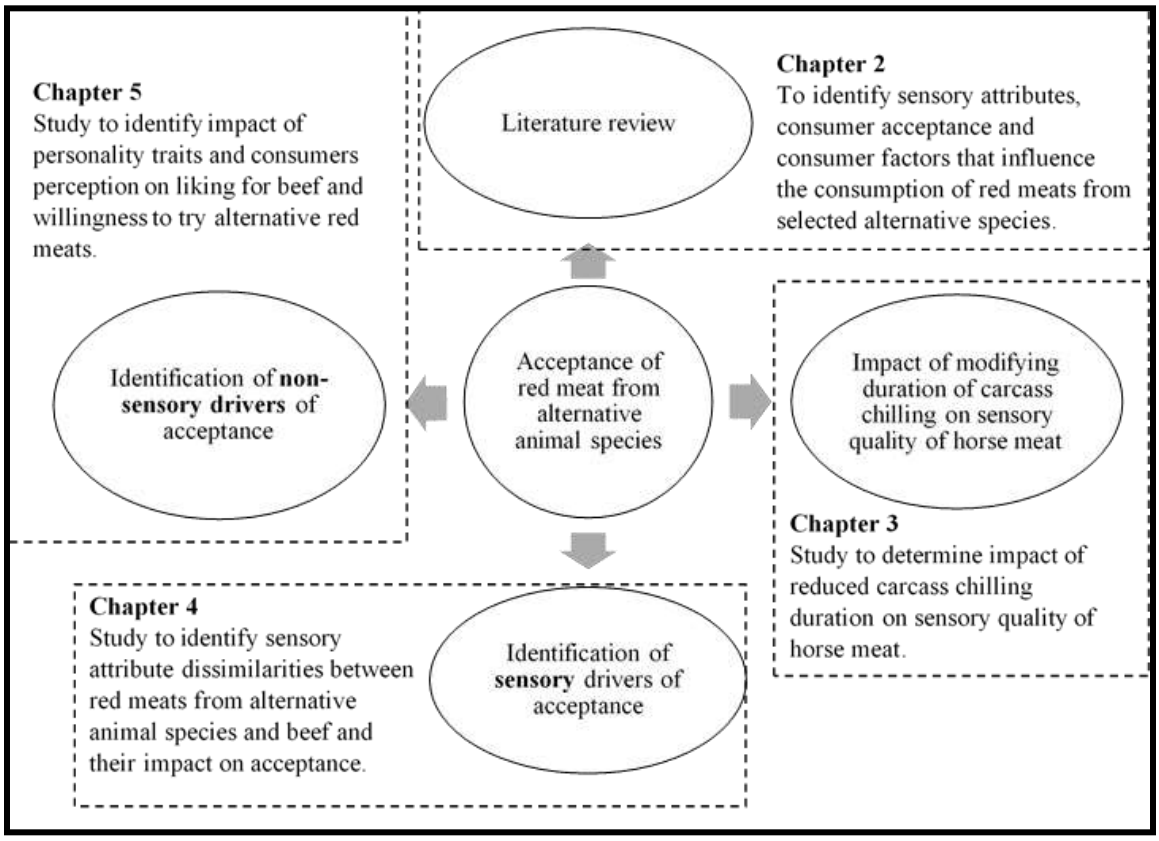


Fig. 1.1: Schematic representation of the research objectives and thesis chapters

Chapter 2. A review of sensory and consumer-related factors influencing the acceptance of red meats from alternative animal species

2.1. Introduction

Globally, the meat consumption pattern is changing, including quantity of meat consumed, consumption across different species of meat and across different geographical locations (Grunert, 2006). With respect to quantity of meat consumed, there is a significant increase in global meat consumption with aggregate meat consumption increasing by over 90% between 1990 and 2019 (OECD, 2020). This is mainly driven by a growing world population together with increasing globalization of food systems, urbanization and rising incomes in developing countries (Graça, 2016; Henchion, McCarthy, Resconi, & Troy, 2014; Maheswarappa & Kiran, 2014). The quantity of meat consumed in developing countries grew three folds more than it did in developed countries between the early 1970s to mid-1990s, mainly due to connotation of wealth and social power associated with consuming large amount of meat in these societies (Delgado, 2003; Ruby et al., 2016).

In most developed countries, there is a declining trend in the quantity of meat consumed with interest in non-animal protein sources, particularly plants, decreased consumption of red meat and increased consumption of white meat (Ali & Pappa, 2011; National Research Council of Canada, 2019; Nosworthy & House, 2017; Statista, 2019). This trend is largely driven by: (1) changing demographics and an aging population, (2) increased consumer health consciousness, (3) consumer concerns about safety of meat due to meat-related disease outbreaks such as foot-and-mouth disease and Bovine Spongiform Encephalopathy (BSE), (4) increasing environmental concerns which has increased interest in organic or naturally produced meat with low input systems, and (5) animal welfare concerns (Ali & Pappa, 2011; Cheah, Sadat Shimul, Liang, & Phau, 2020; Grunert, 2006; Hartmann & Siegrist, 2017; Henchion et al., 2014; Hoffman & Wiklund, 2006; Maheswarappa & Kiran, 2014). These issues have resulted in changing consumer behavior towards meat which is manifested in either reduced consumption, refusal of meat but tolerance of animal products or outright exclusion of meat from the diet (Corallo, Latino, & Spennato, 2019).

With increasing consumer health-consciousness, environmental concern and interest in variety, consumers pay more attention to the nutritional quality and environmental attributes of meat and

protein choices consumed. This may create increased consumer interests in red meats from alternative animal species such as bison, elk, horse and kangaroo. Meats from alternative species are defined as meats derived from game or non-domesticated animals, or non-traditional animals considered unusual for the purpose of consumption (Maheswarappa & Kiran, 2014; Schupp, Gillespie, & Reed, 1998). Most of these meats offer the benefit of lower fat and cholesterol and higher concentration of n-3 polyunsaturated fatty acids when compared to conventional red meats (McDaniel et al., 2013; Polawska, Cooper, Jozwik, & Pomianowski, 2013; Rule, Broughton, Shellito, & Maiorano, 2002). In addition to nutritional benefits, the nutritional needs of most of these animals can be met by grazing on indigenous grasses, hence production require limited agricultural inputs, while some species such as horse emit lower enteric methane, hence do not contribute significantly to global greenhouse gas emission and climate change (Agriculture and Agri-Food Canada, 2019b; Wilson & Edwards, 2019).

Alternative animal species have the potential to produce good quality meat and are thus gaining interest as specialized livestock animals (Polawska et al., 2013). However, the alternative meat industry is generally a niche market with production and consumption representing a low share of the global meat market due to both demand and supply limitations (Schupp et al., 1998). As of 2017, consumption of 'other meats', including wild game, horse and rabbit meats was 2% of global per capita meat consumption (FAOSTAT, 2020b; Ritchie & Roser, 2019).

2.1.1. Global production of alternative red meats

Red deer (*Cervus elaphus*) and fallow deer (*Cervus dama*) are the most common alternative red meat belonging to the cervid specie farmed in Europe (Hoffman & Wiklund, 2006). Deer farming is neither a significant nor growing part of the livestock industry in the UK as production represents less than 0.06% of farmed livestock (Deerfarmer, 2016). In Canada and the USA, the most common cervid species farmed is elk (*Cervus elaphus nelson*) (Hoffman & Wiklund, 2006). Other deer species farmed in Canada include fallow deer (*Dama dama*), white-tailed deer (*Odocoileus virginianus*), red deer, mule deer (*Odocoileus hemionus*) and reindeer (*Rangifer tarandus*) (Deerfarmer, 2016). As of January 2017, there were about 38,000 farm-raised elk and deer on 600 farms in Canada (Agriculture and Agri-Food Canada, 2019a). Between 2009 and 2018, annual exports of Canadian elk meat fell from 356,229 to 116,779 kg (Government of Canada, 2019). Bison is another alternative red meat specie farmed in North America. There were 145,000 bison herds farmed on 975 farms in Canada as

of January 2017, which represents an almost 50% decrease from the 1898 farms reported in 2006 (Agriculture and Agri-Food Canada, 2019a; Canadian Bison Association, 2019; Canadian Bison Association, 2020). Canadian bison meat is exported mainly to the USA and other European countries including France, Netherlands, Switzerland and the UK, generating annual revenue of CAN$17.5 million in 2018. Annual exports fell from 1,699,441 to 943,270 kg between 2009 and 2018 (Canadian Bison Association, 2019; Government of Canada, 2019).

Horse meat has considerable consumption in most Asian and European countries including Italy, Mongolia, Kazakhstan, Kyrgyzstan, Belgium, China, Iceland, Korea Russia, Finland, France, Poland, Spain (Belaunzaran et al., 2015; Lorenzo et al., 2014b). Global production of horse meat was close to 800,000 tonnes in 2018 which represents 0.25% of total global meat production, with the highest production in China (25%) followed by Kazakhstan (15%), Mexico (10%), Russia (5.7%) and Argentina (3.5%) (FAOSTAT, 2020a). Horse meat consumption is only popular among small groups of consumers in countries with a tradition of consumption and not popular elsewhere due to religious, social and/cultural issues together with a strong emotional connection humans have with horses (Belaunzaran et al., 2015; Jastrzębska, Daszkiewicz, Górecka-Bruzda, & Feliś, 2019). Although Canada is a major contributor to the global horse meat export market, ranking third largest exporter to Japan, France, Switzerland and generating about CAN$ 83 million in revenue annually, local consumption of Canadian horse meat represents only 15% of annual production (Canadian Meat Council, 2013; Government of Alberta, 2017; Jastrzębska et al., 2019).

Global production of buffalo was 4,247,413 tonnes in 2018 with India accounting for 40% of production followed by Pakistan (22%) and China 15%. (FAOSTAT, 2020a). India exports buffalo meat to over 48 countries of the world with only a small proportion consumed domestically (Naveena & Kiran, 2014). Kangaroo also produces high quality meat that provides valuable contributions to Australian exports and the economy with gross production value of A$174 million as of 2014 (Kangaroo Industry Association, 2018).

2.1.2. Factors influencing food consumption

The potential of these red meats from alternative animal species to make more substantial contributions to both exports and domestic markets depends on increasing consumption and production. To achieve increased consumption, there is a need to understand consumer motives for

food (specifically meat) so that production and marketing decisions can be designed to meet these specific needs (Sanderson, Hobbs, Shand, & Kerr, 2002). Understanding consumer food consumption motives entails gaining insights into determinants of consumer food-related behaviors including liking, preference, choice and consumption, which are overlapping but not equivalent concepts often used interchangeably (Mak, Lumbers, Eves, & Chang, 2012). Rozin (2006) describes the relationship among these food-related consumption behaviors; liking is a major determinant of preference, preference a major determinant of choice and choice a major determinant of consumption. The relationships, however, depend on the indirect influence exerted by intervening variables (Mak et al., 2012) which have been broadly categorized into food-related, consumer-related and environment-related factors (Jaeger, Bava, Worch, Dawson, & Marshall, 2011; Mak et al., 2012).

Food-related factors include physical and chemical properties, sensory attributes, functional properties and nutrient content of the food while consumer-related factors encompass demographic, economic, consumer food-related expectations and attitudes, ethical concerns, interest in health, as well as physiological and psychological traits and needs of the consumer (Eertmans, Victoir, Vansant, & Van den Bergh, 2005; Johansen, Naes, & Hersleth, 2011). Environment-related factors include the cultural, religious and social factors as well as eating occasion or context, including the time, place, circumstances, and habit by what and with whom food is consumed (Wadolowska, Babicz-Zielinska, & Czarnocinska, 2008). Culture and religion are of particular importance to meat consumption to classify meat as "acceptable" or "non-acceptable", particularly when certain meat types are prohibited or when certain preparation methods are mandated (Mak et al., 2012).

Sensory attributes are inherent characteristics of food products that play a significant role in consumer satisfaction. In the domain of meat research, sensory attributes distinguish meats of animals from different origins (including species, age, sex, production system) and determine the influence of practises such as carcass chilling duration, carcass hanging technique or duration of ageing on meat quality (Henchion, McCarthy, & Resconi, 2017; Lebert, Rousset, Lebert, & Talon, 2003; Lorenzo, Purrinos, & Carballo, 2016). Embedded in the influence of psychological traits is consumers' need for adventure, which is manifested in desire for new taste, new foods and variety at relatively low risk (Schupp et al., 1998). In addition to the influence of sensory acceptance, consumer-related factors are widely accepted as a vital determinant of food consumption behavior (Rozin, 2006).

Production and consumption of red meats from alternate animal species offer economic and nutritional benefits, however, factors influencing acceptance and consumption of these meat types have not been systematically and comprehensively reviewed. There is a need to aggregate what is already known about sensory attributes and consumer perceptions of alternative red meats, including sensory attribute liking and preference, socio-demographic factors affecting choice and consumption of these meats. The objective of this review is to aggregate, summarize, and synthesize existing literature about the sensory and consumer-related factors influencing acceptance and consumption of red meats from alternative animal species.

2.2. Methodology

A systematic review of the literature was performed to overcome bias in literature selection (Ferrari, 2015). A literature search of 5 databases was carried out in June 2017 with a follow-up search in January 2020. The databases included FSTA, EBSCO Host, Scopus, CAB abstract and global health citation, and Web of Science (Core collection). Two search strings were used: one each for sensory evaluation studies and for consumer factor studies (Appendix 1). Review articles, abstracts, conference papers, opinion papers, book chapters and any other article without specific methodology were excluded. Only studies published in English language were included in the review. The review was based on studies of human sensory evaluation of cooked red meats other than beef, lamb, pork and goat while studies based on instrumental sensory evaluation, evaluation of raw meat, white meat, rodents and rabbit were excluded. Studies based on the use of sensory enhancers, shelf-life extenders, electrical stimulation, flavor precursors or any form of treatment that can alter the natural sensory properties of the meat were also excluded from this review.

A total of 1297 studies were identified through the database search with 107 (74 sensory evaluation and 33 consumer factor) studies selected after the screening process. Distribution of the sensory evaluation studies by animal specie is presented in Fig. 2.1a while distribution of studies focused on consumer factors is shown in Fig. 2.1b. Distribution of the studies by publication year is presented in Fig 2.2a and Fig. 2.2b, for sensory attributes and consumer factor studies, respectively.

2.3. Results and discussion

2.3.1. Quantitative evaluation of studies

Quantitative analysis of study numbers by publication year showed research interest in both sensory evaluation and consumer studies of alternative red meats increasing between 2001 and 2005 (Fig. 2.2a & 2.2b). This may be in response to reported cases of Bovine Spongiform Encephalopathy (BSE) in some countries within this period, motivating research into acceptability of red meats other than beef. The sustained interest beyond 2005 could partly be attributed to increasing consumer health consciousness that has resulted in demand for low fat products and healthier fatty acid profiles (Franco et al., 2011; Maheswarappa & Kiran, 2014) which inspired research into healthier red meat alternatives. Sensory evaluation studies of deer were most frequent in the literature, followed by buffalo and horse, while kangaroo, bison, elk, camel, and donkey were less frequently investigated (Fig. 2.2a). The species of deer most investigated for its sensory attributes and acceptability was red deer *(Cervus elaphus)*; 37.5% followed by reindeer *(Rangifer tarandus)*; 20.8% and fallow deer *(Dama dama)*; 12.5%.

A high proportion of studies of consumer-related factors influencing acceptance of red meat from alternative species used the term “game”, “exotics”, “bushmeat”, “wildlife”, “wild ungulates” or “specialty” to describe these meat types. Game/wild ungulate/wild meat was most synonymous with authors in South Africa, bushmeat synonymous with authors in West Africa, while specialty/exotic meat was most synonymous with authors in North America (particularly the US) and authors in Europe used the word “game”. While research on sensory attributes of bison has received little attention, consumer factors influencing acceptance of bison has received considerable attention as studies on bison were the second largest after game. No studies were found for some other animal species (moose, yak, beefalo, caribou) in the search string. A schematic overview of the identified sensory and consumer-related factors influencing acceptance and consumption of these red meats from alternative animal species is presented in Fig. 2.3.

2.3.2. Sensory factors influencing acceptance of red meat from alternative species

The sensory quality of meat encompasses appearance/color, texture/tenderness, juiciness, aroma and flavor attributes which gives satisfaction to the consumer (Listrat et al., 2016; Neethling, Hoffman, &

Muller, 2016; Wu, Fu, Therkildsen, Li, & Dai, 2015). These attributes are influenced by a number of ante-mortem factors including animal species, breed, gender, age, muscle anatomical location, diet and production practise, and post-mortem factors including carcass suspension, meat ageing, packaging and storage conditions (Juárez et al., 2012; Kaic & Potocnik, 2019; Neethling et al., 2016; Spanier, Flores, McMillin, & Bidner, 1997).

Across all the databases searched, the sensory attributes and acceptance of these red meats from alternative animal species were compared only with beef and not with other conventional red meat types. The next two sections of this review summarise studies that evaluate the sensory differences between beef and red meats from alternative species, including identification of sensory drivers of beef acceptance, and sensory acceptance of these meats when evaluated without comparison to beef.

2.3.2.1. Sensory comparison between red meats from alternative species and beef

Tenderness and flavor are two major factors contributing to beef liking (Neely et al., 1998; Realini et al., 2009). Although juiciness impacts consumer liking for beef, it is closely related to tenderness due to the halo effect of dryness on tenderness with dry meats perceived to be tougher (Neethling et al., 2016). With increasing research to improve overall beef tenderness and reduce tenderness variability, flavor is now considered a more important driver of beef liking (Corbin et al., 2015; Miller, 2020; Umberger, Feuz, Calkins, & Killinger-Mann, 2002). Corbin et al. (2015) reported a high correlation ($r = 0.96$) between beef flavor and overall liking among consumers in the United States. Animal age, gender, genetics, duration and type of ageing, diet and production system influence intramuscular fat content and fatty acid composition and subsequently acceptance of flavor, tenderness and juiciness (Miller, 2020; Neethling et al., 2016; Umberger et al., 2002). Details of drivers of beef liking and the effects of ante and post-mortem factors have been extensively discussed by Miller (2020).

A summary of studies on sensory evaluation comparisons between conventional (beef) and alternative red meats is presented in Table 2.1. Flavor is the major distinguishing sensory attribute, while texture differences, particularly tenderness, are inconsistent and dependent on the animal specie. Deer meat has higher flavor and aroma intensity than beef and was more associated with gamey aroma and flavor and off-flavor, while beef was more associated with meaty/beefy flavor

(Brittin, Armes, Ramsey, & Simpson, 1981; Bureš, Bartoň, Kotrba, & Hakl, 2015; Rincker et al., 2006).

Unlike deer meat, the key difference between beef and buffalo meat was the intensity and desirability of texture attributes, although the results across studies were contradictory. Robertson, Bouton, Harris, Shorthose, & Ratcliff, (1983) and Charles (1982) both reported no significant difference in tenderness acceptability and intensity between beef and buffalo meat while Prabhakar & Rao (1986) and Hassan, Abdel-Naeem, Mohamed, & Yassien (2018) reported lower tenderness scores for buffalo meat than beef. Conversely, Merle et al. (2004) reported buffalo meat to be more tender than beef. The contradictory results reported by the various authors may be due to the differences in age and breeds of both cattle and buffalo compared. Another contributing factor may be differences in the species of buffalo (water buffalo) which is endemic to South Asian swamps versus other species of buffalo that are endemic to grasslands.

Bison meat exhibits distinct sensory attributes when compared to beef. Like deer meat, bison was associated with noticeable off-flavor described as intense ammonia, gamey and metallic (Koch, Jung, Crouse, Varel, & Cundiff, 1995). However, regardless of the lower intramuscular fat content of bison when compared to beef, its sensory scores for tenderness and ease of fragmentation were not significantly different from Hereford cattle (Koch, Crouse, & Seideman, 1988). Another study however, reported bison meat to be more tender and juicier than meat from *Bos taurus* breed of cattle and a cross of both *Bos taurus* and bison (Koch et al., 1995). Comparison of sensory quality of meat from eland and cattle raised under similar conditions showed that eland meat scored significantly lower than beef for overall acceptability and intensity of all attributes except odor (Bartoň, Bureš, Kotrba, & Sales, 2014).

Horse meat was differentiated from other animal species mainly based on its appearance attributes. It was rated third darkest meat among 15 species of animal after beaver and hare, and associated with a dry and fibrous appearance (Popoola, Bruce, McMullen, & Wismer, 2019 (Chapter 4 this thesis); Rodbotten, Ueland, Lea, & Kubberod, 2004; Roth, Brewer, Bechtel, Kline, & McKeith, 1995). There is close resemblance between sensory attributes of horse meat and beef as horse meat was located close to beef on the sensory map of 2 separate descriptive sensory analysis studies (Popoola et al., 2019; Rodbotten et al., 2004) and was not significantly different in flavor and tenderness from beef

(Arcos-Garcia, Totosaus, Guerrero, & Perez-Chabela, 2002). This may be due to its low level of distinct flavor and aroma attributes when compared to other animal species. Horse meat was not associated with livery flavor and aroma in both descriptive comparative studies above and when evaluated alone, a citation frequency of 24% was reported for livery flavor on the first day of ageing (Beldarrain et al., 2020). Only one author (Roth et al., 1995) reported distinct livery and metallic flavor for horse meat when compared with reference beef, however, the intensity ratings for these attributes were low (between 5 and 6 on a 15 cm scale). The close resemblance of horse meat to beef may be an explanation for its use as adulterant for beef products, such as the horse meat 'scandal' of 2013 where horse meat DNA was found in meat products labelled as beef in Europe (O'Mahony, 2013). Contrary to reports that horse meat has a sweet taste due to its high glycogen content (Jastrzebska, Daszkiewicz, Gorecka-Bruzda, & Felis, 2019), it was not reported to be significantly sweeter when compared with meats from other animal species. However, when evaluated alone, horse meat was perceived to possess an intermediate level of sweetness with close to 45% of the consumers citing a sweetness term (Beldarrain et al., 2020).

Compared to beef that has meaty flavor and aroma, elk meat has livery, fishy and metallic flavors as well as a musky aroma with bloody and rancid aftertastes (Popoola et al., 2019). Elk meats are also darker than other domestic meat species because of their high myoglobin content as well as the negligible amount of intramuscular fat (Dhanda, Pegg, & Shand, 2003). The livery and metallic flavor and aftertaste are due to the high iron content of elk meat and the high proportion of polyunsaturated fatty acids makes it more susceptible to oxidation (Wood et al., 2004; Yancey et al., 2006), hence the rancid aftertaste. Although livery flavor and aftertaste were major drivers of disliking for meat, a small cluster of consumers showed liking for elk meat, which represent a niche market for this meat type (Popoola et al., 2019). Although there is possibility of altering the fatty acid composition of meat through animal diet, this will decrease concentration of PUFA and increase that of SFA (Muir, Deaker, & Bown, 1998; Wood & Enser, 2017) thus resulting in trade-off between sensory acceptance and nutritional benefit.

2.3.2.2. Sensory drivers of acceptance of red meats from alternative animal species

Evaluation of sensory quality and consumer acceptance of the red meats from alternative species was conducted to determine the influence of various ante and post-mortem factors including gender, age,

diet and production system, anatomical location, carcass suspension technique and ageing. A detailed description of the ante and post-mortem factors are described in the extensive review by Neethling et al. (2016). As eating/sensory quality is the basis of consumer acceptance, consumers' assessment of flavor, juiciness and tenderness will impact overall acceptance (Miller, 2020; Tuorila & Hartmann, 2020). Application of rapid descriptive profiling methods, such as Check-All-That-Apply, that facilitate simultaneous characterization of sensory attributes and identification of its impact on liking, provides information about the impact of specific sensory attributes on consumer acceptance. This method was applied by two authors; Beldarrain et al (2020) to determine effect of ageing time on sensory description and consumer preference of foal meat and by Popoola et al. (2019) to identify sensory drivers of liking for horse, bison and elk meat.

Comparison of studies investigating the influence of these ante-and post-mortem factors on sensory attributes of meats may be difficult as results may be confounded by variations in animal age categories, diet, gender, exercise (wild/farmed), sample preparation, muscle cuts, ageing duration, and even sensory methodologies and statistical analysis (Neethling et al., 2016; Rodbotten et al., 2004). Results of studies on the influence of these factors on sensory quality and consumer acceptance of alternative red meats has been inconsistent even within the same species due to interrelatedness of the factors and differences in consumer preference. Consumer acceptance and specie-specific effects of these ante and post-mortem factors on consumer acceptance of red meats from alternative animal species are described in the next paragraphs.

The influence of animal diet and gender on the sensory quality of deer meat have both positive and negative impacts on consumer acceptance. The high flavor intensity of female deer meat was desirable for some consumers (Postolache, Boisteanu, & Lazar, 2011) and undesirable for others (Daszkiewicz, Janiszewski, & Wajda, 2009). Tenderness and juiciness are desirable attributes for meat and this was higher in female fallow deer meat than male, while juiciness was significantly higher in male fallow deer than female (Piaskowska, Daszkiewicz, Kubiak, & Janiszewski, 2015). Wild fallow deer produce meat with higher aroma desirability, taste desirability and juiciness while tenderness is higher in farmed fallow deer (Daszkiewicz et al., 2009). Livery and sweet flavor was higher in reindeer fed commercial feed while off-flavor was higher in pasture-fed reindeer (Wiklund, Johansson, & Malmfors, 2003). The flavor of grass-fed and feedlot red deer was significantly more

acceptable than wild red deer only at 27 and not at 12 and 18 months (Forss & Manley, 1978). Similarly, consumers showed low acceptability for the grassy flavor of grass-fed deer meat while the palatability score was higher for concentrate-fed deer (Dahlan & Norfarizan Hanoon, 2008; Wiklund, Manley, Littlejohn, & Stevenson-Barry, 2003). Conversely, finishing young fallow deer on grain resulted in significantly stronger venison flavor compared to those finished on pasture, although the impact was not significant on consumers' overall liking (Hutchison, Mulley, Wiklund, & Flesch, 2012). With respect to post-mortem activity, a shorter ageing period of 1 to 3 days is recommended for venison due to faster tenderization as a result of increased activity of proteolytic enzymes; ageing beyond 3 days results in more tender but darker meat (Soriano et al., 2016; Wiklund, Barnier, Smulders, Lundström, & Malmfors, 1997; Wiklund, Dobbie, Stuart, & Littlejohn, 2010).

For camel meat, tenderness, juiciness and flavor are the sensory attributes by which consumers determine quality (Aganga, Aganga, Thema, & Obocheleng, 2003). Evaluation of the desirability of these attributes revealed that the majority of consumers panellists perceived camel meat to be moderately juicy, while almost 70% perceived it to be tender and only 40% of the panelists considered donkey meat to be of good flavor (Aganga et al., 2003). The effect of increased age on reduced tenderness and juiciness of camel meat was weak for animals younger than 26 months of age (Dawood, 1995).

Similar to other meats, tenderness and juiciness are important requirements for consumer acceptance of horse meat, but response to flavor and its role in acceptance is not yet known, probably due to the lack of distinct flavor attributes of horse meat. The influence of production system and diet on the eating quality of horse meat is similar to other meat types. Including substantial amount of concentrate (3 kg) in the finishing diet improved intramuscular fat and organoleptic quality (including increased springiness, sweetness, juiciness and tenderness) of foal meats compared to full extensive pasture grazing or semi extensive system with 1.5 kg concentrate (Franco et al., 2011; Lorenzo et al., 2016). Sex and age of the animal has an impact on flavor intensity of foal meat, with flavor intensity significantly higher for 9 month old female foals than 12 month old males (Franco et al., 2011). Also, due to reduced moisture content and increased intramuscular fat with age, flavor intensity and juiciness is higher for horse meat from older animals above 5 years while tenderness is reduced (Segato, Cozzi, & Andrighetto, 1999). In contrast to beef which can be aged for up to 56 days for optimal meat quality (Ha et al., 2019), an ageing time of 7 to 10 days has been recommended for

horse meat for optimal tenderness, juiciness and overall acceptance as ageing beyond this duration resulted in a decline in sensory quality (particularly color) and acceptance (Beldarrain et al., 2020; Seong et al., 2014; Seong et al., 2016). The color changes during prolonged ageing have been attributed to the high iron content of horse meat which makes it more susceptible to oxidation and darkening (Gill, 2005; Lorenzo et al., 2014a).

Consumers who liked kangaroo meat liked it mainly because of its flavor attributes, whereas tenderness was not a major driver of kangaroo meat liking (Beaton, Spiegel, Thompson, & Wynn, 2002). Although meat from female kangaroo was perceived to be more tender than meat from males, this did not significantly influence overall liking (Marshall & McIntyre, 1989). Tenderness, flavor and overall acceptability decreases with increasing age and dress weight (Beaton et al., 2002; Wynn, Beaton, & Spiegel, 2004). Kangaroo meat was characterized by intense flavor, acceptable tenderness, cohesiveness and juiciness (Balowski, Sobczak, Zochowska-Kujawska, Pytel-Zajac, & Niedzwiedz, 2015).

Flavor acceptability for buffalo meat increases with age as meat from buffaloes older than 4 years had significantly higher flavor acceptability scores, while tenderness and juiciness were more acceptable from animals between 2 and 4 years of age (Rao, Thulasi, & Ruban, 2009). This implies flavor may be a driver of liking for buffalo meat as intramuscular fat content and flavor intensity increase with age (Ngapo et al., 2002). An ideal slaughter age of 2-4 years was recommended for buffalo to yield desirable sensory quality (Rao et al., 2009). Ageing had no significant impact on flavor, odor and connective tissue but significantly increased tenderness, juiciness and chewiness up to 15 days, after which no changes were reported (Irurueta, Cadoppi, Langman, Grigioni, & Carduza, 2010).

2.3.3. Consumer factors influencing consumption of alternative red meats

2.3.3.1. Consumption incentives and deterrents

A summary of studies to identify positive and negative consumer attitude towards alternative red meats is presented in Table 2.2. The majority of the consumers are aware of the health and nutritional benefits of these red meat alternatives (Bodnar, Benak, & Skobrak, 2010; Radder & Le Roux, 2005; Waitt & Appleby, 2014). Specific association with healthfulness was borne out of the perception of low fat and cholesterol relative to conventional red meats (Hoffman, Crafford, Muller, & Schutte,

2003; Kurtu, 2004; Waitt, 2014). In addition to the perception of healthfulness, kangaroo was perceived to be high in iron and humanely farmed (Waitt, 2014), camel meat was thought to have medicinal value (Kurtu, 2004), while game meats in general were perceived to be of better quality (Tolusic, Florijancic, Kralik, Sesar, & Tolusic, 2006), higher protein content than conventional meat types (Tomasevic & Rajkovic, 2015) and a natural source of protein and minerals, particularly iron (Bodnar et al., 2010). A motivating factor for game meat consumption among consumers in South Africa was its association with longevity (Radder & Grunert, 2009) while consumers in the Democratic Republic of Congo considered game meat to be a rare, tasty, natural, organic and luxurious product (Chausson, Rowcliffe, Escouflaire, Wieland, & Wright, 2019). The perception of luxury however, has both a positive and negative connotation as it implies unaffordability for low income earners but also confers social class on those who can afford it and makes it suited to special occasions or restaurant settings (Bodnar et al., 2010; Chausson et al., 2019; Drury, 2011; Radder & Le Roux, 2005; Tomasevic et al., 2018).

Consumer attitudes toward the sensory attributes of the meats differ depending on their level of familiarity with the meat and their willingness to try unfamiliar products. While unique sensory attributes, particularly flavor, is considered a positive factor for existing consumers, (Demartini, Vecchiato, Tempesta, Gaviglio, & Vigano, 2018; Hoffman et al., 2003; Wassenaar, Kempen, & van Eeden, 2019) the desire to try something unique is a factor that may trigger consumer interest (Radder, 2002). This highlights the influence of consumers' personality traits on meat consumption, particularly those related to food neophobia, the fear of trying new foods, or food variety seeking, the tendency to seek new food alternatives (Pliner & Hobden, 1992; van Trijp, Hans C M & Steenkamp, 1992). The influence of personality traits on consumers' choice for alternative red meats is yet to be well investigated; only one study was found on this topic. Schupp, Gillespie, O'Neil, Witoon Prinyawiwatkul, & Makienko, (2005) identified exotic meat eaters as individuals who are venturesome and innovative in their food preferences. However, their classification was not based on segmentation using validated scales that are accepted measures of personality traits but on participants' response to questions relating to their overall risk preference and willingness to eat exotic meat at a friend's home.

As summarized in Fig. 2.3, unique sensory attributes, especially flavor and aroma, are a major deterrent of consumption for some consumers (Bodnar et al., 2010; Hoffman, Muller, Schutte, Calitz,

& Crafford, 2005; Radder & Grunert, 2009; Waitt & Appleby, 2014) and this cannot be overridden by awareness of positive health and nutritional attributes (Hobbs, Sanderson, & Haghiri, 2006; Sanderson et al., 2002; Steiner, Gao Fei, & Unterschultz, 2010; Wassenaar et al., 2019). The unwillingness of consumers to trade-off sensory appeal for health and nutritional benefits, together with the deterrence posed by lack of culinary knowledge for optimal sensory appeal, identified by several authors (Bodnar et al., 2010; Radder & Le Roux, 2005; Waitt & Appleby, 2014), highlights the significant role of sensory attributes in consumers' meat choice. The contradiction in consumers' preference for the sensory attributes of alternative red meats suggests these meats may not substitute fully for conventional meats such as beef but rather represent a niche market for those in favor of its sensory attributes.

Other deterrents to consumption include limited/seasonal availability and high price relative to conventional meats (Hoffman et al., 2005; Radder, 2002; Radder & Le Roux, 2005; Sanderson et al., 2002; Tolusic et al., 2006; Tomasevic et al., 2018), and perceived hygiene and disease risks (Bodnar, Bodnarne, Tanacs, & Pinnyey, 2011; Chausson et al., 2019; E. W. Nganje, Kaitibie, & Taban, 2005). In addition, association of kangaroo with Australia's national emblem and pet food (Waitt & Appleby, 2014; Waitt, 2014) were identified as deterrents to acceptance, while only one study identified fear of wildlife extinction as a deterrent to acceptance of game meat (Hoffman et al., 2003). The deterrence posed by limited availability shows that existing consumers are likely to consume more of these meats if readily available, which necessitates increased production effort (Radder, 2002; Sanderson et al., 2002). With respect to price, consumers' sensitivity to price increases when the meat is considered a close substitute for conventional meat; they are willing to pay slightly more if they have positive attitude towards the meat or consider it to be better than conventional meat (Demartini et al., 2018; Sanderson et al., 2002).

2.3.3.2. Socio-demographic profile of alternative meat consumers

In addition to consumer segments based on sensory preference and motivating and deterring factors, socio-demographic factors contribute to consumer choice for these meat types (Table 2.3). Across different geographical locations and regardless of the animal specie, more males than females consume alternative red meats. This was reported for game meat among consumers in Vietnam (Drury, 2011), Democratic Republic of Congo and 4 countries in West Africa (Chausson et al., 2019;

Luiselli et al., 2019), Eastern Croatia, Poland and 10 other countries in Central and Southeast Europe (Kwiecinska, Kosicka-Gebska, Gebski, & Gutkowska, 2017; Tolusic et al., 2006; Tomasevic et al., 2018),and the United States (McLean-Meyinsse, 1999; Schupp et al., 1998) and for bison meat consumers in the United States (Torok, Mittelstaedt, May, Tatsch, & Bradley, 1998). The effect of consumer age was also similar across geographical locations; alternative meat consumption was more popular among middle aged or older consumers than younger consumers (Chausson et al., 2019; Kwiecinska et al., 2017; Luiselli et al., 2019; Marescotti, Caputo, Demartini, & Gaviglio, 2019; McLean-Meyinsse, 1999; Tomasevic et al., 2018; Torok et al., 1998). This was attributed to increasing urbanization of consumers which has made hunting and consumption of game less socially acceptable (Chausson et al., 2019). This may result in a decline in the market size for alternative meats unless convenience is enhanced through increased availability in regular stores as existing consumers are likely to consume more of these meats if made more readily available (Kwiecinska et al., 2017; Wassenaar et al., 2019).

Unlike the effect of consumer age and sex, reports of the influence of income and education vary. Association of alternative red meats with status symbol and luxury makes it a meat for high income earners, particularly in urban areas where hunting is less likely (Chausson et al., 2019; Drury, 2011), while the inability to afford conventional alternatives and the possibility to hunt animals for meat among rural dwellers makes it meat for low income rural dwellers (Luiselli et al., 2019) particularly in regions where hunting is not highly regulated. A study in the Philippines by Marzan (1982) reported a significant influence of income on consumption and preference for buffalo and refuted the claim that buffalo meat is a food for low income earners as consumption and preference for buffalo meat increased with increasing income. A significant influence of income on consumption frequency for bison was also reported by Nganje & Kaitibie (2003) in 4 states (North Dakota, South Dakota, Montana and Minnesota) in the United States of America.

Education and income both have a closely related influence on consumers' consumption of alternative red meats. Segmentation of buffalo meat consumers in Brazil (Marques et al., 2016) and game meat consumers in Italy (Marescotti et al., 2019) show that highly educated consumers (graduate or post-graduate degrees) with high income are more likely to include these meats in their diets. Moreover, Nganje et al (2005) reported a significant influence of education on consumers'

perception of safety risk for bison meat, with highly educated individuals perceiving bison meat to be safer than low income older consumers. This relationship among education, income and consumption of alternative meats may only be true for urban dwellers as higher education may result in better paying jobs and more ability to afford these meats whereas for rural dwellers, more income may imply their ability to afford conventional meats rather than hunting for alternative meats.

It will be worth-while to know if similar factors identified in this review contribute to the acceptance of alternative white meats species such as rabbit and avian species such as ostrich, pigeon and emu which also offer good quality meat (Maheswarappa & Kiran, 2014; Polawska et al., 2013) but are also niche products. Future reviews in this domain can focus on aggregation of both sensory and consumer-related factors influencing acceptance and consumption of these meats.

2.4. Conclusion and future research

This review aggregates, summarizes and synthesizes established information from literature about consumer acceptance of red meats from alternative animal species and their sensory attribute differences with conventional red meats, benefits and deterrents to their consumption as well as socio-demographic factors influencing their consumption. While acceptance and consumption of red meat from alternative sources may vary across regions and cultural entities around the world, based on this review, inherent sensory attributes, price, limited/seasonal availability and risk of diseases are the key factors limiting acceptance of these red meat alternatives. Although the majority of the studies reviewed reported that consumers are aware of the health and nutritional benefits of alternative red meats, it is apparent that consumers are not willing to trade off sensory preference for nutritional benefits and healthfulness. The majority of the studies identified flavor as the sensory attribute that distinguishes these red meat alternatives from red meat from conventional sources such as beef. Consumers' response to the unique flavor attributes of these meats differ depending on individual preference with the unique flavor being both driver of acceptance and deterrent to acceptance. Improving flavor through diet will adversely impact nutritional benefits, thus production efforts could be directed towards making these meats more available to meet the demand of consumer segments in favor of the unique flavor attributes.

As lack of specialist culinary know-how was also identified as a deterrent to consumption and acceptance, research efforts should be channelled towards identifying suitable cooking/processing

methods for these meat types. It is also apparent that there is dearth of knowledge of the sensory attributes of some alternative red meat species including elk, camel, donkey, moose, caribou and bison. Also, despite the perception of these meats as novel and unfamiliar, the influence of consumers' personality traits, especially those related to food neophobia or variety seeking tendency, on consumers' choice for these meats has surprisingly received little attention in literature. Application of sensory methods that allow simultaneous characterization of sensory attributes and identification of specific attributes driving liking and disliking are yet to be fully explored in this domain. Overall, while the possibility of expansion of the alternative red meat industry beyond niche market may be slim, assurance of consumer safety, education on culinary procedures, increased availability to meet demands and reduced price could enhance the expansion of the alternative red meat market.

2.5 References

Aganga, A. A., Aganga, A. O., Thema, T., & Obocheleng, K. O. (2003). Carcass analysis and meat composition of the donkey. *Pakistan Journal of Nutrition, 2*, 138-147.

Agriculture and Agri-Food Canada. (2019a). Canada's red meat and livestock industry at a glance. Retrieved from http://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/industry-profile/?id=1415860000002

Agriculture and Agri-Food Canada. (2019b). Canadian bison: The red meat with a difference. Retrieved from http://www.agr.gc.ca/eng/food-products/explore-canadian-food-products/canadian-bison/?id=1425927572578

Ali, J., & Pappa, E. (2011). Understanding structural changes in global meat sector: A comparative analysis across geographical regions. Paper presented at the *21st Annual International Food and Agribusiness Management Association (IFAMA) World Forum and Symposium:* On the Road to 2050: Sustainability as a Business Opportunity, Frankfurt, Germany, 22-23 June, 2011.

Arcos-Garcia, G., Totosaus, A., Guerrero, I., & Perez-Chabela, M. d. L. (2002). Physicochemical, sensory, functional and microbial characterization of horse meat. *Revista Brasileira De Agrociência, 8*, 43-46.

Balowski, M., Sobczak, M., Zochowska-Kujawska, J., Pytel-Zajac, O., & Niedzwiedz, M. (2015). Comparison of meat quality of selected exotic animal species. *Folia Pomeranae Universitatis Technologiae Stetinensis, Agricultura, Alimentaria, Piscaria Et Zootechnica, 322*, 5-13.

Bartoň, L., Bureš, D., Kotrba, R., & Sales, J. (2014). Comparison of meat quality between eland (*Taurotragus oryx*) and cattle (*Bos taurus*) raised under similar conditions. *Meat Science, 96*, 346-352. doi://doi.org/10.1016/j.meatsci.2013.07.016

Beaton, A. J. W., Spiegel, N. B., Thompson, J. M., & Wynn, P. (2002). Sensory evaluation of kangaroo meat. *Animal Production Australia, 24*, 21-24.

Belaunzaran, X., Bessa, R. J. B., Lavín, P., Mantecón, A. R., Kramer, J. K. G., & Aldai, N. (2015). Horse meat for human consumption — current research and future opportunities. *Meat Science, 108*, 74-81. doi:https://doi.org/10.1016/j.meatsci.2015.05.006

Beldarrain, L. R., Etaio, I., Morán, L., Sentandreu, M. Á, Barron, L. J. R., & Aldai, N. (2020). Effect of ageing time on consumer preference and sensory description of foal meat. *Food Research International, 129* doi:10.1016/j.foodres.2019.108871

Bodnar, K., Benak, A., & Skobrak, E. B. (2010). Analyses of consumer preferences and attitudes on hungarian game meat market (preliminary report). *Lucrari Stiintifice, Universitatea De Stiinte Agricole Si Medicina Veterinara "Ion Ionescu De La Brad" Iasi, Seria Agronomie, 53*, 9-12.

Bodnar, K., Bodnarne, S. E., Tanacs, L., & Pinnyey, S. (2011). Consumers' opinion about the hygienic risks of the meat of wild ungulates. *Lucrari Stiintifice, Universitatea De Stiinte Agricole Si Medicina Veterinara a Banatului, Timisoara, Seria I, Management Agricol, 13*, 31-36.

Brittin, H. C., Armes, C. L., Ramsey, C. B., & Simpson, C. D. (1981). Palatability of meat from mule deer. *Journal of Food Science, 46*, 1805-1807. doi:10.1111/j.1365-2621.1981.tb04490.x ER

Bureš, D., Bartoň, L., Kotrba, R., & Hakl, J. (2015). Quality attributes and composition of meat from red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and Aberdeen angus and Holstein cattle

(*Bos taurus*). *Journal of the Science of Food and Agriculture, 95*, 2299-2306. doi:10.1002/jsfa.6950

Canadian Bison Association. (2019). Bison market and supply update. Retrieved from https://www.canadianbison.ca/resources/resources/industry-reports/bison-market-and-supply-update

Canadian Bison Association. (2020). Bison history. Retrieved from https://www.canadianbison.ca/producers/about-bison/bison-history

Canadian Meat Council. (2013). Horse meat production in Canada. Retrieved from https://www.cmc-cvc.com/sites/default/files/files/Horse%20Meat%20Production%20in%20Canada%20Feb%202013.pdf

Charles, D. D. (1982). Meat tenderness and palatability of swamp buffalo and four breeds of cattle. *Animal Production, 34*(1), 79-84.

Chausson, A. M., Rowcliffe, J. M., Escouflaire, L., Wieland, M., & Wright, J. H. (2019). Understanding the sociocultural drivers of urban bushmeat consumption for behavior change interventions in pointe noire, Republic of Congo. *Human Ecology, 47*, 179-191. doi:10.1007/s10745-019-0061-z ER

Cheah, I., Sadat Shimul, A., Liang, J., & Phau, I. (2020). Drivers and barriers toward reducing meat consumption. *Appetite, 149*, 104636.

Corallo, A., Latino, M. E., & Spennato, A. (2019). A survey to discover current food choice behaviors. *Sustainability, 11*, 5041-5057.

Corbin, C. H., O'Quinn, T. G., Garmyn, A. J., Legako, J. F., Hunt, M. R., Dinh, T. T. N., . . . Miller, M. F. (2015). Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments. *Meat Science, 100*, 24-31. doi:S0309-1740(14)00298-8 [pii]

Dahlan, I., & Norfarizan Hanoon, N. A. (2008). Chemical composition, palatability and physical characteristics of venison from farmed deer. *Animal Science Journal, 79*, 498-503. doi:10.1111/j.1740-0929.2008.00555.x

Daszkiewicz, T., Janiszewski, P., & Wajda, S. (2009). Quality characteristics of meat from wild red deer (*Cervus elaphus L.*) hinds and stags. *Journal of Muscle Foods, 20*, 428-448.

Dawood, A. A. (1995). Physical and sensory characteristics of Najdi-camel meat. *Meat Science, 39*, 59-69. doi:10.1016/0309-1740(95)80007-7

Deerfarmer. (2016). Farmed deer statistics – UK and Canada. Retrieved from http://deerfarmer.com/wiki/farmed-deer-statistics-canada-united-kingdom

Delgado, C. L. (2003). Rising consumption of meat and milk in developing countries has created a new food revolution. *The Journal of Nutrition, 133*, 3907S-3910S. doi:10.1093/jn/133.11.3907S [doi]

Demartini, E., Vecchiato, D., Tempesta, T., Gaviglio, A., & Vigano, R. (2018). Consumer preferences for red deer meat: A discrete choice analysis considering attitudes towards wild game meat and hunting. *Meat Science, 146*, 168-179. doi:10.1016/j.meatsci.2018.07.031 ER

Dhanda, J. S., Pegg, R. B., & Shand, P. J. (2003). Tenderness and chemical composition of elk (*Cervus elaphus*) meat: Effects of muscle type, marinade composition, and cooking method. *Journal of Food Science, 68*, 1882-1888. doi:10.1111/j.1365-2621.2003.tb12347.x

Drury, R. (2011). Hungry for success: Urban consumer demand for wild animal products in Vietnam. *Conservation and Society, 9*, 247-257. doi:10.4103/0972-4923.86995 ER

Eertmans, A., Victoir, A., Vansant, G., & Van den Bergh, O. (2005). Food-related personality traits, food choice motives and food intake: Mediator and moderator relationships. *Food Quality and Preference, 16*, 714-726. doi:https://doi.org/10.1016/j.foodqual.2005.04.007

FAOSTAT. (2020a). FAO statistical yearbook: Livestock primary. Retrieved from http://www.fao.org/faostat/en/#data/QL

FAOSTAT. (2020b). New food balances. *Food and Agriculture Organization of the United Nations,* Retrieved from http://www.fao.org/faostat/en/#data/FBS

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing, 24*, 230-235.

Forss, D. A., & Manley, T. R. (1978). An evaluation of the eating qualities of venison from farmed and feral red deer. *Advances in Deer Farming.,*25-26.

Franco, D., Rodriguez, E., Purrinos, L., Crecente, S., Bermudez, R., & Lorenzo, J. M. (2011). Meat quality of "Galician mountain" foals breed. effect of sex, slaughter age and livestock production system. *Meat Science, 88*, 292-298. doi:https://doi.org/10.1016/j.meatsci.2011.01.004

Gill, C. O. (2005). Safety and storage stability of horse meat for human consumption. *Meat Science, 71*, 506-513. doi:https://doi.org/10.1016/j.meatsci.2005.04.030

Government of Alberta. (2017). Alberta horse meat exports by destination. Retrieved from *Https://Open.Alberta.Ca/Dataset/Alberta-Horse-Meat-Exports-by-Destination-2005-2014/Resource/65163962-A4ff-4635-B6a6-98b2b66fc408,*

Government of Canada. (2019). Annual game report by species in Canada. Retrieved from *Http://Www.Agr.Gc.Ca/Eng/Animal-Industry/Red-Meat-and-Livestock/Red-Meat-and-Livestock-Market-Information/Supply-Sheets-by-Species/Annual-Game-Report-by-Species/?Id=1415860000117,*

Graça, J. (2016). Towards an integrated approach to food behaviour: Meat consumption and substitution, from context to consumers. *Psychology, Community & Health, 5*, 152-169. doi:http://dx.doi.org/10.5964/pch.v5i2.169

Grunert, K. G. (2006). Future trends and consumer lifestyles with regard to meat consumption. *Meat Science, 74*, 149-160. doi:https://doi.org/10.1016/j.meatsci.2006.04.016

Ha, M., McGilchrist, P., Polkinghorne, R., Huynh, L., Galletly, J., Kobayashi, K., . . . Warner, R. D. (2019). Effects of different ageing methods on color, yield, oxidation and sensory qualities of

Australian beef loins consumed in Australia and Japan. *Food Research International, 125*, 108528. doi:https://doi-org.login.ezproxy.library.ualberta.ca/10.1016/j.foodres.2019.108528

Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science & Technology, 61*, 11-25. doi:https://doi.org/10.1016/j.tifs.2016.12.006

Hassan, M. A., Abdel-Naeem, H. H. S., Mohamed, H. M. H., & Yassien, N. A. (2018). Comparing the physico-chemical characteristics and sensory attributes of imported Brazilian beef meat and imported Indian buffalo meat. *Journal of Microbiology Biotechnology and Food Sciences, 8*, 672-677. doi:10.15414/jmbfs.2018.8.1.672-677

Henchion, M. M., McCarthy, M., & Resconi, V. C. (2017). Beef quality attributes: A systematic review of consumer perspectives. *Meat Science, 128*, 1-7. doi://doi.org/10.1016/j.meatsci.2017.01.006

Henchion, M. M., McCarthy, M., Resconi, V. C., & Troy, D. (2014). Meat consumption: Trends and quality matters. *Meat Science, 98*, 561-568. doi://doi.org/10.1016/j.meatsci.2014.06.007

Hobbs, J. E., Sanderson, K., & Haghiri, M. (2006). Evaluating willingness-to-pay for bison attributes: An experimental auction approach. *Canadian Journal of Agricultural Economics, 54*, 269-287. doi:10.1111/j.1744-7976.2006.00049.x ER

Hoffman, L. C., Crafford, K., Muller, N., & Schutte, D. W. (2003). Perceptions and consumption of game meat by a group of tourists visiting South Africa. *South African Journal of Wildlife Research, 33*, 125-130.

Hoffman, L. C., Muller, M., Schutte, D. W., Calitz, F. J., & Crafford, K. (2005). Consumer expectations, perceptions and purchasing of South African game meat. *South African Journal of Wildlife Research, 35*, 33-42.

Hoffman, L. C., & Wiklund, E. (2006). Game and venison - meat for the modern consumer. *Meat Science, 74*, 197-208. doi://dx.doi.org/10.1016/j.meatsci.2006.04.005

Hutchison, C. L., Mulley, R. C., Wiklund, E., & Flesch, J. S. (2012). Effect of concentrate feeding on instrumental meat quality and sensory characteristics of fallow deer venison. *Meat Science, 90*, 801-806. doi:10.1016/j.meatsci.2011.11.018

Irurueta, M., Cadoppi, A., Langman, L., Grigioni, G., & Carduza, F. (2010). Effect of aging on meat characteristics from water buffalo grown in Delta del Parana in Argentina. *Revista Veterinaria, 21*, 499-505.

Jaeger, S. R., Bava, C. M., Worch, T., Dawson, J., & Marshall, D. W. (2011). The food choice kaleidoscope. A framework for structured description of product, place and person as sources of variation in food choices. *Appetite, 56*, 412-423. doi://doi.org/10.1016/j.appet.2011.01.012

Jastrzebska, E., Daszkiewicz, T., Gorecka-Bruzda, A., & Felis, D. (2019). Current situation and prospects for the horse meat market in Poland and the world. *Medycyna Weterynaryjna, 75*, 196-202.

Johansen, S. B., Naes, T., & Hersleth, M. (2011). Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. *Appetite, 56*, 15-24.

Juárez, M., Basarab, J. A., Baron, V. S., Valera, M., Larsen, I. L., & Aalhus, J. L. (2012). Quantifying the relative contribution of ante- and post-mortem factors to the variability in beef texture. *Animal, 6*, 1878-1887. doi:10.1017/S1751731112000572

Kaic, A., & Potocnik, K. (2019). Tenderness of horsemeat. *Meso, 21*, 71-78.

Kangaroo Industry Association. (2018). Economic benefits of the kangaroo industry. Retrieved from http://www.kangarooindustry.com/industry/economic/

Koch, R. M., Crouse, J. D., & Seideman, S. C. (1988). Bison, Hereford and Brahman growth and carcass characteristics. *Beef Research Progress Report, Roman L. Hruska US Meat Animal Research Center*, 3, 26-28.

Koch, R. M., Jung, H. G., Crouse, J. D., Varel, V. H., & Cundiff, L. V. (1995). Growth, digestive capability, carcass, and meat characteristics of *Bison bison*, *Bos taurus,* and bos x bison.*73*, 1271-1281.

Kurtu, M. Y. (2004). An assessment of the productivity for meat and the carcass yield of camels (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. *Tropical Animal Health and Production, 36*, 65-76. doi:TROP.0000009520.34657.35

Kwiecinska, K., Kosicka-Gebska, M., Gebski, J., & Gutkowska, K. (2017). Prediction of the conditions for the consumption of game by Polish consumers. *Meat Science, 131*, 28-33. doi:10.1016/j.meatsci.2017.04.038 ER

Lebert, I., Rousset, S., Lebert, A., & Talon, R. (2003). MEAT | eating quality. In B. Caballero (Ed.), *Encyclopedia of food sciences and nutrition (second edition)* (pp. 3777-3785). Oxford: Academic Press. doi:https://doi.org/10.1016/B0-12-227055-X/00753-7 "

Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., . . . Bugeon, J. (2016). How muscle structure and composition influence meat and flesh quality. *The Scientific World Journal, 16* doi:https://doi.org/10.1155/2016/3182746

Lorenzo, J. M., Purrinos, L., & Carballo, J. (2016). A survey on the effect of livestock production system and finishing diet on sensory characteristics of foal meat using Generalized Procrustes Analysis. *The Scientific World Journal,* 1-6. doi:https://doi.org/10.1155/2016/8729053

Lorenzo, J. M., Victoria Sarries, M., Tateo, A., Polidori, P., Franco, D., & Lanza, M. (2014b). Carcass characteristics, meat quality and nutritional value of horsemeat: A review. *Meat Science, 96*, 1478-1488. doi:https://doi.org/10.1016/j.meatsci.2013.12.006

Luiselli, L., Hema, E. M., Segniagbeto, G. H., Ouattara, V., Eniang, E. A., Vittorio, M. d., . . . Fa, J. E. (2019). Understanding the influence of non-wealth factors in determining bushmeat consumption: Results from four West African countries. *Acta Oecologica, 94*, 47-56. doi:10.1016/j.actao.2017.10.002 ER

Maheswarappa, N. B., & Kiran, M. (2014). Emu meat: New source of healthier meat towards niche market. *Food Reviews International, 30*, 22-35. doi:10.1080/87559129.2013.853773

Mak, A. H. N., Lumbers, M., Eves, A., & Chang, R. C. Y. (2012). Factors influencing tourist food consumption. *International Journal of Hospitality Management, 31*, 928-936.

Marescotti, M. E., Caputo, V., Demartini, E., & Gaviglio, A. (2019). Discovering market segments for hunted wild game meat. *Meat Science, 149*, 163-176. doi:10.1016/j.meatsci.2018.11.019 ER

Marques, C. S. S., Oaigen, R. P., Moraes, C. M. d., Santos, M A S dos, Lourenco Junior, J de B, & Abel, I. (2016). Segmentation of the buffalo meat consumer market in Belem, Para, Brazil. *Revista Brasileira De Zootecnia, 45*, 336-344.

Marshall, T., & McIntyre, B. L. (1989). A preliminary evaluation of the eating quality of meat derived from red kangaroos. *Australian Zoologist, 25*, 88-90. doi://dx.doi.org/10.7882/AZ.1989.009

Marzan, E. G.,Jr. (1982). Socio-economic factors and marketability of carabeef in Central Luzon. *CLSU Scientific Journal, 2*, 1-8.

McDaniel, J., Askew, W., Bennett, D., Mihalopoulos, J., Anantharaman, S., Fjeldstad, A. S., . . . Richardson, R. S. (2013). Bison meat has a lower atherogenic risk than beef in healthy men. *Nutrition Research, 33*, 293-302.

McLean-Meyinsse, P. (1999). An analysis of factors affecting consumers' decisions to shop at stores offering specialty meat. *Journal of Food Distribution Research, 30*, 134-139.

Merle, S., Sencleer, J., Rodas-Gonzalez, A., Gonzalez, J., Mansutti, D., & Huerta-Leidenz, N. (2004). Comparison of water buffalo (*Bubalus bubalis*) vs zebu-type intact male bovines in slaughter characteristics, carcass traits, cutability and longissimus palatability. *Archivos Latinoamericanos De Produccion Animal, 12*, 110-118.

Miller, R. (2020). Drivers of consumer liking for beef, pork, and lamb: A review. *Foods (Basel, Switzerland), 9*, 428. doi: 10.3390/foods9040428. doi:10.3390/foods9040428 [doi]

Muir, P. D., Deaker, J. M., & Bown, M. D. (1998). Effects of forage- and grain-based feeding systems on beef quality: A review. *New Zealand Journal of Agricultural Research, 41*, 623-635. doi:10.1080/00288233.1998.9513346

National Research Council of Canada. (2019). *Plant-based protein market: Global and Canadian market analysis.* Retrieved from https://nrc.canada.ca/en/research-development/research-collaboration/programs/plant-based-protein-market-global-canadian-market-analysis

Naveena, B. M., & Kiran, M. (2014). Buffalo meat quality, composition, and processing characteristics: Contribution to the global economy and nutritional security. *Animal Frontiers, 4*, 18-24. doi:10.2527/af.2014-0029 ER

Neely, T. R., Lorenzen, C. L., Miller, R. K., Tatum, J. D., Wise, J. W., Taylor, J. F., . . . Savell, J. W. (1998). Beef customer satisfaction: Role of cut, USDA quality grade, and city on in-home consumer ratings. *Journal of Animal Science, 76*, 1027-1033. doi:10.2527/1998.7641027x [doi]

Neethling, J., Hoffman, L. C., & Muller, M. (2016). Factors influencing the flavor of game meat: A review. *Meat Science, 113*, 139-153. doi:10.1016/j.meatsci.2015.11.022 ER

Nganje, E. W., Kaitibie, S., & Taban, T. (2005). Multinomial logit models comparing consumers' and producers' risk perception of specialty meat. *Agribusiness (New York), 21*, 375-390. doi:10.1002/agr.20053 ER

Nganje, E. W., & Kaitibie, S. (2003). *Food safety risk perception and consumer choice of specialty meats.* Agribusiness and Applied Economics Miscellaneous Report - Department of Agribusiness and Applied Economics, North Dakota State University, 193, 1-24.

Ngapo, T. M., Berge, P., Culioli, J., Dransfield, E., De Smet, S., & Claeys, E. (2002). Perimysial collagen crosslinking and meat tenderness in Belgian blue double-muscled cattle. *Meat Science, 61*, 91-102. doi:https://doi.org/10.1016/S0309-1740(01)00169-3

Nosworthy, M. G., & House, J. D. (2017). Factors influencing the quality of dietary proteins: Implications for pulses. *Cereal Chemistry, 94*, 49-57. doi:10.1094/CCHEM-04-16-0104-FI

OECD. (2020). Meat consumption (indicator). Retrieved from: https://data.oecd.org/agroutput/meat-consumption.htm

O'Mahony, P. J. (2013). Finding horse meat in beef products—a global problem. *QJM: An International Journal of Medicine, 106*, 595-597. doi:10.1093/qjmed/hct087

Piaskowska, N., Daszkiewicz, T., Kubiak, D., & Janiszewski, P. (2015). The effect of gender on meat (*Longissimus lumborum* muscle) quality characteristics in the fallow deer (*Dama dama L.*). *Italian Journal of Animal Science, 14*, 3845. doi:10.4081/ijas.2015.3845

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120. doi:https://doi.org/10.1016/0195-6663(92)90014-W

Polawska, E., Cooper, R. G., Jozwik, A., & Pomianowski, J. (2013). Meat from alternative species - nutritive and dietetic value, and its benefit for human health - a review. *CyTA -- Journal of Food, 11*, 37-42.

Popoola, I. O., Bruce, H. L., McMullen, L. M., & Wismer, W. V. (2019). Consumer sensory comparisons among beef, horse, elk, and bison using preferred attributes elicitation and check-all-that-apply methods. *Journal of Food Science, 84*, 3009-3017. doi:10.1111/1750-3841.14780

Postolache, A. N., Boisteanu, P. C., & Lazar, R. (2011). Red deer meat (*Cervus elaphus L.*): Between hunting and necessity. *Lucrari Stiintifice - Universitatea De Stiinte Agricole Si Medicina Veterinara, Seria Zootehnie, 56*, 265-269.

Prabhakar, K., & Rao, N. P. L. (1986). Comparison of organoleptic and related characters of buffalo meat with beef. *Journal of Food Science and Technology, India, 23*, 90-93.

Radder, L. (2002). Restaurants and venison marketing: A South African experience. *Food Service Technology, 2*, 109-114. doi://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1471-5740/issues

Radder, L., & Grunert, K. G. (2009). Consumers' perceptions of African wildlife meat: A laddering study. *Journal of Food Products Marketing, 15*(2), 164-174. doi:10.1080/10454440802317022 ER

Radder, L., & Le Roux, R. (2005). Factors affecting food choice in relation to venison: A South African example. *Meat Science, 71*, 583-589.

Rao, V. A., Thulasi, G., & Ruban, S. W. (2009). Effect of age and sex on meat quality characteristics of South Indian non-descript buffalo. *Buffalo Bulletin, 28*, 138-147.

Realini, C. E., Font i Furnols, M., Guerrero, L., Montossi, F., Campo, M. M., Sañudo, C., . . . Oliver, M. A. (2009). Effect of finishing diet on consumer acceptability of Uruguayan beef in the European market. *Meat Science, 81*, 499-506. doi:https://doi.org/10.1016/j.meatsci.2008.10.005

Rincker, P. J., Bechtel, P. J., Finstadt, G., Van Buuren, R., Killefer, J., & McKeith, F. K. (2006). Similarities and differences in composition and selected sensory attributes of reindeer, caribou and beef. *Journal of Muscle Foods, 17*, 65-78. doi:10.1111/j.1745-4573.2006.00036.x

Ritchie, H., & Roser, M. (2019). Meat and dairy production. Retrieved from https://ourworldindata.org/meat-production

Robertson, J., Bouton, P. E., Harris, P. V., Shorthose, W. R., & Ratcliff, D. (1983). A comparison of some properties of beef and buffalo (*Bubalus bubalis*) meat. *Journal of Food Science, 48*, 686-690,. doi:10.1111/j.1365-2621.1983.tb14876.x ER

Rodbotten, M., Ueland, O., Lea, P., & Kubberod, E. (2004). A sensory map of the meat universe. sensory profile of meat from 15 species. *Meat Science, 68*, 137-144.

Roth, D. M., Brewer, M. S., Bechtel, P. J., Kline, K. H., & McKeith, F. K. (1995). Sensory, color, and composition characteristics of young and mature chevaline. *Journal of Muscle Foods, 6*, 83-89. doi:10.1111/j.1745-4573.1995.tb00559.x ER

Rozin, P. (2006). The integration of biological, social, cultural and psychological influences on food choice. In R. Shepherd, & M. Raats (Eds.), *The psychology of food choice* (pp. 19-39). Oxfordshire: CAB International.

Ruby, M. B., Alvarenga, M. S., Rozin, P., Kirby, T. A., Richer, E., & Rutsztein, G. (2016). Attitudes toward beef and vegetarians in Argentina, Brazil, France, and the USA. *Appetite, 96*, 546-554. doi:https://doi.org/10.1016/j.appet.2015.10.018

Rule, D. C., Broughton, K. S., Shellito, S. M., & Maiorano, G. (2002). Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. *Journal of Animal Science, 80*, 1202-1211.

Sanderson, K., Hobbs, J. E., Shand, P., & Kerr, W. A. (2002). Consumer preferences in the emerging bison industry: Marketing implications. *Journal of International Food & Agribusiness Marketing, 14*, 57-78. doi:10.1300/J047v14n03_05 ER

Schupp, A., Gillespie, J., O'Neil, C. E., Witoon Prinyawiwatkul, & Makienko, I. (2005). The impact of an "exotic" label on consumer willingness to taste test, purchase, and price a new meat product. *Journal of Food Distribution Research, 36*, 50-60.

Schupp, A., Gillespie, J., & Reed, D. (1998). Consumer choice among alternative red meats. *Journal of Food Distribution Research, 29*, 35-43.

Segato, S., Cozzi, G., & Andrighetto, I. (1999). In Piva, G. Bertoni, G. Masoero, F. Bani, P. Calamari,L. (Ed.), *Effect of animal morphotype, sex and age on quality of horse meat imported from Poland.* Recent progress in animal production science. Proceedings of the A.S.P.A XIII Congress, Piacenza, Italy, 21-24 June, 1999.

Seong PilNam, Park KuyngMi, Cho SooHyun, Kang GeunHo, Chae HyunSeok, Park BeomYoung, & Hoa Van Ba. (2016). Effect of cut type and post-mortem ageing on the technological quality, textural profile and sensory characteristics of horse meat. *Animal Production Science, 56*, 1551-1559.

Seong PilNam, Park KyoungMi, Cho SooHyun, Kang GeunHo, Kang SunMun, Park BeomYoung, & Ba HoaVan. (2014). Effect of post-mortem ageing time on quality characteristics of horse meat. *Archivos Latinoamericanos De Produccion Animal, 22*, 69-71.

Soriano, A., Montoro, V., Vicente, J., Sanchez-Migallon, B. F., Benitez, S., Utrilla, M. C., & Garcia Ruiz, A. (2016). Influence of evisceration time and carcass ageing conditions on wild venison quality. preliminary study. *Meat Science, 114*, 130-136. doi:10.1016/j.meatsci.2015.12.021 ER

Spanier, A. M., Flores, M., McMillin, K. W., & Bidner, T. D. (1997). The effect of post-mortem aging on meat flavor quality in brangus beef. correlation of treatments, sensory, instrumental and chemical descriptors. *Food Chemistry, 59*, 531-538. doi:https://doi.org/10.1016/S0308-8146(97)00003-4

Statista. (2019). Per capita meat consumption in Canada from 1998 to 2018, by type. Retrieved from https://www.statista.com/statistics/442461/per-capita-meat-consumption-by-type-canada/

Steiner, B., Gao Fei, & Unterschultz, J. (2010). Alberta consumers' valuation of extrinsic and intrinsic red meat attributes: A choice experimental approach. *Canadian Journal of Agricultural Economics, 58*(2), 171-189. doi:10.1111/j.1744-7976.2009.01177.x ER

Tolusic, Z., Florijancic, T., Kralik, I., Sesar, M., & Tolusic, M. (2006). Game meat market in Eastern Croatia. *Poljoprivreda, 12*, 58-63.

Tomasevic, I., & Rajkovic, A. (2015). The sensory quality of meat, game, poultry, seafood and meat products as affected by intense light pulses: A systematic review. *Procedia Food Science, 5*, 285-288. doi:10.1016/j.profoo.2015.09.081 ER

Tomasevic, I., Novakovica, S., Solowiej, B., Zdolec, N., Skunca, D., Krocko, M., . . . Djekic, I. (2018). Consumers' perceptions, attitudes and perceived quality of game meat in ten European countries. *Meat Science, 142*, 5-13. doi:10.1016/j.meatsci.2018.03.016

Torok, S.J., Bradley, E., Phillips, C., & Bernateau, G. (1996). International market segmentation analysis of a new meat product. *Agribusiness, 12, 443-459.*

Torok, S. J., Mittelstaedt, J., May, G. J., Tatsch, K., & Bradley, E. (1998). Identification of bison consumer characteristic dimensions and restaurant marketing strategies. *Agribusiness: An International Journal, 14*, 33-48.

Tuorila, H., & Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Current Opinion in Food Science, 33*, 1-8. doi:https://doi.org/10.1016/j.cofs.2019.09.004

Umberger, W. J., Feuz, D. M., Calkins, C. R., & Killinger-Mann, K. (2002). U.S. consumer preference and willingness-to-pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction. *Agribusiness, 18*, 491-504. doi:10.1002/agr.10034

van Trijp, Hans C M, & Steenkamp, J. E. M. (1992). Consumers' variety seeking tendency with respect to foods: Measurement and managerial implications, *European Review of Agricultural Economics, 19*, 181-195.

Wadolowska, L., Babicz-Zielinska, E., & Czarnocinska, J. (2008). Food choice models and their relation with food preferences and eating frequency in the Polish population: POFPRES study. *Food Policy, 33*, 122-134. doi:10.1016/j.foodpol.2007.08.001 ER

Waitt, G., & Appleby, B. (2014). 'It smells disgusting': Plating up kangaroo for a changing climate. *Continuum-Journal of Media & Cultural Studies, 28*, 88-100. doi:10.1080/10304312.2013.854863

Waitt, G. (2014). Embodied geographies of kangaroo meat. *Social & Cultural Geography, 15*(4), 406-426. doi:10.1080/14649365.2014.894113

Wassenaar, A., Kempen, E., & van Eeden, T. (2019). Exploring South African consumers' attitudes towards game meat-utilizing a multi-attribute attitude model. *International Journal of Consumer Studies, 43*, 437-445. doi:10.1111/ijcs.12523

Wiklund, E., Barnier, V. M. H., Smulders, F. J. M., Lundström, K., & Malmfors, G. (1997). Proteolysis and tenderisation in reindeer (*Rangifer tarandus tarandus L.*) bull *Longissimus thoracis* muscle of varying ultimate pH. *Meat Science, 46*, 33-43. doi:https://doi.org/10.1016/S0309-1740(97)00015-6

Wiklund, E., Dobbie, P., Stuart, A., & Littlejohn, R. P. (2010). Seasonal variation in red deer (*Cervus elaphus*) venison (*M. Longissimus dorsi*) drip loss, calpain activity, color and tenderness. *Meat Science, 86*, 720-727. doi:https://doi.org/10.1016/j.meatsci.2010.06.012

Wiklund, E., Johansson, L., & Malmfors, G. (2003). Sensory meat quality, ultimate pH values, blood parameters and carcass characteristics in reindeer (*Rangifer tarandus tarandus L.*) grazed on natural pastures or fed a commercial feed mixture. *Food Quality and Preference, 14*, 573-581. doi://doi.org/10.1016/S0950-3293(02)00151-9

Wiklund, E., Manley, T. R., Littlejohn, R. P., & Stevenson-Barry, J. M. (2003). Fatty acid composition and sensory quality of musculus *Longissimus* and carcass parameters in red deer (*Cervus elaphus*) grazed on natural pasture or fed a commercial feed mixture. *Journal of the Science of Food and Agriculture, 83*, 419-424. doi:10.1002/jsfa.1384

Wilson, G., & Edwards, M. (2019). Professional kangaroo population control leads to better animal welfare, conservation outcomes and avoids waste. *Australian Zoologist, 40*, 181-202. doi:10.7882/AZ.2018.043

Wood, J. D., Richardson, R. I., Nute, G. R., Fisher, A. V., Campo, M. M., Kasapidou, E., . . . Enser, M. (2004). Effects of fatty acids on meat quality: A review. *Meat Science, 66*(1), 21-32. doi://doi.org/10.1016/S0309-1740(03)00022-6

Wood, J. D., & Enser, M. (2017). Manipulating the fatty acid composition of meat to improve nutritional value and meat quality. In P. P. Purslow (Ed.), *New aspects of meat quality* (pp. 501-535) Woodhead Publishing. doi://doi.org/10.1016/B978-0-08-100593-4.00023-0

Wu, W., Fu, Y., Therkildsen, M., Li, X., & Dai, R. (2015). Molecular understanding of meat quality through application of proteomics. *Food Reviews International, 31*, 13-28. doi:10.1080/87559129.2014.961073

Wynn, P., Beaton, A., & Spiegel, N. (2004). Meat quality of kangaroos. *Rural Industries Research and Development Corporation, 4,* 1-71.

Yancey, E. J., Grobbel, J. P., Dikeman, M. E., Smith, K. A., Hachmeister, E. C., Chambers IV, E. C., . . . Dressler, E. A. (2006). Effects of total iron, myoglobin, hemoglobin, and lipid oxidation of uncooked muscles on livery flavor development and volatiles of cooked beef steaks. *Meat Science*, *73*, 680-686.

Table 2.1: Summary of studies on comparison of selected sensory attributes and acceptance between red meats from alternative animal species and beef

Species compared	Method used	Juiciness	Tenderness	Flavor/aroma	Overall acceptability	Reference
Red & fallow deer/Holstein and Aberdeen Angus Cattle	Attribute intensity	No difference	Venison more tender	Venison had higher flavor and aroma intensity	Not applicable	Bureš et al. (2015)
Deer reindeer &caribou/Cattle	Attribute intensity	No difference	Venison more tender	Venison had higher off-flavor, livery and gamey flavor	Not applicable	Rincker et al. (2006)
Mule deer/cattle	Attribute intensity/ Acceptability	Venison less juicy	Venison more tender	Flavor acceptability lower in venison	Venison less acceptable	Brittin et al. (1981)
Buffalo/Cattle	Attribute intensity /Acceptability	Buffalo less juicy	No difference	Buffalo had less acceptable flavor	Venison less acceptable	Robertson et al. (1983)
Water Buffalo /Cattle	Attribute intensity	No difference	Buffalo meat more tender	No difference	Not applicable	Merle et al. (2004)
Water Buffalo/Cattle	Attribute intensity/ Acceptability	No difference	No difference	No difference	No difference	Charles (1982)
Buffalo/Cattle	Acceptability	No difference	Buffalo tenderness less acceptable	No difference	Not applicable	Prabhakar and Rao (1986)
Camel /Cattle	Acceptability	Camel more juicy	Camel more tender	Camel more flavorful	Camel more acceptable	Aganga et al. (2003)
Eland /Cattle	Attribute intensity /Acceptability	Eland less juicy	Eland less tender	Eland had less flavor intensity	Eland had less overall acceptability	Bartoň et al. (2014)
Bison /Cattle	Attribute intensity	Bison more juicy	Bison more tender	Bison had higher off flavor	Not applicable	Koch et al. (1995)
Bison /Hereford and Brahman Cattle	Attribute intensity	Bison similar to Hereford but both higher than Brahman	Bison similar to Hereford but both higher than Brahman	Higher off flavor in Bison than both Hereford and Brahman	Not applicable	Koch et al. (1988)

Table 2.2: Summary of benefits and deterrents to consumption of red meat from alternative species

Animal specie	Study location	Study type and sample size	Benefits	Deterrents to consumption	References
Game / wildlife	Western Cape, South Africa	Survey using self-administered questionnaire n=300	Leanness, healthfulness and typical flavor	Seasonal availability, price, hygiene and strong aroma	Hoffman et al. (2005)
Game / wildlife	Eastern Cape, South Africa	Laddering n=40	Longevity	Price, convenience, sensory appeal dryness and disgust	Radder & Grunert (2009)
Game / wildlife	Eastern Cape, South Africa	Consumer choice framework n=300	N/A	Seasonal availability, dryness, unfamiliarity, lack of culinary know-how, price.	Radder & Le Roux (2005)
Game / wildlife	Western Cape, South Africa	Survey using self-administered questionnaire n=60	Low cholesterol, fat & calorie, no BSE & taste	Fear of wildlife extinction	Hoffman et al. (2003)
Game / wildlife	Eastern Cape, South Africa	Telephone interviews n=144 restaurants	Healthfulness & desire to try something new	Lack of dem&, seasonal availability, price	Radder (2002)
Game / wildlife	South Plain region, Hungary	Face-to-face survey n=250	N/A	Risk of diseases & hygiene risks at hunting	Bodnar et al. (2011)
Game / wildlife	Csongrád County, Hungary	Face-to-face interview n=200	Healthfulness	Lack of culinary know-how & unfavorable unique taste	Bodnar et al. (2010)
Game / wildlife	Eastern Croatia	Questionnaire n=101	Healthfulness & better quality	Price	Tolusic et al. (2006)
Camel	Eastern region Harar & Jijjiga, Ethiopia	Survey n=320	Low fat & cholesterol & high medicinal value	Price, seasonal availability, tough texture & undesirable flavor	Kurtu (2004)
Kangaroo	Wollongong, Australia	Taste-driven qualitative study n=32 households	Leanness & healthfulness	Strong lingering taste, chewiness, unique aroma & association with Australia's national emblem	Waitt & Appleby (2014)
Kangaroo	Wollongong, Australia	Taste-driven qualitative study n=30 households	Low fat, no cholesterol, high in iron, humanely farmed	Lack of specialist culinary skills & recipes, aversion to its sensory attributes & association with pet food	Waitt (2014)
Bison	South & North Dakota, Montana, Minnesota USA	Survey, n=404	Not applicable	Price, risk perception, lack of familiarity	Nganje et al. (2005)

2.2:Summary of studies on characteristics of consumers of alternative red meats

Animal specie	Study location	Study type/methodology & sample size	Consumers' profile	References
Game/wildlife meat	Poland, Nationwide	Quantitative survey by mail n=1000	Males, middle age, consumers with high positive assessment of diet & nutrition, consumers whose income can only meet their basic needs.	Kwiecinska et al. (2017)
Game/wildlife meat	Central Hanoi, Vietnam	Face-to-face interview using structured questionnaire n= 915	Males, high income earners	Drury (2011)
Game/exotic/specialty meat deer, buffalo	Louisiana, USA	Mail survey n=3,180	Males, whites, low-income earners, respondents with children	Schupp et al. (1998)
Exotics	Boston, Denver, San Francisco, Indianapolis & New Orleans USA	Mail survey n= 414	Individuals who are venturesome & innovative in their food preferences.	Schupp et al. (2005)
Game/wildlife meat	Louisiana & Southern Texas	Computer Assisted Telephone Interview n=1002	White, blue collar workers, males, middle age 18-44 years with household income of $50,000 or more	McLean-Meyinsse et al. (1995)
Bison	Anger, France	Taste panel n=52	High income, homeowners, moderate to heavy meat eaters & respondents with family members involved in meat sales & marketing	Torok et al. (1996)
Bison	Colorado, United States of America	Taste panel n=52	Male, homeowners, pre-grandparent age group, variety & game meat eaters & moderate price & health-conscious	Torok et al. (1998)
Water buffalo	Central Luzon, Philippines	Survey n=500	Low family size, self-employed respondents with college education. Buffalo meat consumption increases with income but decreases with age.	Marzan (1982)
Buffalo	Belém, Pará, Brazil	Sensory analysis & interviews n=447	Young people between 25 & 45 years, technical education, low salary earners	Marques et al. (2016)
Bison	South & North Dakota, Montana, Minnesota	Survey, n=404	Highly educated, male	Nganje et al. (2005)

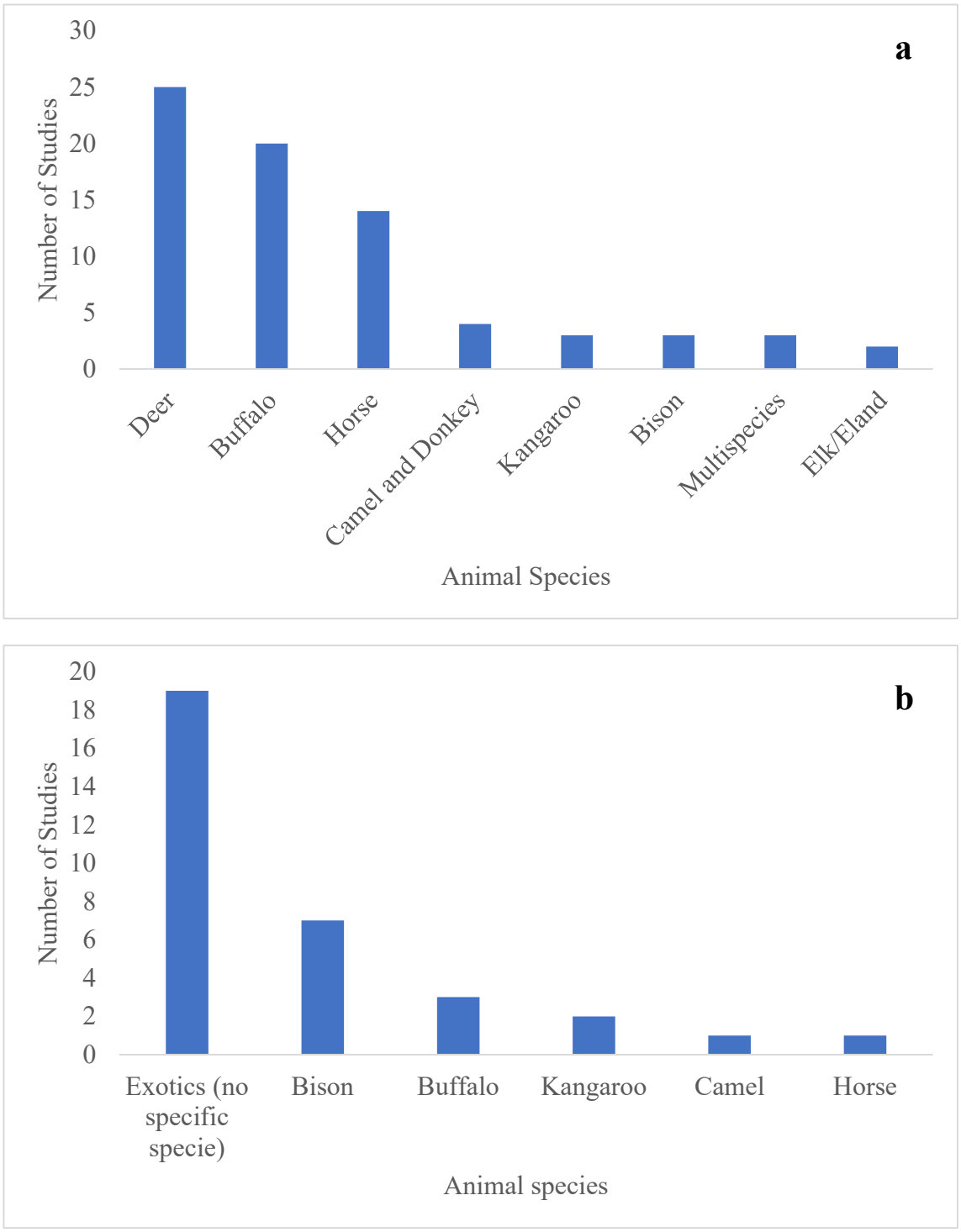


Fig. 2.1: Frequency distribution by animal species of studies on (a) sensory attributes and (b) consumer factors influencing acceptance of meat from unconventional sources

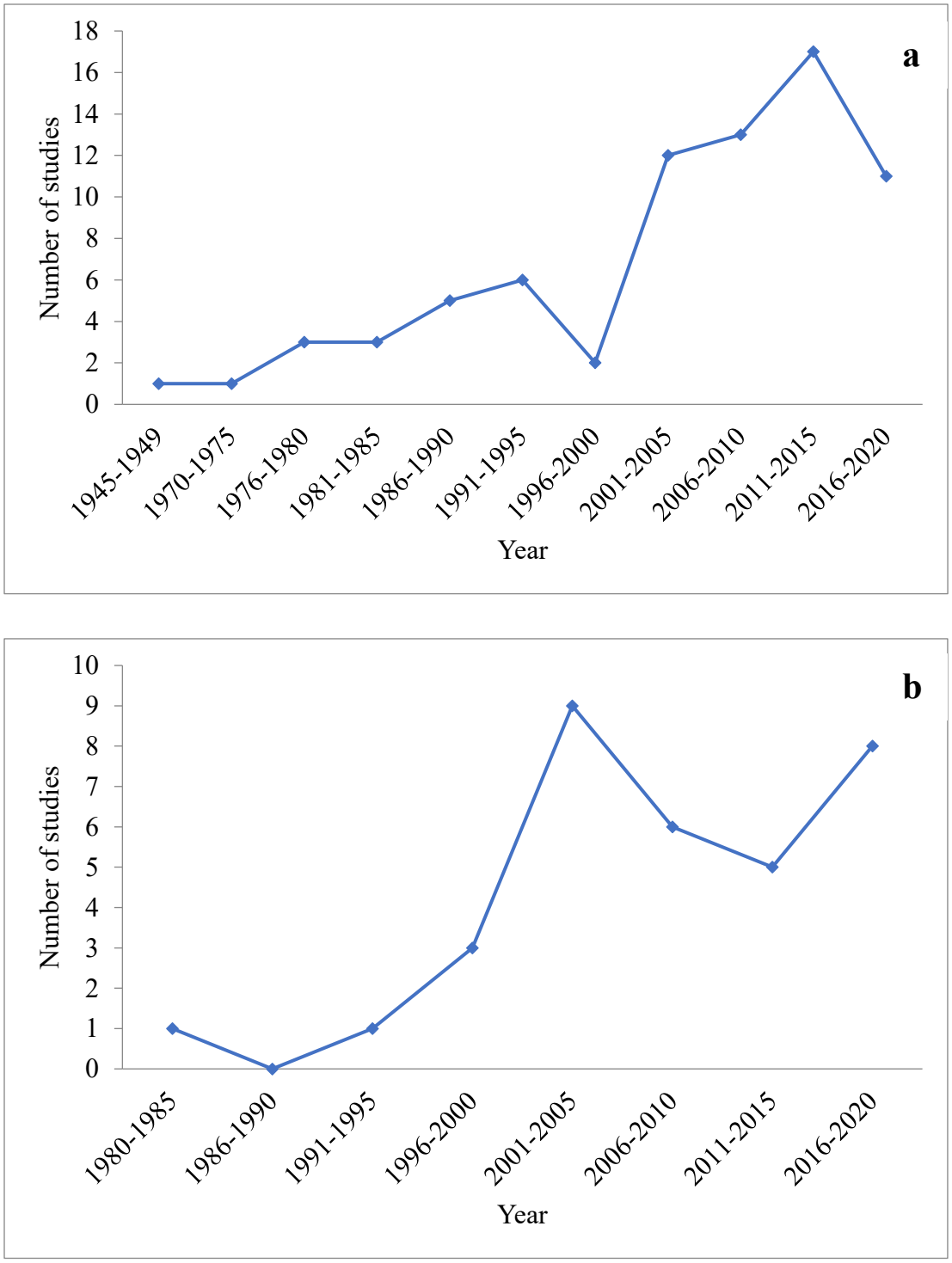


Fig. 2.2: Frequency distribution by year of studies on (a) sensory attributes and (b) consumer factors influencing acceptance of red meat from unconventional sources

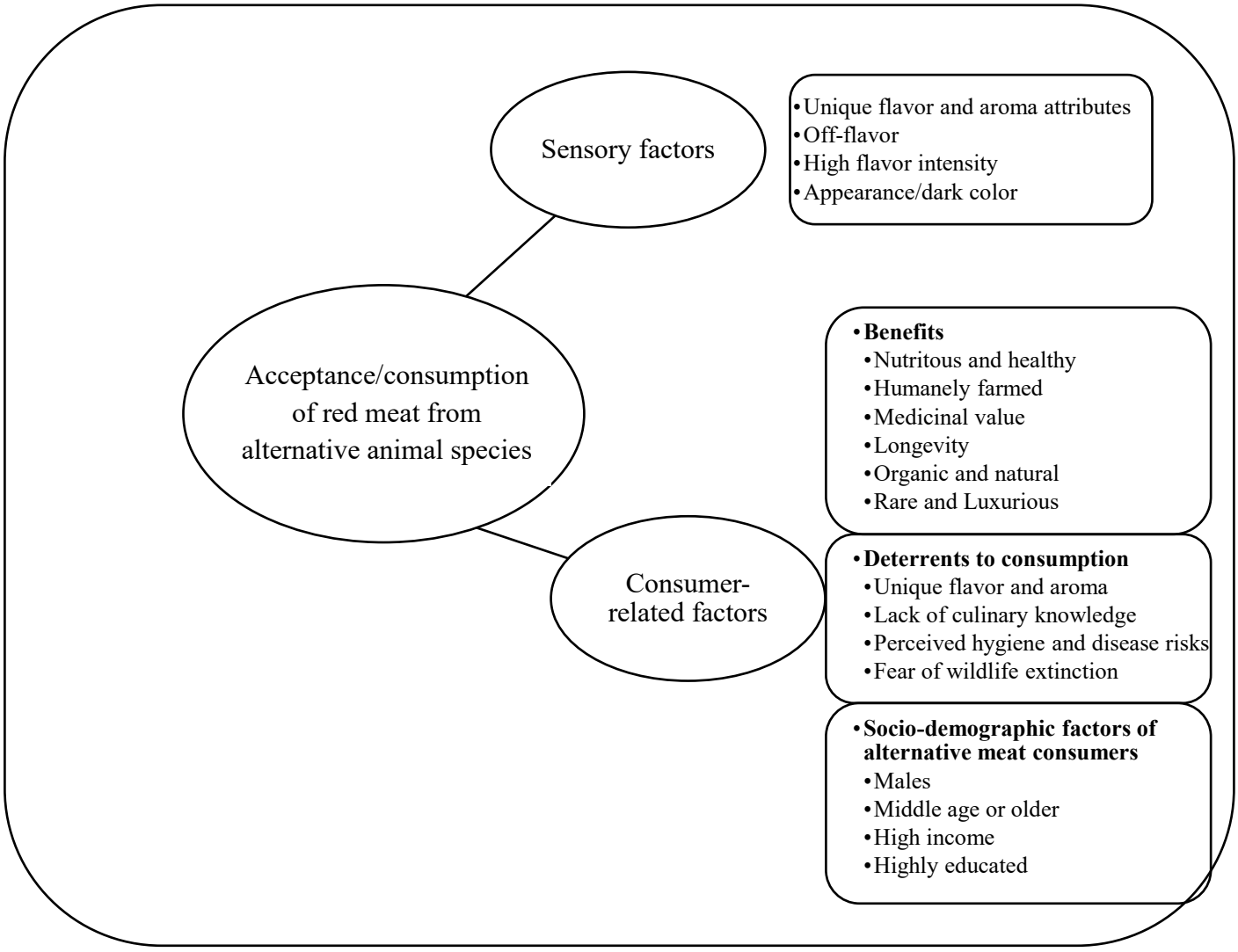


Fig. 2.3: Schematic overview of identified sensory and consumer-related factors influencing acceptance and consumption of red meats from alternative animal species

Chapter 3. Consumer acceptance of horse meat with reduced carcass chilling time

3.1. Introduction

Biochemical processes that take place in the carcass within 24 h of slaughter have profound impact on meat safety and quality, and are highly dependent on carcass chilling regimes (Savell, Mueller, & Baird, 2005a). Hence, carcass chilling is guided by policies to ensure microbial safety, technological quality (pH, water holding capacity, cooking loss, shear force) and sensory quality of meat. Refrigeration accounts for between 60 and 70% of total energy consumed in slaughter houses (DEFRA, 2010); with initial carcass chilling accounting for about 30% of the total electrical energy used to run a slaughter house while maintaining the dressed carcass at below 10^{o}C after harvesting and fabrication accounts for the remaining energy consumption (McGinnis et al., 1994). thus carcass chilling is an expensive and important determinant of profitability (Aalhus et al., 2002). The Canadian Food Inspection Agency (2017) requires that carcasses harvested for meat have the warmest part cooled to 7^{o}C before harvesting. Alternative chilling processes are permitted only if supported with scientific data and positively reviewed by the agency.

Under conventional chilling i.e. chiller temperature of 0 - 4^{o}C and air velocity of 0.5m/s (Zhu et al., 2011), the time to achieve this internal temperature varies depending on the species of animal, with horse carcasses requiring about 30 h (Walker, 2017), beef taking 39 h or more (Mallikarjunan & Mittal, 1996) and lamb taking 16 h (Sheridan, 1990). As the policy does not stipulate chilling duration, attempts have been made to reduce the time taken to achieve this internal temperature; including rapid chilling whereby carcasses are chilled to -1^{o}C within 5 h (Joseph, 1996). While rapid chilling has the advantage of reduced cooling times, increased product turnover and decreased shrinkage, it produces darker and tougher meats with lower marbling scores unless combined with electrical stimulation (Aalhus et al., 2001; Janz et al., 2004; Pinto Neto et al., 2013). A modified hot boning method that removes lower value cuts and associated bone and fat from the dressed carcass so that only the remaining high value posterior carcass quarter was chilled conventionally has been investigated; however, this did not significantly reduce the chilling duration of the deep hip location (McGinnis et al., 1994).

Another option is chilling using conventional means but for a shorter duration such that meat is harvested from carcasses at about 13ºC, which is higher than the stipulated 7ºC. The oxidative nature of beef and other red muscle fiber types slows early post mortem muscle pH decline, making them more susceptible to cold shortening (Savell et al., 2005a) so that harvesting at higher temperatures may not be possible. However, horse tissue is higher in glycogen than beef (22 mg/g glycogen for horse meat; ≤10 mg/g for beef) (Gill, 2005) and although not yet proven, this may result in a faster rate of glycolysis so that a muscle pH of <5.8 is achieved before 24 h. Hence a shorter carcass chilling duration may be ideal for horse meat.

Considering the amount of revenue generated from Canadian horse meat export (17.7 million kilograms valued at CAN$ 83 million in 2012) (Canadian Meat Council, 2013), reduced duration for horse carcass chilling will potentially increase industry profitability by reducing energy inputs for chilling and maximizing slaughterhouse throughput However, reduced chilling time could impact the microbial safety, technological and sensory quality of horse meat. Earlier studies have shown that chilling duration for horse meat carcass can be reduced from 30 to 17 h without significant impact on microbial safety (Walker, 2017) and technological quality (Rahman et al., 2017); the impact of reduced chilling time on sensory quality is yet to be investigated. Moreover, while much attention has been given to the influence of ante-mortem factors such as diet/production system, age and sex on sensory quality of horse meat (Franco et al., 2011; Lorenzo, Purrinos, & Carballo, 2016; Sarries & Beriain, 2005), the influence of early post-mortem factors, particularly carcass chilling, on eating quality of horse meat has not received commensurate attention.

In addition to industry benefits, innovations such as process improvement must result in products that are of acceptable eating quality to consumers. Hence, these innovations are often guided by sensory science methods that identify the extent to which the products differ from consumers' ideal and the impact of the deviation on consumer acceptance (Ares et al., 2017). An example of such sensory methods is the Just-About-Right (JAR) method which uses a 3 to 9-point bi-polar scale to determine if the intensity of a sensory attribute is "too weak", "just-about-right" or "too strong", with the mid-point representing just-about-right and the two opposite ends of the scale representing "too weak" and "too strong" (Gere et al., 2017). Together with hedonic ratings

(overall liking scores), JAR provides information on sensory attributes with the greatest impact on consumer acceptance when related mathematically using penalty analysis (Ares et al., 2017). Consumers will give the highest hedonic rating when an attribute is perceived to be "just about right" while ratings will be penalized when the attribute is perceived to be "too weak" or "too strong" (Martinez-Navarrete, Camacho, Agudelo, & Salvador, 2018; Ruicong Zhi, Lei Zhao, & Jingye Shi, 2016). If over 20% of the consumers perceive an attribute to deviate from "just about right" and this results in a decrease in acceptability of more than one point, then the penalty is considered to be significant (Martinez-Navarrete et al., 2018), while an attribute is considered optimal when at least 70% of the consumers perceive it to be "just about right" (Ruicong Zhi et al., 2016).

The JAR consumer sensory method has found limited application in meat studies except for few studies on poultry (Fanatico et al., 2007; Oloo et al., 2018; Saha, Lee, Meullenet, & Owens, 2009b; Youngseung Lee, Rui Xiong, & Meullenet, 2014b) and processed meat products (Almeida et al., 2016; Garcia-Diez et al., 2017; Yung Hung & Verbeke, 2018b). Moreover, with the exception of the study by Beldarrain et al. (2020) where the Check-All-That-Apply (CATA) method was used to identify ideal horse meat based on ageing duration, studies on consumers' ideal sensory quality for horse meat are limited and there are no published studies of the use of the JAR method for horse meat. Beyond the acceptable microbiological and technological meat properties, horse meat obtained from the modified chilling regime will only be successful if consumers perceive the sensory attributes to be ideal or if deviations from ideal do not result in a significant mean drop in liking. Additionally, sensory studies are often carried out under controlled laboratory conditions using sensory booths in a Central Location Test (CLT), however, this does not represent the usual condition under which the food is consumed (Schouteten, Gellynck, & Slabbinck, 2019; Sinesio et al., 2019). With respect to sensory evaluation of meat where samples are prepared without flavorings and presented as small cubes, this controlled preparation and serving limit the influence of contextual factors on sensory ratings; results obtained may not be representative of the sensory quality of the meat under a natural eating occasion such as a Home Use Test (HUT). The primary objective of this study was to investigate the influence of reduced horse carcass chilling time from 30 to 17 h prior to muscle

harvesting on sensory quality and consumer acceptance of the final cooked product. A secondary objective was to compare the acceptance of horse meat samples in a CLT versus HUT on the results obtained in the objective above.

3.2. Materials and Methods

3.2.1. Product selection and preparation

Sixteen horse carcasses were selected by a federally inspected slaughterhouse in Alberta, Canada; the same facility used by Rahman et al. (2017), Walker (2017) and Roy, Walker, Rahman, Bruce, & McMullen (2018). Information about the age, sex, breed, diet and pre-slaughter conditions of the animals used for the study were not available as the animals were selected from a commercial horse slaughter facility. Eight of the carcasses were randomly assigned to the 30 h chilling regime while the remaining 8 were assigned to the 17 h chilling regime. Carcass sides were arranged on a rail and chilled at 2ºC. A thermocouple was inserted into the obturator foramen of the aitch bone and the internal temperature of the center of the hip was recorded every 30 min. A complementary study by Rahman et al. (2017) and Walker (2017) evaluated muscle pH at 1, 3 and 48 h post-mortem and reported the pH for the carcasses chilled at 48 h post-mortem to be the same (5.43) as that for carcasses chilled for 17 and 30 h.
After chilling, the *Semimembranosus* (SM) muscle was taken from the left carcass side, weighed, vacuum-packaged in a Cryovac bag (Sealed Air, Charlotte, NC, USA) and transported at 4ºC from the slaughterhouse in Alberta to Quebec for consumer sensory evaluation. This muscle was chosen because it is located deep inside the hip of the animal and takes longer to chill than other parts of the animal (Walker, 2017). Purge loss during transport was calculated as the percent weight loss of the whole SM muscle before and after vacuum-packaging (Strydom, Luhl, Kahl, & Hoffman, 2016). The SM muscle samples were stored overnight at 3ºC, removed from the vacuum pack and each cut into 5 roasts (shown in Fig. 3.1) after removing part of the narrow proximal end. Each of the 5 roasts were vacuum packaged and refrigerated at 3ºC for 24 h until evaluation. For both 17 and 30 h chilling durations, the first and third roasts were assigned to the CLT while the second, fourth and fifth roasts were assigned to the HUT (Fig. 3.1). The same part of the muscle was used consistently for CLT and HUT to minimize variation in the sensory

ratings for the meats due to location within the muscle so that the chilling duration is the only source of variation.

3.2.2. Consumer sensory evaluation

The procedure for the sensory evaluation was approved by a Research Ethics Board at the University of Alberta (Pro00083168). The study was conducted in the province of Quebec, where consumption of horse meat is common. Consumers were recruited from the database of a Sensory and Consumer Research firm in Saint-Hyacinthe, Quebec and screened to ensure consumption of horse meat at least once in 3 months. Consumers provided written informed consent before participating in the study and received a cash token as incentive for participation.

3.2.2.1. Central Location Test (CLT)

The CLT was conducted over 2 days. Ten muscles (5 muscles from each of the 2 treatments) were evaluated by consumers in 3 sessions on the first day and the remaining 6 muscles (3 muscles subjected to each of the 2 treatments) were evaluated in 2 sessions on the second day. Each session consisted of 10 – 16 consumers who evaluated samples from the two treatments presented at once in a balanced order. Evaluations were performed in individual sensory booths under white light with water and unsalted crackers for palate cleansing.

Sample preparation was performed according to AMSA methods (2016) and Lorenzo et al. (2016). Roasts were wrapped in aluminum foil, placed on racks over shallow pans and cooked in conventional ovens at 163ºC until an internal temperature of 71ºC was reached; this took approximately 90 min. Temperature was monitored by a thermometer inserted in the geometric center of each roast. Cooking loss was calculated as percent weight loss between the raw and the cooked meat samples (Franco et al., 2011). Meat cubes (1.5 cm) were cut from the roast and individually wrapped in aluminum foil, coded with three-digit random numbers, and kept warm at 60ºC in a humidified oven until evaluation. Samples were evaluated within 1 h of preparation. For each chilling treatment, consumers received 2 cubes, one from the first portion of the SM muscle (roast 1) and the other from the third portion (roast 3).

Consumers evaluated their liking of color, texture, juiciness, flavor, and overall liking for the samples on a 9-point hedonic scale (1 = “dislike extremely”, 9 = “like extremely”) on a

computerized system. In addition, these attributes were evaluated on a 5-point JAR scale with the mid-point corresponding to "just about right" and the left and right ends anchored at low intensity (e.g. "too light") and high intensity (e.g. "too dark") respectively (Li, Hayes, & Ziegler, 2014). Consumers provided information about their age, gender and horse meat consumption including frequency of consumption, context of consumption and preparation methods.

3.2.2.2. Home Use Test (HUT)

As a secondary test of consumer acceptance, interested participants from the CLT were invited to the HUT. Due to the limited meat sample, consumers received only one roast from each treatment. A total of 47 consumers took part in the HUT, 24 received roasts from carcasses chilled for 30 h while 23 received roasts from carcasses chilled for 17 h. Consumers were instructed to prepare the roasts in any recipe of their choice within 2 days. They performed the same on-line hedonic and JAR evaluations as the CLT and provided information on the recipes prepared.

3.2.3. Statistical analyses

Carcass weight, purge loss and cooking loss data were subjected to independent sample t-test while hedonic data from CLT and HUT were subjected to non-parametric test (Wilcoxon signed-rank test) at 95% confidence level ($p<0.05$) due to the violation of the assumption of normality. These analyses were carried out using R Statistical software (R Core Team, 2018). The JAR and overall liking data were subjected to penalty analysis to determine the drop in mean overall liking when consumers perceived an attribute to be at low intensity or high intensity (Costa et al., 2017) using XLSTAT® version 2019.1.1 software (Addinsoft, Boston, USA). Prior to the penalty analysis, the 5 JAR values were collapsed into 3 categories with categories 1 and 2 reduced to "too low" and 4 and 5 reduced to "too high". The JAR frequency distributions were also compared using chi-squared test for equality of distributions with significant difference determined at $p < 0.05$ (Bordi, Lambert, Smith, Hollender, & Borja, 2001).

3.3. Results and discussion

3.3.1. Carcass and meat characteristics

Table 3.1 shows the weights of the carcass sides and SM muscle, purge, and cooking loss of the horse meat from carcasses chilled for 17 and 30 h. There was no significant difference in the weight of the carcass sides randomly assigned to the 2 chilling conditions. Weights of carcass sides chilled for 17 h ranged between 104 and 204 kg while carcass sides chilled for 30 h ranged between 114 and 181 kg. Purge loss was significantly higher for meat from carcasses subjected to 17 h chilling than for meat from carcasses chilled for 30 h. Moisture loss during the early chilling period has been attributed to the lateral and longitudinal shrinkage of the myofilament which results in migration of water from the myofilament lattice to the extracellular myofilament space where is it lost as drip (Huff-Lonergan & Lonergan, 2005). However, because horse carcasses subjected to 17 h chilling were harvested earlier, the moisture was not lost as drip but as purge. This is supported by the lack of significant difference in cooking loss between meat from carcasses chilled for 17 h and 30 h. Rahman et al. (2017) also reported decreased purge loss with increasing carcass chilling duration for horse meat subjected to 17, 26 and 30 h chilling; with the lowest purge loss reported for meat from carcasses chilled for 30 h and the highest purge loss reported for that from carcasses chilled for 17 h.

3.3.2. Carcass cooling profile

Temperature curves based on average carcass weights for the carcass sides chilled for 17 and 30 h are presented in Fig. 2. Carcass sides chilled for 30 h were harvested at an average internal temperature of 7.2^{o}C ± 0.43 while carcass sides chilled for 17 h were harvested at an average internal temperature of 12.6^{o}C ± 0.7.

3.3.3. Consumer sensory evaluation

3.3.3.1. Participant characteristics

A large proportion of the consumers (94% and 87% for CLT and HUT, respectively) consumed meat of any kind more than three times a week, while consumption of horse meat was mainly

once or twice a month to once or twice a year (Table 3.2). Ninety-four percent of consumers in both the CLT and HUT prepared horse meat at home; with pan-frying the predominant method of preparation followed by grilling and roasting.

3.3.3.2. Hedonic ratings of cooked roasts

For the CLT, color and juiciness of the cooked roasts from carcasses chilled for 30 h were liked significantly more than those chilled for 17 h; hedonic ratings for other attributes and overall liking were not significantly different. There was no significant difference in hedonic ratings for all attributes and overall liking ratings for the HUT (Fig. 3.3a & b). The ratings of all the attributes and overall liking ranged between 5.3 and 6.8 on the 9-point scale for the CLT, an indication that liking was between "neither like nor dislike" and "like moderately", while ratings from the HUT ranged between 6.4 ("like moderately") and 7.9 ("like very much").
Mean overall liking and liking for all sensory attributes were significantly higher for the HUT than CLT. Similar results were reported by Boutrolle, Arranz, Rogeaux, & Delarue (2005) for fermented milk beverage, Boutrolle, Delarue, Arranz, Rogeaux, & Köster (2007) for fermented milk beverage, salted crackers and sparkling water and Sveinsdottir, Martinsdottir, Hyldig, & Sigurgisladottir (2010) for cod products, and also supported in a review by Jaeger & Porcherot (2017). The lower hedonic ratings in a CLT setting have been attributed to the analytical and critical evaluation of the samples by consumers owing to the controlled and standardized nature of CLT testing (Boutrolle et al., 2007; Sveinsdottir et al., 2010). On the other hand, freedom to prepare samples according to preference, lack of restriction on the amount of sample consumed and the more relaxed evaluation condition, which improves consumers satisfaction, contributes to the higher hedonic ratings in a HUT (Boutrolle et al., 2005).

3.3.3.3. Just-about-right and penalty analysis

Fig. 4 (a) and (b) shows the proportion of consumers in the CLT and HUT respectively that perceived attributes of the horse meat samples to be "too weak", JAR or "too strong". Only the frequency count for JAR ratings of color was significantly different for the CLT (χ^2 (3, 191) = 8.89, $p < 0.05$), while the frequency count for all attributes was not significant for the HUT. With respect to color, 51% of the consumers in CLT considered the meat from carcasses chilled for 17

h to be “too light” as compared to 30% for meat from carcasses chilled for 30 h while 45% and 64% of consumers considered the color of the 17 and 30 h samples respectively, to be JAR. Result corroborates the observation made by Rahman et al. (2017) on the instrumental color analysis of horse meat from carcasses chilled for 17, 26 and 30 h with the L* score significantly lower for samples chilled for 30 h.

When consumers used roasts to prepare recipes of their choice, the proportion of consumers that considered the color to be JAR increased for samples from both carcasses chilled for 17 and 30 h, with only 4% perceiving the color of 17 h samples to be “too light”. Similar observations were made for flavor and juiciness, with the proportion of consumers considering the flavor and juiciness to be JAR increasing for both 17 and 30 h samples. This is an indication that consumers considered the color, flavor and juiciness to be optimal regardless of the duration of chilling. Increased positive sensory evaluations of the samples in the HUT compared to the CLT confirm the need to substantiate results of CLT sensory evaluation of meat (particularly whole muscle products) with home use testing.

A large proportion of the consumers perceived horse meat texture to be “too tough” regardless of the chilling duration and preparation location. Although the proportion of consumers that perceived the samples to be too tough decreased for the HUT, the proportion of consumers that perceived texture to be JAR was below 70% even when samples were prepared at home. While the perception of toughness is contrary to the generally held opinion that horse meat is tender (Lorenzo et al., 2014; Pawshe, Khedkar, & Pundkar, 2016; Rossier, 2003), *Semimembranosus* muscle used in this study was reported to be the least tender of six muscles (Lorenzo, Pateiro, & Franco, 2013). The impact of muscle type on meat tenderness has been attributed to the different physiological functions of the muscles based on their anatomical location, which informs different histological characteristics including sarcomere length, collagen quantity and solubility (Franco & Lorenzo, 2014; Tateo, De Palo, Ceci, & Centoducati, 2008).

Penalty analysis is shown in Fig 5 for CLT (a) and HUT (b). Although over 50% of the CLT consumers considered the color of the 17 h samples to be too light, this did not result in a significant mean drop in overall liking while juiciness, texture and flavor JAR ratings resulted in

significant drop in mean overall liking. A large proportion of the consumers perceived the meat samples to be" too dry" and "too tough" which resulted in a mean liking drop of 1.53 and 2.32 for juiciness and texture, respectively. While only 8% perceived the flavor to be "too strong", this resulted in a greater mean drop in overall liking than when flavor was perceived to be "too weak". A similar trend was reported for 30 h samples except for color, which a small proportion of consumers perceived to be "too dark" and resulted in higher drop in overall liking than when it was perceived to be "too light. This is an indication that horse meat is more acceptable when perceived to be lighter than when perceived to be darker than ideal. While perception of toughness resulted in a significant mean drop for the samples from carcasses chilled for17 h, the mean drop was not significant for the samples from carcasses chilled for 30 h. The reverse was observed for juiciness as perception of dryness resulted in significant mean drop for 30 h but not for 17 h samples.

Unlike darker and tougher meats obtained from previous attempts by researchers to reduce refrigeration costs via rapid chilling (Aalhus et al., 2001; Janz et al., 2004; Pinto Neto et al., 2013), conventional chilling with reduced chilling duration resulted in horse meat of lighter color and similar tenderness to standard chilling duration. Results of this study together with studies by Walker (2017) and Rahman et al., (2017) showed that horse meat can be harvested after 17 h of chilling when the deepest part of the carcass is at a temperature of approximately 12^{o}C without adverse effect on the sensory, technological and microbial quality. This will guide policy changes to permit shorter chilling duration for horse meat for reduced chilling inputs and increased profitability for the industry.

The more positive sensory ratings of horse meat roasts evaluated in the HUT versus the CLT has been observed for other food products and aligns with the current paradigm that food eaten and evaluated in its usual context increases the ecological validity of the study results (Stelick & Dando, 2018). The application of HUT in consumer acceptability studies of meat products may be limited by the greater quantity of meat required relative to a CLT.

A limitation of this study was the inability to control or identify antemortem factors of the animals such as age and breed, which could have influenced the sensory attributes, particularly tenderness of the meat.

3.4. Conclusion

Reduction of chilling time for horse carcasses from 30 to 17 h had no significant effect on consumer acceptance of *Semimembranosus* muscle roasts in a home use test (HUT). Consumers liked color and juiciness of meat samples from carcasses chilled for 30 h significantly more than those from carcasses chilled for 17 h in a laboratory-based central location testing (CLT); however, this did not reduce overall liking. Overall consumer acceptance ratings were higher in the HUT than the CLT. These consumer sensory acceptance results, and previous microbiological and technical quality evaluations, support potential policy changes to permit a carcass chill time of 17 h to reduce energy inputs and increase profits for the horse meat industry. Future studies could investigate the influence of antemortem factors such has breed, age of the animal and muscle type that could influence sensory attributes and consumer acceptance under reduced carcass chilling duration conditions. The use of HUT for consumer evaluation of meats is recommended to provide appropriate context for their evaluation.

3.5. References

Aalhus, J. L., Janz, J. A. M., Tong, A. K. W., Jones, S. D. M., & Robertson, W. M. (2001). The influence of chilling rate and fat cover on beef quality. *Canadian Journal of Animal Science, 81*, 321-330. doi:https://doi.org/10.4141/A00-084

Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., & Best, D. R. (2002). Very fast chilling of beef carcasses. *Canadian Journal of Animal Science, 82*, 59-67. doi:https://doi.org/10.4141/A01-020

Almeida, M. A. d., Villanueva, N. D. M., Saldana, E., Pinto, J. S. D. S., Fadda, S. G., & Castillo, C. J. C. (2016). The use of just-about-right (JAR) scales to identify drivers of customer acceptance for low-sodium Italian salami. *Meat Science, 112* doi:https://doi.org/10.1016/j.meatsci.2015.08.032

AMSA. (2016). *Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness of Meat* (2nd ed.). Champaign, Illinois, USA: American Meat Science Association.

Ares, G., Andrade, J. C. d., Antunez, L., Alcaire, F., Swaney-Stueve, M., Gordon, S., & Jaeger, S. R. (2017). Hedonic product optimisation: CATA questions as alternatives to JAR scales. *Food Quality and Preference, 55*, 67-78. doi:https://doi.org/10.1016/j.foodqual.2016.08.011

Beldarrain, L. R., Etaio, I., Morán, L., Sentandreu, M. Á, Barron, L. J. R., & Aldai, N. (2020). Effect of ageing time on consumer preference and sensory description of foal meat. *Food Research International, 129* doi:10.1016/j.foodres.2019.108871

Bordi, P. L., Lambert, C. U., Smith, J., Hollender, R., & Borja, M. E. (2001). Acceptability of soy protein in oatmeal muffins. *Foodservice Research International, 13*, 101-110. doi:https://doi.org/10.1111/j.1745-4506.2001.tb00034.x

Boutrolle, I., Arranz, D., Rogeaux, M., & Delarue, J. (2005). Comparing central location test and home use test results: Application of a new criterion. *Food Quality and Preference, 16*, 704-713. doi:https://doi.org/10.1016/j.foodqual.2005.03.015

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M., & Köster, E. P. (2007). Central location test vs. home use test: Contrasting results depending on product type. *Food Quality and Preference, 18*, 490-499. doi:https://doi.org/10.1016/j.foodqual.2006.06.003

Canadian Food Inspection Agency. (2017). Refrigeration of carcasses and carcass parts. Retrieved from http://www.inspection.gc.ca/food/meat-and-poultry-products/manual-of-procedures/chapter-17/eng/1367723343665/1367723573062?chap=12

Canadian Meat Council. (2013). Horse meat production in Canada. Retrieved from https://www.cmc-cvc.com/sites/default/files/files/Horse%20Meat%20Production%20in%20Canada%20Feb%202013.pdf

Costa, M. P., Monteiro, M. L. G., Frasao, B. S., Silva, V. L. M., Rodrigues, B. L., Chiappini, C. C. J., & Conte-Junior, C. A. (2017). Consumer perception, health information, and instrumental parameters of cupuassu (T*heobroma grandiflorum*) goat milk yogurts. *Journal of Dairy Science, 100*, 157-168. doi:https://doi.org/10.3168/jds.2016-11315

DEFRA. (2010). Fostering the development of technologies and practices to reduce the energy inputs
into the refrigeration of food. *Department for Environment, Food and Rural Affairs*. Retrieved from https://www.grimsby.ac.uk/documents/defra/sectrep-meatchill.pdf

Fanatico, A. C., Pillai, P. B., Emmert, J. L., Gbur, E. E., Meullenet, J. F., & Owens, C. M. (2007). Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. *Poultry Science, 86*, 2441-2449. doi:https://doi.org/10.3382/ps.2007-00092

Franco, D., & Lorenzo, J. M. (2014). Effect of muscle and intensity of finishing diet on meat quality of foals slaughtered at 15 months. *Meat Science, 96*, 327-334. doi:https://doi.org/10.1016/j.meatsci.2013.07.018

Franco, D., Rodriguez, E., Purrinos, L., Crecente, S., Bermudez, R., & Lorenzo, J. M. (2011). Meat quality of "Galician mountain" foals breed. Effect of sex, slaughter age and livestock production system. *Meat Science, 88*, 292-298. doi:https://doi.org/10.1016/j.meatsci.2011.01.004

Garcia-Diez, J., Alheiro, J., Pinto, A. L., Soares, L., Falco, V., Fraqueza, M. J., & Patarata, L. (2017). The impact of essential oils on consumer acceptance of chourico de vinho - a dry-cured sausage made from wine-marinated meat - assessed by the hedonic scale, JAR intensity scale and consumers' "will to consume and purchase". *Journal of Food Processing and Preservation, 41* doi:https://doi.org/10.1111/jfpp.13056 ER

Gere, A., Szabo, Z., Pasztor-Huszar, K., Orban, C., Kokai, Z., & Sipos, L. (2017). Use of JAR-based analysis for improvement of product acceptance: A case study on flavored kefirs. *Journal of Food Science, 82*, 1200-1207. doi:https://doi.org/10.1111/1750-3841.13701 ER

Gill, C. O. (2005). Safety and storage stability of horse meat for human consumption. *Meat Science, 71*, 506-513. doi:https://doi.org/10.1016/j.meatsci.2005.04.030

Huff-Lonergan, E., & Lonergan, S. M. (2005). Mechanisms of water-holding capacity of meat: The role of post-mortem biochemical and structural changes. *Meat Science, 71*, 194-204. doi:https://doi.org/10.1016/j.meatsci.2005.04.022

Jaeger, S. R., & Porcherot, C. (2017). Consumption context in consumer research: Methodological perspectives. *Current Opinion in Food Science, 15*, 30-37. doi:https://doi.org/10.1016/j.cofs.2017.05.001

Janz, J. A. M., Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., Larsen, I. L., & Landry, S. (2004). The effects of modified carcass chilling on beef carcass grade and quality of several muscles. *Canadian Journal of Animal Science, 84*, 377-384. doi:https://doi.org/10.4141/A03-067

Joseph, R. L. (1996). Very fast chilling of beef and tenderness—a report from an EU concerted action. *Meat Science, 43*, 217-227. doi:https://doi.org/10.1016/0309-1740(96)00067-8

Li, B., Hayes, J. E., & Ziegler, G. R. (2014). Just-about-right and ideal scaling provide similar insights into the influence of sensory attributes on liking. *Food Quality and Preference, 37*, 71-78. doi:https://doi.org/10.1016/j.foodqual.2014.04.019

Lorenzo, J. M., Purrinos, L., & Carballo, J. (2016). A survey on the effect of livestock production system and finishing diet on sensory characteristics of foal meat using generalized procrustes analysis. *The Scientific World Journal, 2016*, 1-6. doi:https://doi.org/10.1155/2016/8729053

Lorenzo, J. M., Victoria Sarries, M., Tateo, A., Polidori, P., Franco, D., & Lanza, M. (2014). Carcass characteristics, meat quality and nutritional value of horsemeat: A review. *Meat Science, 96*, 1478-1488. doi:https://doi.org/10.1016/j.meatsci.2013.12.006

Lorenzo, J. M., Pateiro, M., & Franco, D. (2013). Influence of muscle type on physicochemical and sensory properties of foal meat. *Meat Science, 94*, 77-83. doi:https://doi.org/10.1016/j.meatsci.2013.01.001

Mallikarjunan, P., & Mittal, G. S. (1996). Selection criteria for beef carcass chilling. *Food Research International, 29*(7), 661-666. doi:https://doi.org/10.1016/S0963-9969(96)00064-6

Martinez-Navarrete, N., Camacho, M. M., Agudelo, C., & Salvador, A. (2018). Sensory characterization of juice obtained via rehydration of freeze-dried and spray-dried grapefruit. *Journal of the Science of Food and Agriculture, 99*, 244-252. doi:https://doi.org/10.1002/jsfa.9166 ER

McGinnis, D. S., Aalhus, J. L., Chabot, B., Gariepy, C., & Jones, S. D. M. (1994). A modified hot processing strategy for beef: Reduced electrical energy consumption in carcass chilling. *Food Research International, 27*, 527-535. doi:10.1016/0963-9969(94)90138-4 ER

Oloo, B., Mahungu, S., & Kahi, A. (2018). Descriptive sensory quality of Kenya's indigenous chicken meat from different ecotype-clusters reared under an intensive system. *African Journal of Food, Agriculture, Nutrition and Development, 18*, 13202-13225. doi:https://doi.org/10.18697/ajfand.81.16900 ER

Pawshe, M., Khedkar, C., & Pundkar, C. (2016). Horse meat. In B. Caballero, P. Finglas & F. Toldrá (Eds.), *Reference module in food and health* (pp. 353-356). London: Elsevier.

Pinto Neto, M., Beraquet, N. J., & Cardoso, S. (2013). Effects of chilling methods and hot-boning on quality parameters of *M. Longissimus lumborum* from *Bos indicus nelore* steer. *Meat Science, 93*, 201-206. doi:https://doi/10.1016/j.meatsci.2012.08.024

R Core Team. (2018). R: A language and environment for statistical computing. R foundation for statistical computing [computer software]. Vienna, Austria:

Rahman, M. M., Walker, B., Roy, B. C., McMullen, L., & Bruce, H. L. Effects of chilling and ageing period on horse meat quality. Paper presented at the *63rd International Congress of Meat Science and Technology, Cork, Ireland, 13-18, August, 2017, 212-213.*

Rossier, E. (2003). Horse meat. In B. Caballero (Ed.), *Encyclopedia of Food Sciences and Nutrition (second edition)* (pp. 3174-3178). Oxford: Academic Press. doi:https://doi.org/10.1016/B0-12-227055-X/00607-6

Roy, B. C., Walker, B., Rahman, M. M., Bruce, H. L., & McMullen, L. (2018). Role of myofibers, perimysium and adipocytes in horse meat toughness. *Meat Science, 146*, 109-121. doi:https://doi.org/10.1016/j.meatsci.2018.08.005

Ruicong Zhi, Lei Zhao, & Jingye Shi. (2016). Improving the sensory quality of flavored liquid milk by engaging sensory analysis and consumer preference. *Journal of Dairy Science, 99*, 5305-5317. doi:https://doi.org/10.3168/jds.2015-10612 ER

Saha, A., Lee, Y., Meullenet, J. F., & Owens, C. M. (2009). Consumer acceptance of broiler breast fillets marinated with varying levels of salt. *Poultry Science, 88*, 415-423. doi:https://doi.org/10.3382/ps.2008-00230 ER

Sarries, M. V., & Beriain, M. J. (2005). Carcass characteristics and meat quality of male and female foals. *Meat Science, 70*, 141-152. doi:10.1016/j.meatsci.2004.12.006

Savell, J. W., Mueller, S. L., & Baird, B. E. (2005). The chilling of carcasses. *Meat Science, 70*, 449-459. doi:https://doi.org/10.1016/j.meatsci.2004.06.027

Schouteten, J. J., Gellynck, X., & Slabbinck, H. (2019). Influence of organic labels on consumer's flavor perception and emotional profiling: Comparison between a central

location test and home-use-test. *Food Research International, 116*, 1000-1009. doi:https://doi.org/10.1016/j.foodres.2018.09.038

Sheridan, J. J. (1990). The ultra-rapid chilling of lamb carcasses. *Meat Science, 28*, 31-50. doi:https://doi.org/10.1016/0309-1740(90)90018-2

Sinesio, F., Saba, A., Peparaio, M., Saggia Civitelli, E., Paoletti, F., & Moneta, E. (2019). Reprint of "capturing consumer perception of vegetable freshness in a simulated real-life taste situation". *Food Research International, 117*, 2-9. doi:https://doi.org/10.1016/j.foodres.2018.10.084

Stelick, A., & Dando, R. (2018). Thinking outside the booth—the eating environment, context and ecological validity in sensory and consumer research. *Current Opinion in Food Science, 21*, 26-31. doi:https://doi.org/10.1016/j.cofs.2018.05.005

Strydom, P., Luhl, J., Kahl, C., & Hoffman, L. C. (2016). Comparison of shear force tenderness, drip and cooking loss, and ultimate muscle pH of the loin muscle among grass-fed steers of four major beef crosses slaughtered in Namibia. *South African Journal of Animal Science, 46*, 348-359. doi:https://doi.org/10.4314/sajas.v46i4.2 ER

Sveinsdottir, K., Martinsdottir, E., Thorsdottir, F., Schelvis-Smit, A. A. M., Kole, A., & Thorsdottir, I. (2010). Evaluation of farmed cod products by a trained sensory panel and consumers in different test settings. *Journal of Sensory Studies, 25*, 280-293. doi:https://doi.org/10.1111/j.1745-459X.2009.00257.x

Tateo, A., De Palo, P., Ceci, E., & Centoducati, P. (2008). Physicochemical properties of meat of Italian heavy draft horses slaughtered at the age of eleven months. *Journal of Animal Science, 86*, 1205-1214. doi:https://doi.org/10.2527/jas.2007-0629

Walker, B., Bruce, H., & McMullen, L. (2017). Effects of boning time on bacterial load of horse meat. *Journal of Food Protection, 80* doi:https://doi.org/10.4315/0362-028X-80.sp1.1 ER

Walker, B. (2017). *Impact of Carcass Chill Time on the Microbiology of Horse Meat.* Retrieved from https://era.library.ualberta.ca/items/502543e7-6ddc-4f59-90fb-b786ad9cfee9/view/fd5ba37d-3bca-48c0-ab81-3a4150e49074/Walker_Brian_D_201709_MSc.pdf

Youngseung Lee, Rui Xiong, & Meullenet, J. F. (2014). Prediction of sensory texture of broiler breast meat using instrumental spectral stress-strain analysis. *International Journal of Food Science & Technology, 49*, 2269-2275. doi:https://doi.org/10.1111/ijfs.12542

Yung Hung, & Verbeke, W. (2018). Sensory attributes shaping consumers' willingness-to-pay for newly developed processed meat products with natural compounds and a reduced level of nitrite. *Food Quality and Preference, 70*, 21-31. doi:https://doi.org/10.1016/j.foodqual.2017.02.017 ER

Zhu, L., Gao, S., & Luo, X. (2011). Rapid chilling has no detrimental effect on the tenderness of low-voltage electrically stimulated *M. longissimus* in Chinese bulls. *Meat Science*, *88*, 597-601. doi:https://doi.org/10.1016/j.meatsci.2011.02.005

Table 3.1:Mean left carcass side weight and Semimembranosus muscle weight, purge loss and cooking loss from horse carcasses chilled for 17 h (n = 8) and 30 h (n = 8)

	30 h		17 h		Sig ($p<0.05$)
	Mean	SEM	Mean	SEM	
Carcass weight (Kg)	164.25	9.5	148.88	7.6	0.26
Muscle weight (Kg)	4.16	0.24	4.19	0.16	0.93
Purge loss (%)	1.504	0.21	2.12	0.14	0.04
Cooking loss (%)	31.36	1.53	33.25	0.91	0.34

Table 3.2: Characteristics of consumers in the CLT and HUT

		CLT (%) N = 96	HUT (%) N = 47
Gender	Male	46	53
	Female	54	47
Age	18-25years	13	13
	26-35years	21	21
	36-45years	26	26
	46-55years	12	11
	56-65years	23	17
	66 years and older	5	13
Meat consumption frequency	**Meat of any kind**		
	Three or more times a week	94	87
	Once or twice a week	4	13
	Once every 2 weeks	1	
	Once or twice a month	1	
	Horse meat		
	Three or more times a week	2	4
	Once or twice a week	12	13
	Once every 2 weeks	11	9
	Once or twice a month	36	32
	Once or twice a year	37	40
Horse meat preparation method	**Home prepared**	**94**	**94**
	Roasted	23	49
	Grilled	38	40
	Stewed	25	21
	Pan-fried	53	60
	Others	16	13
	Restaurant	**16**	**11**
	Others	2	6

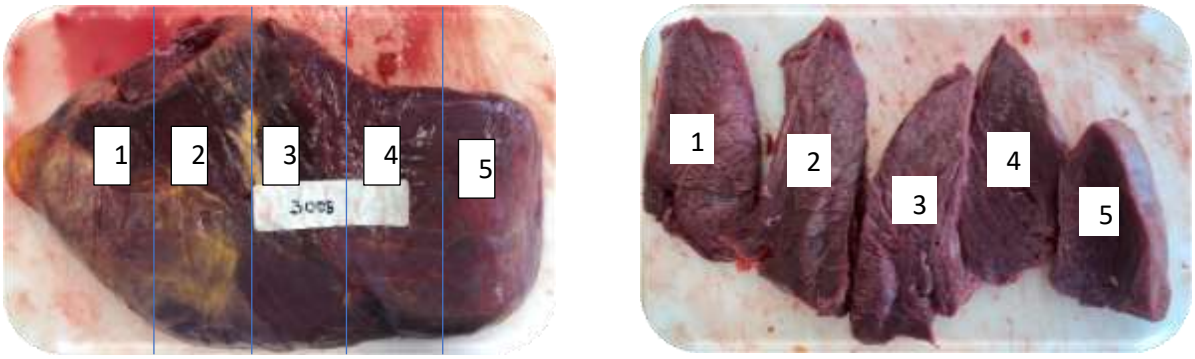


Fig. 3.1: Assignment of roasts from Semimembranosus muscle of horse. Roasts 1 and 3 were used for CLT while roasts 2, 4 and 5 were used for HUT

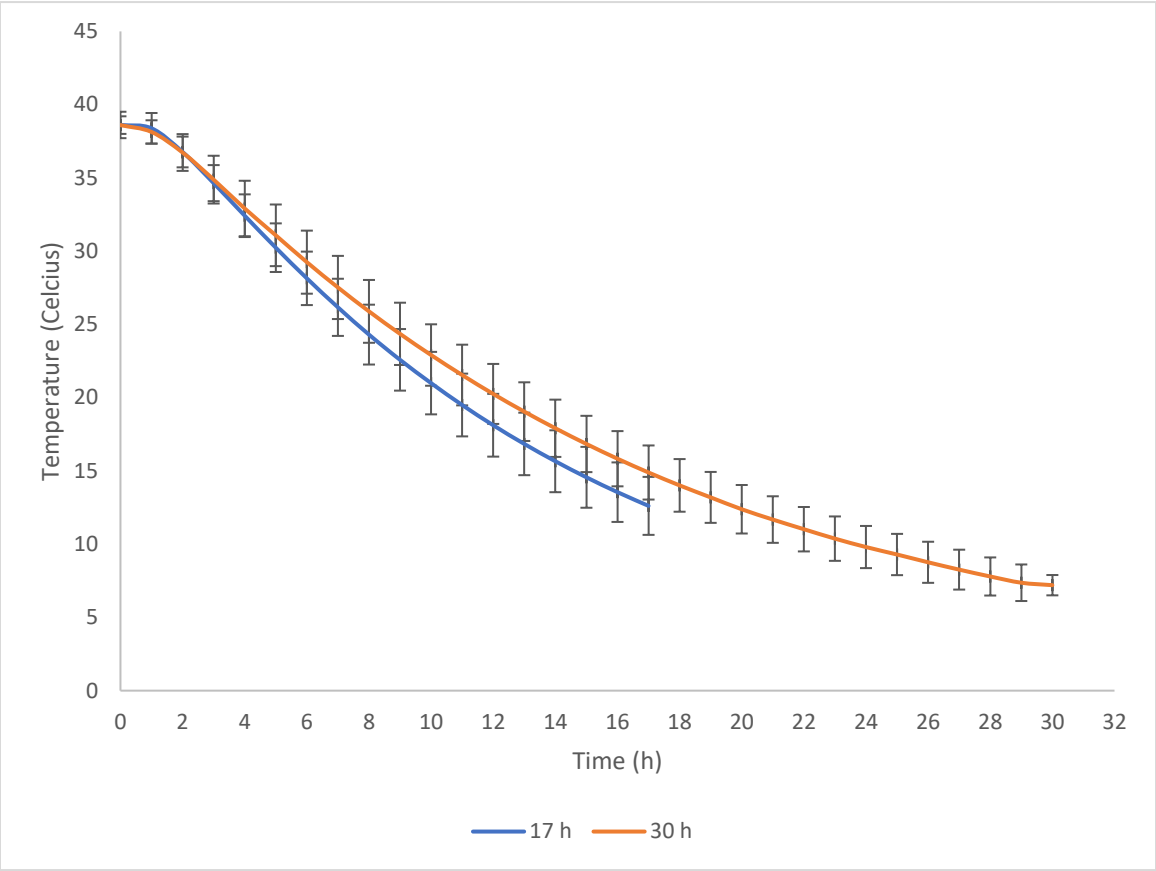


Fig. 3.2: Chilling profile based on average weight (n=8) for carcasses chilled for 17 or 30 h

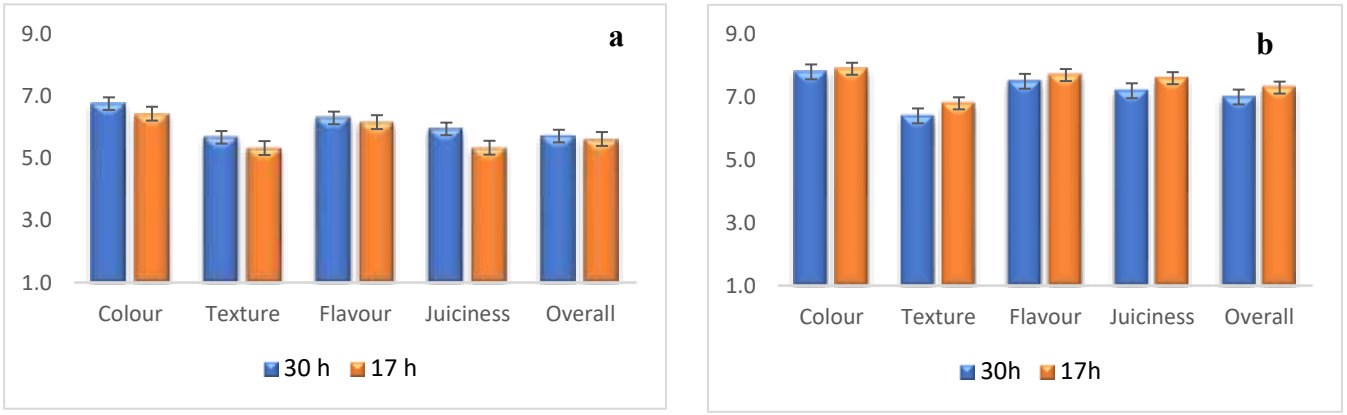


Fig. 3.3: Mean liking score for color, texture, flavor, juiciness and overall for horse meat from carcasses chilled for 30 h or 17 h for (a) CLT and (b) HUT.

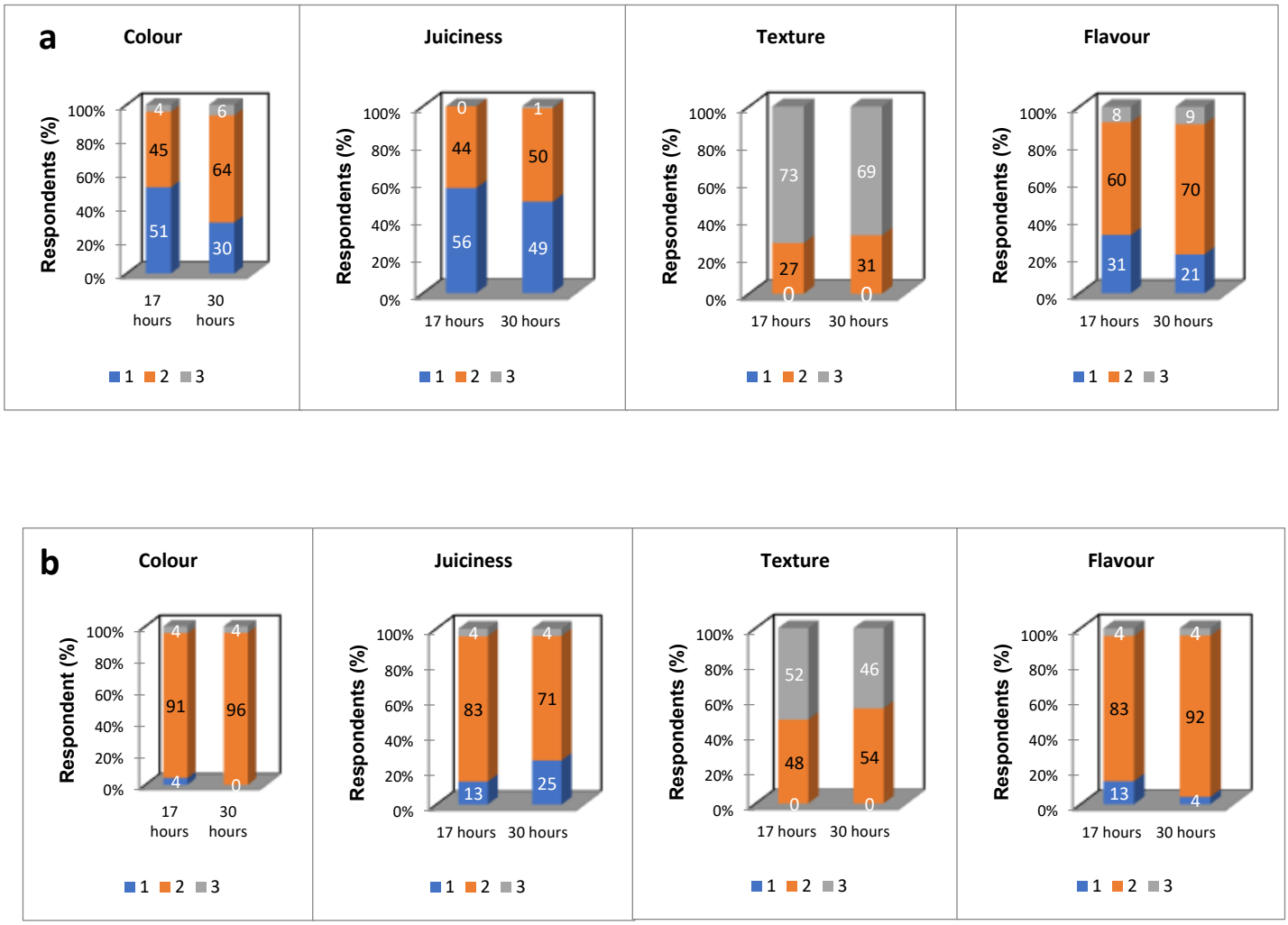
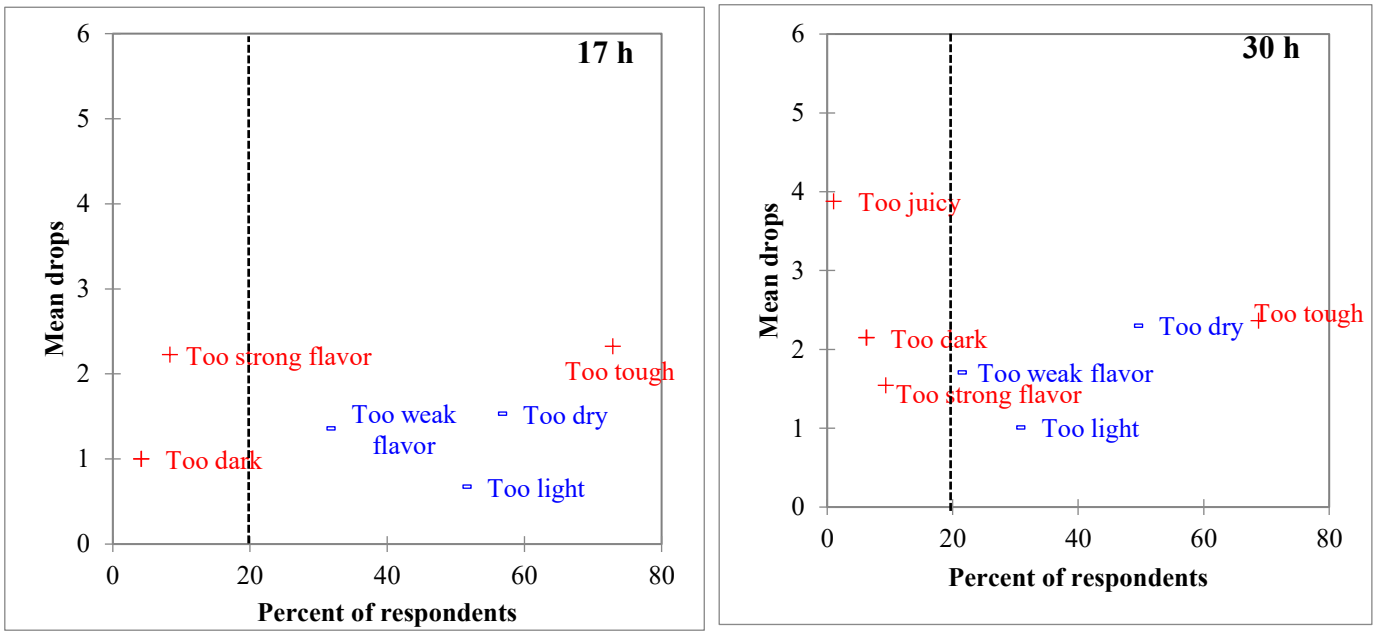


Fig. 3.4: Percentage of consumer JAR evaluations of horse meat from carcasses chilled for 30 or 17 h for (a) CLT and (b) HUT. Color: 1 = “too light”, 2 = “JAR”, 3 = “too dark”; Juiciness: 1 = “too dry”; 2 = “JAR”, 3 = “too juicy”; Texture: 1= “too tender

a)



b)

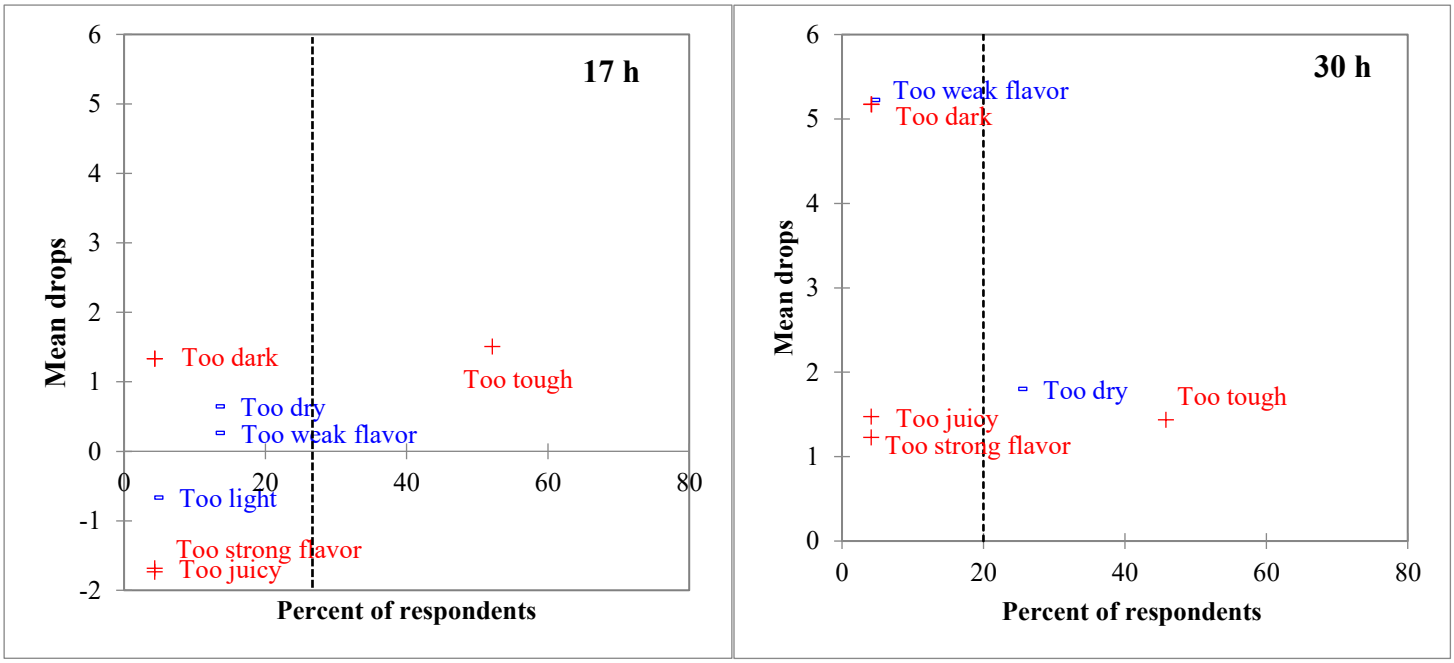


Fig. 3.5: Penalty analysis from JAR data for horse meat from carcasses chilled for 17 or 30 h for both (a) CLT and (b) HUT. Attributes that were "too little" (-) or "too much" (+) with frequency less than 20% of total responses are considered insignificant

Chapter 4. Consumer Sensory Comparisons among Beef, Horse, Elk and Bison using Preferred Attributes Elicitation and Check All That Apply Methods

4.1. Introduction

Red meats from unconventional sources such as bison, elk and horse possess positive attributes of low fat and cholesterol and high concentration of n-3 polyunsaturated fatty acids (Polawska, Cooper, Jozwik, & Pomianowski, 2013; Rule, Broughton, Shellito, & Maiorano, 2002) which may suit the needs of the health-conscious consumer. However, consumption of these unconventional meats is low when compared to red meats from conventional sources such as beef, which may in part be due to the sensory differences. The magnitude of these differences and the extent to which they influence consumer acceptance is not known. No published study has compared the sensory attributes of beef with horse, bison and elk meats and linked these attributes to liking. Rodbotten, Ueland, Lea, & Kubberod (2004) developed a sensory map of 15 different meat species by describing the sensory similarities and dissimilarities that exist among the meat species, but only beef and horse were included in their study while elk was not. Moreover, their study did not link these attributes to consumer acceptance. Koch, Crouse, & Seideman (1988) compared some specific attributes of bison with 2 breeds of cattle (Hereford and Brahman) using a trained panel; this was also not linked to consumer acceptance.

Traditional descriptive profiling methods entail the use of trained panels to describe and discriminate both qualitative and quantitative sensory characteristics of food and beverages (Dominique, Sylvie, Lelièvre Maud, & Abdi Hervé, 2012). The advantage of traditional descriptive profiling methods lies in detailed, consistent, and reproducible results generated by highly specialized descriptive panels (Moussaoui & Varela, 2010). However, creating and maintaining a well-trained and calibrated sensory panel can be laborious, expensive and time intensive (Varela & Ares, 2012). Another limitation of traditional descriptive profiling is that it does not link the individual attributes to consumer acceptance (Grygorczyk, Lesschaeve, Corredig, & Duizer, 2013). These limitations have led to the development of rapid descriptive sensory profiling methods using untrained consumers who give satisfactory overall sensory description and provide insight into attributes that influence consumer acceptance (Muggah &

McSweeney, 2017). While traditional descriptive profiling is used extensively in meat studies (Bureš, Bartoň, Kotrba, & Hakl, 2015; Lorenzo, Sarries, & Franco, 2013), novel consumer descriptive profiling has received limited use.

Check-all-that-apply (CATA) is an example of rapid descriptive profiling method (Adams, Williams, Lancaster, & Foley, 2007) whereby panelists select terms from a list that best describe the samples under evaluation (Ares, Dauber, Fernández, Giménez, & Varela, 2014). Usually the number of panelists range between 50 and 100 and the lists of attributes are generated by trained assessors or from previous focus groups.

Another novel rapid descriptive profiling method is the Preferred Attributes Elicitation (PAE) method in which untrained consumers simultaneously agree on the attributes that describe a set of products and rank the attributes in order of importance to liking (Grygorczyk et al., 2013; McSweeney, Sisopha, T'ien, Rector, & Duizer, 2017; Muggah & McSweeney, 2017). The advantage of this method is that it is conducted with untrained panelists within a single session using fewer panelists compared to CATA. Most importantly, the PAE method provides insight into the importance of the sensory attributes to liking, similar to penalty analysis of CATA data. The PAE method is yet to gain wide application in the food industry; its use may be broadened if it compares well with other existing rapid methods. The primary study aim was to elicit and compare the sensory attributes of beef, horse, bison and elk meat and identify attributes that influence consumer acceptance. The secondary aim of this study was to determine the suitability of PAE for consumer descriptive meat profiling by comparing results of PAE with CATA.

4.2. Materials and Methods

The study protocol was approved by an institutional review board at the University of Alberta (Edmonton, AB, Canada) and each participant completed written informed consent. All data were collected using Compusense® Cloud Software (Guelph, ON, Canada) software and panelists received a small gift card to acknowledge their participation.

4.2.1. Sample preparation

Inside round cuts of beef, horse, elk and bison were obtained from a federally inspected slaughterhouse (Bouvry Exports, Fort McLeod, AB), production background and diet of the animals from which the meats were sourced was not available. The choice of inside round cut was based on its characteristics as intermediate yield and tenderness cut (Boles & Shand, 2008). Due to its seasonal availability, elk meat was purchased frozen, thawed completely, cut into roasts, vacuum packed and frozen again until needed while the other meats were obtained fresh. All meats were cut into approximately 700 g roasts, vacuum packaged and kept frozen (-20ºC) until ready for evaluation. Prior to evaluation, the roasts were thawed for 48 h in a refrigerator. Roasts were wrapped in aluminum foil, placed on racks over shallow pans and cooked in conventional ovens (model number GRSL3500ZWW, General Electric) at 163˚C until an internal temperature of 71˚C was reached (AMSA, 2016). Temperature was monitored by a thermocouple (DOT^{TM} Proseries thermosistor probe, ThermoWorks Inc., Utah, USA) inserted in the geometric center of the roasts and cooking took approximately 90 min. Samples were weighed before and after cooking to determine cooking loss which was calculated using the formula described by Franco et al. (2011). Cooked meat samples were cut into 1.5cm cubes, wrapped in aluminum foil (Lorenzo, Purrinos, & Carballo, 2016), placed in glass jars coded with 3-digit random numbers, covered and kept in a water bath at 60˚C until evaluation.

4.2.2. Participants recruitment and sample presentation

Participants who liked and consumed red meat regularly were recruited from the university community; recruitment was not based on stratified sampling. Participants were informed about the types of meats to be evaluated via the recruitment materials, letter of initial contact and information and consent form. Panelists received all 4 samples at once in both PAE and CATA trials based on a Williams Latin Square sample presentation design. Samples were coded with three-digit random numbers and kept warm during evaluation by placing the samples jars in water baths placed on microwaveable hot plates (Mastrad® Orka® Magma®, Mastrad, Paris, France) for each panelist. Panelists were instructed to consume the distilled water and unsalted crackers for palate cleansing before consuming the first sample and in between samples.

4.2.3. Preferred Attributes Elicitation (PAE)

PAE was conducted according to method described by McSweeney, Duizer, Seetharaman, & Dan Ramdath, (2016); Grygorczyk et al., (2013) and Muggah & McSweeney, (2017) with slight modifications. Three PAE sessions were conducted with 3 groups of different individuals. The first 2 PAE sessions were conducted simultaneously before the CATA/consumer test (n=7 panelists for each session) while the last PAE session was conducted after the consumer test as a means of validating results of the first two PAE studies using 11 panelists. The choice to use approximately 10 panelists in each PAE test rather than 10 to 25 used in previous PAE studies was based on the recommendation of McSweeney et al., (2017) to ensure equal contributions to the discussion by each panelist. Unlike the previous PAE studies where hedonic data, attribute generation, intensity rating and ranking for importance to liking were conducted in one session, the present PAE studies were conducted in 2 sessions each for each group. This was necessary because panelists evaluated all characteristics of the meat samples (appearance, aroma, flavor, texture, juiciness, and aftertaste) and because each panelist generated an attribute list independently before group discussion. Ranking for importance to liking was also performed individually so that data could be analyzed statistically. This was a limitation in previous PAE studies as it was noted that dominant personalities led the discussion so that information on attributes important for consumer acceptance may be skewed towards these personalities (Muggah & McSweeney, 2017). PAE 1 consisted of people with sensory evaluation or meat quality experience while panelists in PAE 2 and PAE 3 had neither meat nor sensory evaluation experience.

4.2.4. Check-all-that-apply (CATA) and consumer testing

CATA and consumer acceptance data were collected from 63 consumers (34 males). Ares, Tárrega, Izquierdo, & Jaeger, (2014) recommend a panel size of at least 60 to obtain a stable sample and descriptor configurations from CATA for samples that are widely different. Consumers rated their liking for the characteristics (appearance, aroma, flavor and texture) and overall liking for each sample on a 9-point hedonic scale. Next, the CATA questions were completed with 43 attributes generated from PAE 1 and PAE 2; attributes from PAE 3 were not

included in the CATA study as this was done after the CATA study. “Not applicable” was not included in the CATA list as participants were expected not to check any attribute they did not perceive in the samples. Antonymous attributes that were put on opposite ends of the scale in the PAE study (e.g. dry and juicy, tender and tough, pale and dark) were listed as individual attributes for the CATA study.

4.2.5. Statistical analyses

All analyses were performed using XLSTAT® software (Addinsoft, NY, USA, 2017). Descriptive data from PAE were subjected to Generalized Procrustes Analysis (GPA) which was used to condense individual evaluations or matrices into a consensus matrix which was then used to determine product and attribute positioning in a dimensional space (Muggah & McSweeney, 2017). Prior to GPA, intensity data from the PAE were subjected to one-way ANOVA at $p < 0.25$ with attribute intensity ratings dependent on the meat type and only discriminant descriptors were retained for the GPA (Oxana, Anna, & Luis, 2016). The cooking loss data, hedonic data from the PAE and consumer testing were subjected to ANOVA at 0.05 level of significance followed by Tukey’s HSD test. Overall liking scores from the consumer testing data were subjected to Agglomerative Hierarchical Cluster Analysis based on Euclidean distances and Ward aggregation. Preference maps were then generated by regressing the clusters onto the product coordinates from the descriptive step of the PAE 1 (Muggah & McSweeney, 2017). Frequency of use of each sensory term from the CATA question was determined by counting the number of consumers that used the term to describe each meat sample. Cochran’s Q test was then used to determine significant differences (at 0.05 and 0.1 level) among the meat samples for the sensory terms on the CATA questionnaire. The matrix containing frequency of use of each term for each meat sample in columns and the samples in rows was then subjected to Correspondence Analysis using Chi-square distance to obtain a bi-dimensional representation of the meat samples and the sensory terms (Ares et al., 2014). Only attributes that were significantly different among the meat samples were selected for Correspondence Analysis and construction of the sensory map (Alexi et al., 2018). Penalty analysis was carried out to determine mean drop in overall liking based on whether an attribute was used to describe the samples or not. Multiple Factor Analysis (MFA) was used to compare results from the three PAE groups with CATA to

obtain visual description of the alignment between the PAE description and CATA description of the meat samples. Alignment between the consensus matrices of the PAE and CATA trials was also determined using RV coefficients.

4.3. Results and Discussion

4.3.1. Panelists' descriptive statistics

For PAE, panelists' age ranged between 18 and 45 years and they consumed meat of any kind at least once a week. Most of the panelists consumed beef at least thrice a week while the majority had never consumed bison, elk or horse meat. For CATA and consumer testing, over 80% of the consumers belonged to 18-35 years age group, 12% belonged to the 36-45 years age group, while the rest were 46-55 years and above. A large proportion (92%) of the consumers consumed any kind of meat at least 3 times a week while about 60% consumed beef at least once in a week. Almost all panelists had never consumed horse, elk or bison.

4.3.2. Cooking loss

Cooking loss ranged between 32% and 35% among the four meat types with the highest cooking loss (35%) reported for horse meat followed by bison meat (34.5%) while the lowest (32%) was reported for elk meat. Cooking loss was significantly higher for horse meat than elk while there was no significant difference in cooking loss between bison and beef and between beef and elk. The high cooking loss values across all four meats could be attributed to the size of the roasts which necessitated longer cooking times thus resulting in more moisture loss. Differences in cooking time has been shown to produce large difference in moisture loss (Bouton, Harris, & Shorthose, 1976).

4.3.3. Preferred attribute elicitation

The attributes generated by the 3 PAE groups after removing hedonic-related and imprecise terms are presented in Table 4.1. Participants in all 3 groups differed in their level of experience with meat and sensory evaluation, with participants in PAE 1 more experienced than the 2 other groups, however, participants in all 3 groups performed well in generating descriptors for the

samples. PAE 1 generated a total of 25 attributes while PAE 2 generated 22 attributes and PAE 3 generated 27. Across all the 3 PAE groups, 12 similar attributes were generated to describe the meats including descriptors relating to the intensity of color, aroma, flavor and aftertaste. Participants in PAE group 1 grouped bloody and metallic flavor similarly while those in PAE 3 considered the 2 attributes as different but considered iron, gamey and metallic flavor to be the same attribute. Panelists also described beefy flavor/aroma to be the same as meaty flavor/aroma. Musky aroma and grainy/coarse texture were common between PAE 2 and PAE 3 while Livery flavor and fibrous texture were used by PAE 1 and PAE 3 and umami and sweet flavor common between PAE 1 and PAE 2. Only PAE 3 used rotten, gamey and urine/ammonia terms to describe the meat samples while PAE 1 did not use the livery term.

Due to the long list of attributes and because panelists chose their own top 5 attributes from the list, data analysis for ranking for importance to liking was based on the frequency count of the participants that chose an attribute regardless of the rank. For instance, 5 out of 7 panelists in PAE 1 ranked meaty/beefy aroma as important for their liking, however, 3 out of the 5 panelists ranked this as second most important attribute while one person ranked this as first and the last panelists ranked it as third. Nonetheless, only attributes with high counts were considered important to liking. The top 3 attributes important for meat liking for PAE 1 were juiciness and beefy aroma followed by beefy flavor and tender texture; for PAE 2, they were tender texture followed by mild aroma and juiciness. Among PAE 3, juiciness was also ranked first followed by tenderness while mild and meaty/beefy flavor were ranked third. The choice of beefy aroma and flavor as important attributes of meat liking may be because all the meats were red meats which participants likened to beef. Although attributes driving disliking were not evaluated in the study, the implication of the preference for mild flavor and aroma is that consumers found meat with strong flavor and aroma unacceptable. Across the three PAE groups, color and appearance attributes were not considered as important. Color is an important attribute for purchase decisions of raw meat (Mancini & Hunt, 2005) but was not considered an important attribute to liking in this study because only cooked meat samples were evaluated.

Results of one-way ANOVA (not presented) of attributes intensity ratings for the three PAE groups showed that for PAE 1, 18 out of the 25 attributes were rated significantly different

among the meats while only 2 out of 22 were significantly different for PAE 2 and 12 of 27 attributes were significantly different for PAE 3. Hence, only the significant attributes from PAE 1 and PAE 3 were used for further statistical analyses while PAE 2 was excluded from further analysis. The ability of panelists in PAE 1 to differentiate among the samples may be due to their prior experience with sensory evaluation and meat quality while the results obtained from PAE 3 was due to the larger number of panelists.

Results of GPA on significant intensity ratings from PAE 1 and 3 are presented in Figure 4.1a and 1b. Dimensions 1 and 2 explained most of the variation; 83.53% and 77.48% for PAE 1 and PAE 3 respectively. Panelists in PAE 1 associated horse meat only to fibrous appearance while beef was associated with firm, fibrous and chewy texture, meaty/beefy flavor, and aroma. PAE 1 distinguished bison meat mainly based on aroma attributes with bison meat associated with intense metallic and livery aroma, intense aftertaste, and moist appearance. Conversely, elk meat was differentiated mainly based on flavor and aftertaste attributes and was associated with livery, fishy, bloody/metallic flavor, and livery and bloody aftertaste. On the contrary, PAE 3 differentiated elk meat mainly based on aroma attributes with elk meat associated with musky, rotten, urine/ammonia aroma while bison was differentiated mainly based on appearance and color attributes and was associated with intense, dark brown color and coarse appearance. While PAE 1 associated elk meat with juiciness alone, PAE 3 associated elk meat with both tenderness and juiciness; which was contrary to the general belief that game meats including elk are dry and tough owing to their low intramuscular fat content (Neethling et al., 2016). The significantly lower cooking loss reported for elk meat may have contributed to the perception of juiciness. Moreover, studies have shown a positive impact of freezing and thawing on meat tenderness due to loss of structural integrity as a result of ice crystal formation (Leygonie, Britz, & Hoffman, 2012) hence, the perception of tenderness may be because the elk meat used for this study was obtained frozen while the other meats were obtained in the fresh form. Positioning of the meats on the GPA map for PAE 3 (4.1b) showed that beef and horse meat were close together; which was similar to results by Rodbotten et al., (2004); an indication that panelists did not differentiate well between beef and horse meat or that they considered the two meat types to have close sensory attributes. However, PAE 1 easily differentiated between horse meat and beef although

both were on the same axis. Results of hedonic ratings of the PAE trials are considered a priming step by previous PAE authors to encourage participants to think about the samples and the attributes that drive their liking (McSweeney et al.,2016; Grygorczyk et al., 2013 and Muggah & McSweeney, 2017).

4.3.4. Check-all-that-apply and consumer testing

4.3.4.1. Liking scores and cluster analysis

Results of the hedonic ratings for the four meat samples are presented in 4.2. Generally, for all the meats, liking scores ranged between 5.2 and 6.4, between *neither like nor dislike* and *like slightly*. The relatively low level of liking may be due to the simplified cooking and presentation of the meats which differs from preparation of the meats in the home. There was no significant difference in aroma and texture liking among the four meats. In terms of appearance and overall liking, there was no significant difference among beef, horse, and bison meats; however, these three meats were liked significantly more than elk meat. Beef flavor was liked significantly more than horse and elk while there was no significant difference in flavor liking scores between beef and bison and among bison, horse and elk.

Figure 4.2 shows the preference map generated from the consumer clusters regressed onto the GPA map produced from PAE 1. Cluster 1, the largest segment (49%), consisted of consumers who liked beef and bison; cluster 2, the next largest segment (32%) consisted of those that liked beef followed by horse but disliked bison and elk. The smallest segment - cluster 3 (19%) consisted of consumers who liked horse followed by elk but disliked beef and bison. Although this segment is small, they may present a niche market for elk and horse meat. Observation of the cluster membership showed that participants in clusters 1 and 2 were equally distributed in terms of age and gender while over 60% of members of cluster 3 were males and 50% belong to the 25 to 35 years age group. While this may provide indications of the demographic characteristics of target consumers for horse and elk meat, care should be taken in generalizing this result considering the limited sample size and number of participants within this cluster.

4.3.4.2. Check-all-that-apply (CATA)

The frequency of significant terms (21 out of 43 at $p < 0.1$ and $p < 0.05$) used to describe the four meat samples is presented in 4.3; only these were shown in the correspondence analysis map. Six of these terms were based on appearance/color, while 4 were based on aroma, 3 based on flavor, 4 on texture and juiciness and 4 were based on aftertaste attributes. The significant difference associated with these attributes, particularly those relating to color/appearance and texture/juiciness, implied that consumers were able to detect differences among the meat samples based on these attributes. However, this may not influence acceptance, particularly since color/appearance attributes were not ranked as important to meat liking for the PAE groups, and consumer testing showed no significant difference in texture liking scores among the four meat samples.

Results of correspondence analysis showed that dimensions 1 and 2 explained 88.1% of the variation (Figure 4.3). This was higher than 83.5%, and 77.5% explained by the two dimensions of PAE 1 and 3 respectively; an indication that CATA was more effective in distinguishing among the meat samples. Nevertheless, considering that both PAE and CATA are consumer methods with dimensions which explained a high proportion of variability of the data shows the effectiveness of consumer methods for descriptive profiling of the sensory attributes of meat. The CATA group characterized beef, elk and bison similarly to the PAE 1 group, with beef characterized by meaty/beefy flavor and aroma and firm texture by both. In addition, the CATA group characterized beef by tough texture (which was on the opposite axis of tender), mild aftertaste and uneven color. Bison was positioned on the opposite axis of beef by the CATA group and was characterized by tender texture and reddish-brown color in addition to moist appearance which was synonymous between both PAE 1 and CATA. Horse meat was characterized by dark brown color and dryness (both in appearance and in the mouth). Finally, elk meat was characterized by even color, bloody, metallic, livery aroma, as well as livery flavor and aftertaste and rancid aftertaste. Association of elk meat with rancid aftertaste may be due to the high proportion of polyunsaturated fatty acids in game meats, including elk, which makes it susceptible to oxidation (Wood et al., 2004). The CATA group characterized elk meat based on aroma, flavor and aftertaste attributes rather than appearance and texture, an indication that elk

meat has unique aroma, flavor and aftertaste attributes that distinguished it from the 3 other meats particularly beef.

The high discriminative ability of CATA for elk meat due to its unique aroma, flavor and aftertaste attributes corroborates the suggestion of Ares et al., (2015) that CATA may not be a suitable method for characterization of similar products or for discrimination of small differences among samples but may rather be the ideal method for characterizing highly dissimilar products. This explanation may hold considering that elk meat was described by more terms than the other three meat types. The consistency of terms used to describe beef and elk across the PAE 1 and CATA groups have implication for the nature of foods suitable for characterization by the PAE method. Similar to CATA, PAE may be ideal for characterization of highly dissimilar products but offers the advantage of achieving this with fewer panelists, which is a limitation of the CATA method.

In terms of color intensity, some discrepancies existed among the two PAE groups and CATA, with PAE 1 associating elk with dark color, while PAE 3 associated intense, dark brown color with bison meat and CATA associated the same with horse meat. The discrepancy in color association among the three meats is due to their dark colors, which made it difficult for the consumer panel to agree on the meat with the most intense color. No previously reported study has compared the color intensity of these three meat types; nonetheless, the color of these meats has been investigated individually or in comparison with beef by different authors. Elk meat is darker than meat from domestic animal species owing to its high myoglobin content and negligible intramuscular fat content (Dhanda, Pegg, & Shand, 2003). Similarly, bison was darker than beef from Hereford and Brahman breeds of cattle (Koch et al., 1988) while horse meat had the third most intense color after beaver and hare (Rodbotten et al., 2004). Moreover, lack of panelists training makes it difficult for untrained panelists to agree on both definition of terms and intensity of the attributes (Ares, Cecilia, Rosires, Gimenéz, & Gámbaro, 2010; McSweeney et al., 2016). Except for the CATA group, which described the appearance and juiciness of horse meat, consumers were unable to characterize the flavor and aroma attributes of horse meat. This may be due to the low to intermediate levels of distinct flavor and aroma attributes when compared to elk and bison. For instance, in a study of fifteen species of animals, horse meat was

not listed among species with distinct metallic, gamey and liver flavor and aroma (Rodbotten et al., 2004) and Lorenzo et al., (2013) reported low intensity of rancid and abnormal flavor for male and female horse.

Penalty analysis (Figure 4.4) showed that 10 sensory descriptors had significantly high mean impact on overall liking. Tenderness had the largest positive impact on meat liking followed by meaty/beefy flavor and meaty/beefy aroma. This result was similar to the ranking results from the three PAE groups; an indication that PAE ranking for liking may provide a quick means of identifying attributes important for product liking and directions for product improvement which is the purpose of penalty analysis (Ares et al., 2014). Although juiciness in the mouth, which was among the attributes ranked for meat liking by the PAE group did not positively influence overall liking among the CATA group, penalty analysis showed that dryness (which is the opposite of juiciness) resulted in significantly high mean drop in overall liking. Although, ranking for top attributes influencing disliking was not investigated in the PAE study, since these attributes were not ranked as important to liking, they can be considered as contributing to disliking among the PAE groups. Future PAE studies should rank attributes important for both liking and disliking. The implication of the mean impact score is that drivers of disliking for elk meat were its livery flavor and aftertaste while dryness drove dislike for horse meat considering the higher frequency counts of the meats on these attributes.

4.3.5 Comparison of the three PAE groups and CATA based on Multiple Factor Analysis (MFA) and RV coefficients

The consensus MFA map with the superimposed partial points from the PAE and CATA groups is presented in Figure 4.5. The first and second dimensions of the MFA explained a total of 84.7% of the variation and positioning of the products on the map showed that the meat samples were well differentiated. The RV coefficients (0.856 ($p=0.33$) between PAE 1 and PAE 3; 0.843 ($p=0.28$) between PAE 1 and CATA; and 0.925 ($p=0.30$) between PAE 3 and CATA) showed similar but insignificant consensus matrix for all three sensory maps. This is indication that the three panels perceived the meats in the same way and produced similar sensory maps. The lack of significance may be due to differences in the number of attributes and the sample size among

the three test groups. A graphical presentation of the proximity among the partial points obtained from the three tests and between the partial points and consensus point is also shown in Figure 4.5. Results showed that for all four meats, CATA and PAE 3 were closer together for the evaluation of bison and elk while CATA and PAE 1 were closer together for the evaluation of horse and beef.

4.3.6 Methodological overview

The ability of PAE panelists to describe and discriminate among beef, horse, elk and bison and the similarity of the PAE results with CATA demonstrated the usefulness of PAE method as a rapid means of characterizing the sensory attributes of meats from different animal species and identifying drivers of liking. The advantages of PAE over CATA are the ability to achieve similar results to CATA with few panelists and the generation of sensory attributes by PAE panelists, unlike CATA where the attributes must be provided. This study modified the PAE method in terms of attributes generation and ranking for importance to liking, which will allow the use of sufficiently large number of panelists for PAE studies without concerns that results may be based on the opinion of few panelists with domineering personalities. Conducting a one-way ANOVA on the intensity data from PAE before GPA allowed the use of attributes that contributed significantly to differentiation among the meat samples, thus necessitating the exclusion of PAE 2 which consisted of inexperienced panelists. Hence, a larger panel size (above 10) may be ideal for a PAE study if completely naïve consumers are included, while fewer than ten panelists may be ideal when panelists have either sensory evaluation or product experience. The design of this study confirms the suitability of PAE for the evaluation of many sensory modalities (appearance, aroma, flavor, texture, juiciness and aftertaste) at once, although this necessitated splitting the sessions into two. Future studies on the evaluation of the application of PAE for meat sensory descriptive profiling should focus on evaluation of meats from the same animal species subjected to different treatments and compare results with that provided by trained assessors. A limitation of this study lies in the use of younger panelists (mostly 18-45 years) who may not provide the same description and appreciation of the meat samples as those older than this age range.

4.4. Conclusion

Two consumer descriptive profiling methods were used to characterize the sensory attributes of beef, horse, elk and bison and their impact on liking. Horse, bison and especially elk were described with unique sensory attributes which negatively impacted their acceptance. Cluster analysis identified a consumer group that showed acceptance for elk and horse meat which may represent a niche market for these meat types. This study demonstrated that the PAE method is an effective method for meat sensory descriptive profiling and a rapid means of identifying drivers of meat liking while achieving this with fewer panelists than CATA. However, care should be taken with the panel size and panelist level of experience as this study showed that experienced panellists or panel size of more than 10 contributed significantly to differentiation among the meat samples.

4.5. References

Adams, J., Williams, A., Lancaster, B., & Foley, M. (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. *7th Pangborn Sensory Science Symposium. Minneapolis, USA, 12-16 August, 2007.*

Alexi, N., Nanou, E., Lazo, O., Guerrero, L., Grigorakis, K., & Byrne, D. V. (2018). Check-all-that-apply (CATA) with semi-trained assessors: Sensory profiles closer to descriptive analysis or consumer elicited data? *Food Quality and Preference, 64*, 11-20. http://doi:10.1016/j.foodqual.2017.10.009ER.

AMSA. (2016). *Research guidelines for cookery, sensory evaluation and instrumental tenderness of meat* (2nd ed.). Champaign, IL: American Meat Science Association.

Ares, G., Antúnez, L., Bruzzone, F., Vidal, L., Giménez, A., Pineau, B., . . . Jaeger, S. R. (2015). Comparison of sensory product profiles generated by trained assessors and consumers using CATA questions: Four case studies with complex and/or similar samples. *Food Quality and Preference, 45,* 75-86. https://doi.org/10.1016/j.foodqual.2015.05.007.

Ares, G., Cecilia, B., Rosires, D., Gimenéz, A., & Gámbaro, A. (2010). Application of a check-all-that-apply question to the development of chocolate milk desserts. *Journal of Sensory Studies, 25,* 67-86. https://doi:10.1111/j.1745-459X.2010.00290.x.

Ares, G., Dauber, C., Fernández, E., Giménez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. *Food Quality and Preference, 32,* 65-76. https://doi.org/10.1016/j.foodqual.2013.05.014.

Ares, G., Tárrega, A., Izquierdo, L., & Jaeger, S. R. (2014). Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-that-apply (CATA) questions. *Food Quality and Preference, 31,* 135-141. https://doi.org/10.1016/j.foodqual.2013.08.012.

Boles, J. A., & Shand, P. J. (2008). Effect of muscle location, fiber direction, and slice thickness on the processing characteristics and tenderness of beef stir-fry strips from the round and chuck. *Meat Science, 78,* 369-374. https://doi://doi.org/10.1016/j.meatsci.2007.06.024.

Bouton, P. E., Harris, P. V., & Shorthose, W. R. (1976). Factors influencing cooking losses from meat. *Journal of Food Science, 41*, 1092-1095. https://doi:10.1111/j.1365-2621.1976.tb14394.x

Bureš, D., Bartoň, L., Kotrba, R., & Hakl, J. (2015). Quality attributes and composition of meat from red deer (cervus elaphus), fallow deer (dama dama) and aberdeen angus and holstein cattle (bos taurus). *Journal of the Science of Food and Agriculture, 95,* 2299-2306. https://doi:10.1002/jsfa.6950.

Dhanda, J. S., Pegg, R. B., & Shand, P. J. (2003). Tenderness and chemical composition of elk (*Cervus elaphus*) meat: Effects of muscle type, marinade composition, and cooking method. *Journal of Food Science, 68,* 1882-1888. https://doi:10.1111/j.1365-2621.2003.tb12347.x.

Dominique, V., Sylvie, C., Lelièvre Maud, & Abdi Hervé. (2012). Quick and dirty but still pretty good: A review of new descriptive methods in food science. *International Journal of Food Science & Technology, 47,* 1563-1578. https://doi:10.1111/j.1365-2621.2012.03022.x.

Franco, D., Rodriguez, E., Purrinos, L., Crecente, S., Bermudez, R., & Lorenzo, J. M. (2011). Meat quality of "Galician mountain" foals breed. effect of sex, slaughter age and livestock production system. *Meat Science, 88*, 292-298. http://doi:10.1016/j.meatsci.2011.01.004.

Grygorczyk, A., Lesschaeve, I., Corredig, M., & Duizer, L. (2013). Extraction of consumer texture preferences for yogurt: Comparison of the preferred attribute elicitation method to conventional profiling. *Food Quality and Preference, 27,* 215-222. https://doi.org/10.1016/j.foodqual.2012.02.017.

Koch, R. M., Crouse, J. D., & Seideman, S. C. (1988). Bison, Hereford and Brahman growth and carcass characteristics. *Beef Research Progress Report, Roman L. Hruska US Meat Animal Research Center.* 3, 26-28.

Leygonie, C., Britz, T. J., & Hoffman, L. C. (2012). Impact of freezing and thawing on the quality of meat: Review. *Meat Science, 91,* 93-98. https://doi.org/10.1016/j.meatsci.2012.01.013.

Lorenzo, J. M., Purrinos, L., & Carballo, J. (2016). A survey on the effect of livestock production system and finishing diet on sensory characteristics of foal meat using generalized proscrutes analysis. *The Scientific World Journal, Article ID 8729053,* http://dx.doi.org/10.1155/2016/8729053.

Lorenzo, J. M., Sarries, M. V., & Franco, D. (2013). Sex effect on meat quality and carcass traits of foals slaughtered at 15 months of age. *Animal, 7,* 1199-11207. http://doi:10.1017/S1751731113000189.

Mancini, R. A., & Hunt, M. C. (2005). Current research in meat color. *Meat Science, 71,* 100-121. http://doi:10.1016/j.meatsci.2005.03.003 ER.

McSweeney, M. B., Duizer, L. M., Seetharaman, K., & Dan Ramdath, D. (2016). Assessment of important sensory attributes of millet-based snacks and biscuits. *Journal of Food Science, 81,* S1209-S1209. http://doi: 10.1111/1750-3841.13281.

McSweeney, M. B., Sisopha, A., T'ien, C., Rector, M., & Duizer, L. M. (2017). Comparing preferred attribute elicitation to trained panelists' evaluations using a novel food product. *Journal of Sensory Studies, 32*. http://doi:10.1111/joss.12300 ER.

Moussaoui, K. A., & Varela, P. (2010). Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis. *Food Quality and Preference, 21,* 1088-1099. http://doi://doi.org/10.1016/j.foodqual.2010.09.005.

Muggah, E. M., & McSweeney, M. B. (2017). Using preferred attribute elicitation to determine how males and females evaluate beer. *Journal of Food Science, 82,* 1916-1923. http://doi:10.1111/1750-3841.13799 ER.

Neethling, J., Hoffman, L. C., & Muller, M. (2016). Factors influencing the flavor of game meat: A review. *Meat Science, 113,* 139-153. http://doi:10.1016/j.meatsci.2015.11.022 ER.

Oxana, L., Anna, C., & Luis, G. (2016). A comparison of two methods for generating descriptive attributes with trained assessors: check-all-that-apply (CATA) vs. free choice profiling (FCP). *Journal of Sensory Studies, 31*, 163-176. http://doi:10.1111/joss.12202.

Polawska, E., Cooper, R. G., Jozwik, A., & Pomianowski, J. (2013). Meat from alternative species - nutritive and dietetic value, and its benefit for human health - A review. *CyTA Journal of Food, 11,* 37-42.

Rodbotten, M., Ueland, O., Lea, P., & Kubberod, E. (2004). A sensory map of the meat universe. sensory profile of meat from 15 species. *Meat Science, 68,* 137-144. https://doi.org/10.1016/j.meatsci.2004.02.016.

Rule, D. C., Broughton, K. S., Shellito, S. M., & Maiorano, G. (2002). Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. *Journal of Animal Science, 80,* 1202-1211.

Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. *Food Research International, 48,* 893-903. http://doi://doi.org/10.1016/j.foodres.2012.06.037.

Wood, J. D., Richardson, R. I., Nute, G. R., Fisher, A. V., Campo, M. M., Kasapidou, E., . . . Enser, M. (2004). Effects of fatty acids on meat quality: A review. Meat Science, *66,* 21-32*,* http://doi://doi.org/10.1016/S0309-1740(03)00022-6.

Table 4.1.: Sensory attributes generated by the three PAE groups for the description of cooked beef, horse, elk and bison meats

	PAE 1 (n=7)	PAE 2 (n=7)	PAE 3 (n=11)
Appearance/Color	**Intense color**	**Intense color**	**Intense color**
	Brown color	**Brown color**	**Brown color**
	Reddish /pinkish color	**Reddish-brown color**	**Reddish/pinkish color**
	Fibrous appearance [a]	Distinct fiber [a]	
	Moist appearance [b]		Fatty/marbled appearance [b]
			Coarse appearance
			Shiny green appearance
		Even color	
Aroma	**Intense/strong aroma**	**Intense/strong aroma**	**Intense/strong aroma**
	Meaty/beefy aroma*	**Meaty/beefy aroma**	**Beefy aroma**
		Fatty aroma	
	Fishy/bloody/metallic aroma [a]	Raw/bloody aroma [a]	
	Livery aroma		
			Rotten aroma
			Urine/ammonia aroma
			Savory aroma
		Musky aroma [c]	Musky aroma [c]
Flavor	**Intense/strong flavor**	**Intense/strong flavor**	**Intense/strong flavor**
	Meaty/beefy flavor*	**Meaty/beefy flavor**	**Meaty flavor***
	Bloody/metallic flavor [b]		Iron/gamey/metallic flavor[b]
	Fishy flavor		
	Sweet [a]	Sweet [a]	
			Musky flavor
			Bloody flavor [b]
			Rotten flavor
		Raw flavor	
	Livery flavor [b]		Livery flavor [b]
	Umami flavor [a]	Umami flavor [a]	
		Earthy flavor	
Texture and juiciness	**Tender texture***	**Tender texture***	**Tender texture**
	Firm texture		Dense/thick texture
		Smooth texture	Coarse texture [c]
	Chewy	**Chewy/fibrous**	**Chewy**
	Fibrous texture		**Fibery/stringy texture**
	Juicy*	**Juicy***	**Juicy***
Aftertaste	**Intense/strong aftertaste**	**Intense/strong aftertaste**	**Intense/strong aftertaste**
		Rancid aftertaste	
	Livery aftertaste		
	Bloody aftertaste		
	Umami aftertaste		
			Gamey/metallic aftertaste

Attributes in bold were generated by all three PAE groups, attributes with superscript [a] were generated by PAE 1 and 2, attributes with superscript [b] were generated by PAE 1 and 3, attributes with superscript [c] were generated by PAE 2 and 3. *Attributes were ranked as important to liking

Table 4.2: Mean, Standard Error of Mean (SEM) and p-value for appearance, aroma, flavor, texture and overall liking scores for cooked beef, bison, horse and elk meats (N=63)

	Beef	Bison	Horse	Elk	SEM	p-value[3]
Appearance	5.8[ab]	6.4[a]	6.1[ab]	5.6[b]	0.196	**0.046**
Aroma	5.9[a]	5.9[a]	5.7[a]	5.2[a]	0.225	0.069
Flavor	6.4[a]	6.3[ab]	5.5[b]	5.5[b]	0.229	**0.005**
Texture	5.9[a]	6.4[a]	5.9[a]	5.7[a]	0.247	0.240
Overall	6.3[a]	6.5[a]	5.8[ab]	5.5[b]	0.220	**0.006**

Values in the same row with different letters are significantly different at $p < 0.05$, rated on 9-point hedonic scale (1 = dislike extremely, and 9 = like extremely), [3] Significant values highlighted in bold.

Table 4.3: Frequency count N (%) of significant CATA terms used to describe cooked beef, bison, horse and elk meats and results of Cochran's Q test for comparison among the samples.

	N (%)			
Attributes	Beef	Horse	Bison	Elk
Appearance/color				
Dark brown color**	**12 (18.2)**	**23 (34.8)**	**15 (22.7)**	**16 (24.2)**
Moist appearance*	14 (20.3)	12 (17.4)	30 (43.5)	13 (18.8)
Uneven color*	15 (39.5)	8 (21.1)	13 (34.2)	2 (5.3)
Reddish brown color*	3 (10.7)	6 (21.4)	13 (46.2)	6 (21.4)
Even color*	25 (20.0)	34 (27.2)	26 (20.8)	40 (32.0)
Dry appearance*	28 (28.3)	30 (30.3)	10 (10.1)	31 (31.3)
Aroma				
Meaty/beefy aroma*	43 (28.7)	35 (23.3)	44 (29.3)	28 (18.7)
Livery aroma*	10 (21.7)	10 (21.7)	7 (15.2)	19 (41.3)
Metallic aroma**	7 (36.8)	1 (5.3)	3 (15.8)	8 (42.1)
Bloody aroma**	7 (20.6)	5 (14.7)	8 (23.5)	14 (41.2)
Flavor				
Meaty/beefy flavor*	43 (27.0)	39 (24.4)	46 (28.8)	32 (20.0)
Livery flavor*	12 (21.4)	13 (23.2)	6 (10.7)	25 (44.6)
Metallic flavor*	6 (16.2)	6 (16.2)	10 (27.0)	15 (40.5)
Texture and juiciness				
Tough texture*	25 (38.5)	21 (32.3)	9 (13.8)	10 (15.4)
Tender texture*	10 (14.5)	15 (21.7)	24 (34.8)	20 (29.0)
Firm texture*	28 (36.0)	20 (25.6)	15 (19.2)	15 (19.2)
Dry*	27 (28.4)	29 (30.5)	12 (12.6)	27 (28.4)
Aftertaste				
Mild aftertaste*	45 (29.8)	39 (25.8)	37 (24.5)	30 (20.0)
Livery aftertaste*	13 (23.6)	10 (18.2)	7 (12.7)	25 (45.6)
Bloody aftertaste*	6 (12.5)	7 (14.6)	15 (31.3)	20 (41.7)
Rancid aftertaste**	1 (7.1)	6 (43.0)	3 (21.4)	4 (28.6)

Count taken from 63 consumers, attributes with * significantly different at $p < 0.05$, attributes with ** significantly different at $p < 0.1$.

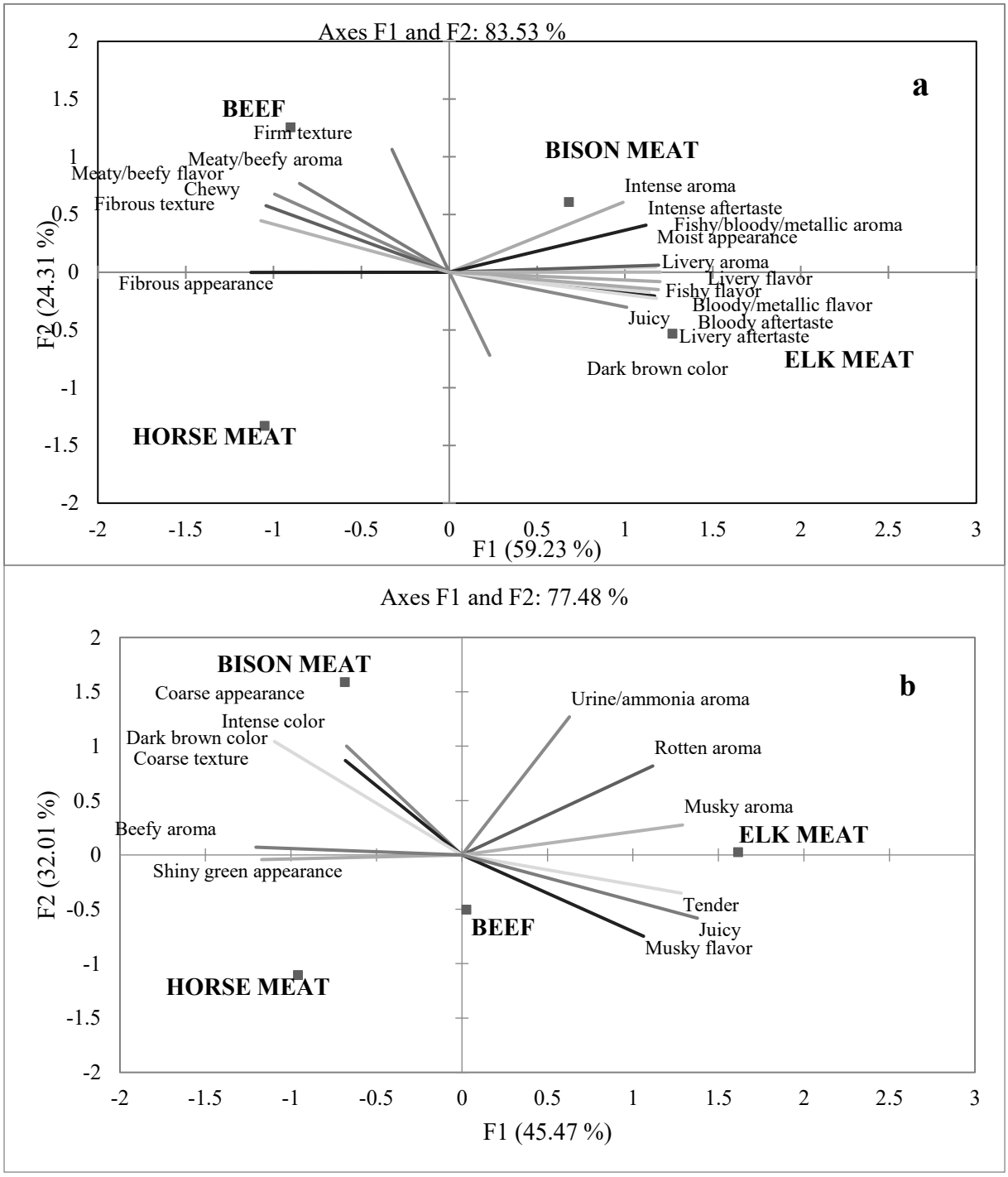


Fig. 4.1: Sensory attributes generated by panelists in (a) PAE 1 (n=7) and (b) PAE 3 (n=11) when evaluating cooked beef, bison, horse and elk meats. The descriptive data from the PAE session were combined and normalized using Generalized Procrustes Analysis

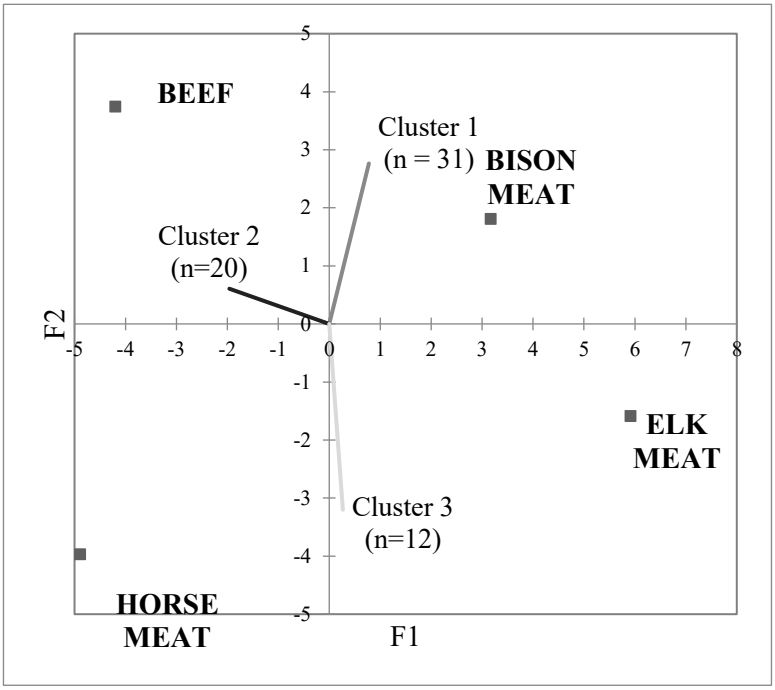


Fig. 4.2: Preference map based on overall liking generated from results of consumer test (n=63) and PAE 1 (n=7). Clusters represent direction of liking for each consumer cluster.

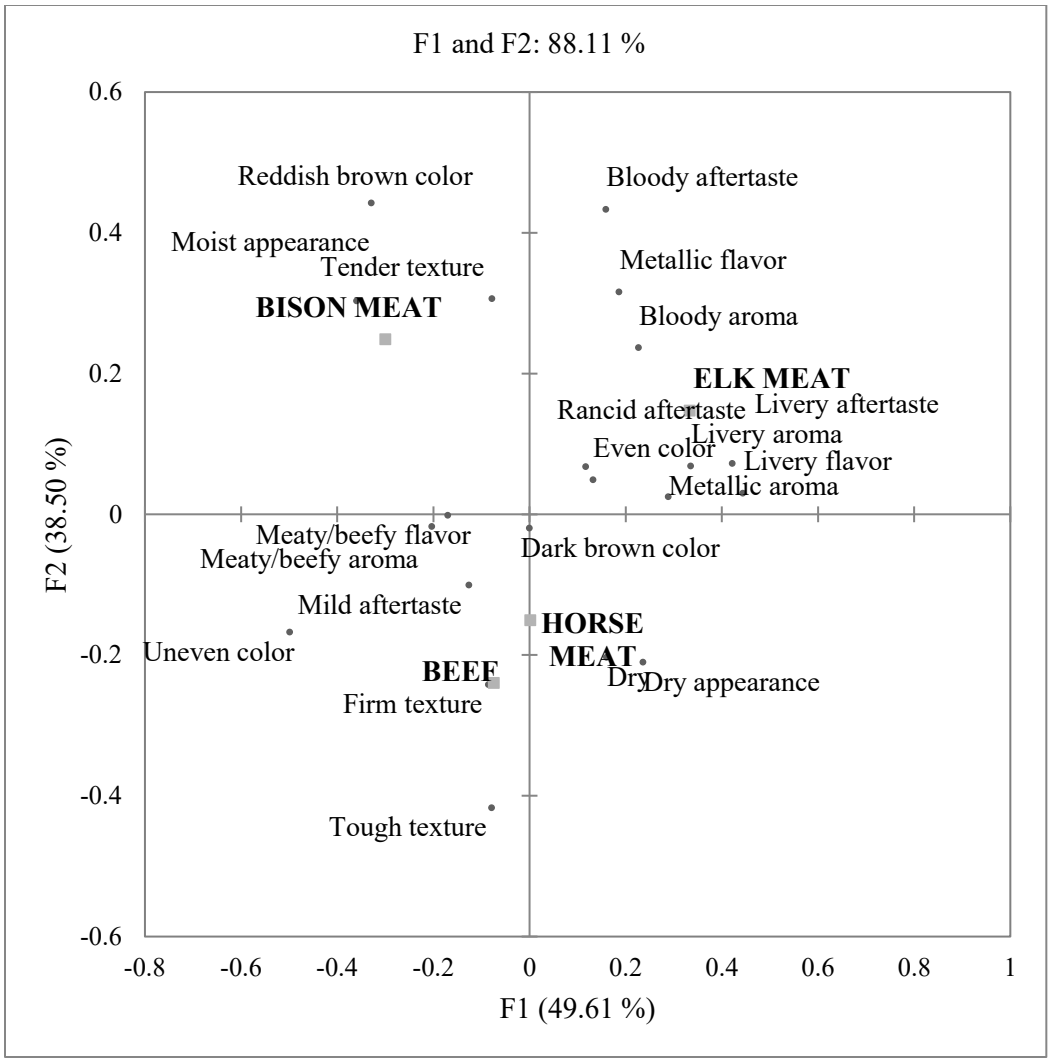


Fig. 4.3: Representation of cooked beef, horse, bison and elk meats in dimensions 1 and 2 of the correspondence analysis performed on the CATA count with insignificant factors removed

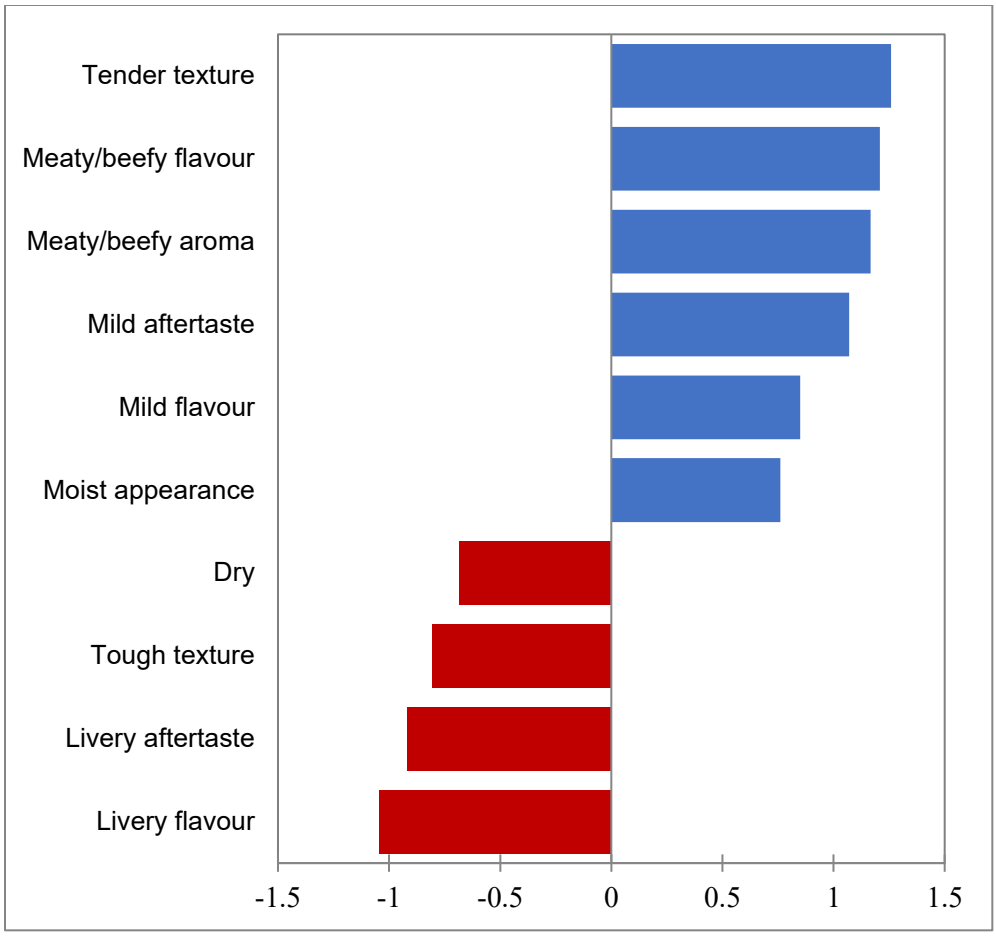


Fig. 4.4: Penalty analysis based on proportion of consumers that checked an attribute differently than for the ideal meat. Only attributes that resulted in significant increase or decrease in overall liking are presented.

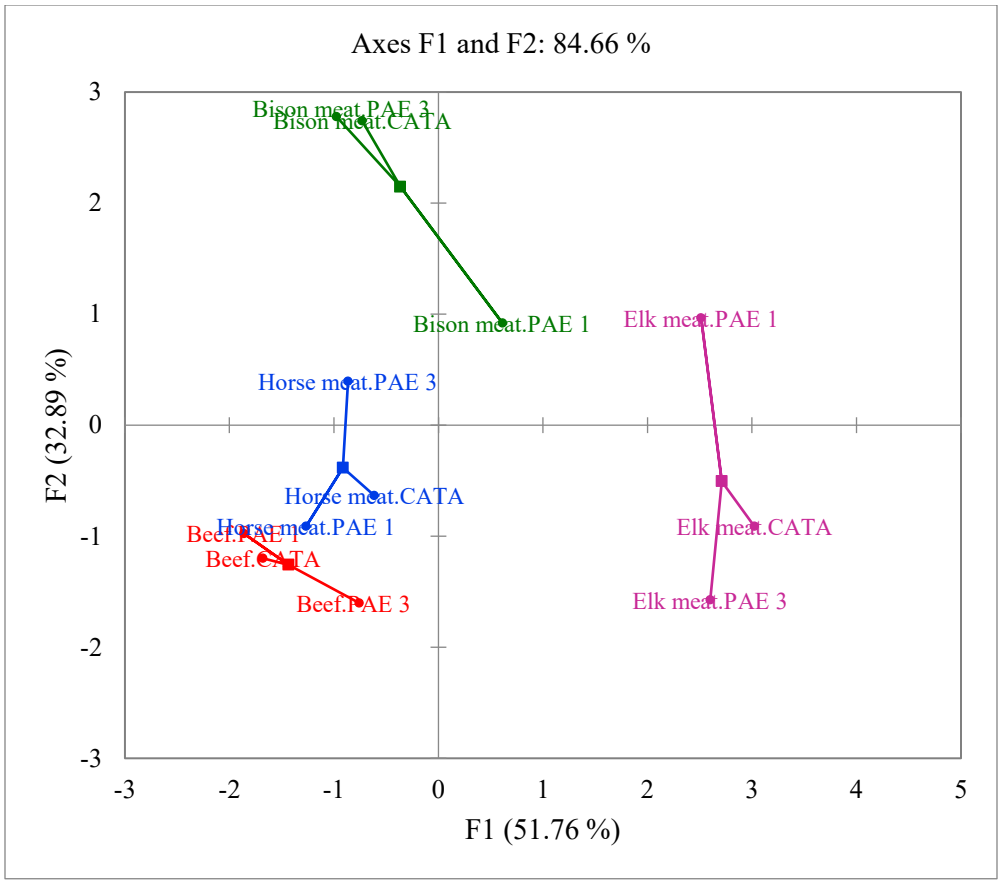


Fig. 4.5: Consensus MFA map with the partial points from PAE 1, PAE 3 and CATA (●) superimposed on the consensus MFA point (■).

Chapter 5. Consumer response to familiar and unfamiliar meats: the role of perception, variety seeking and food involvement

5.1. Introduction

Meat has been a central part of people's diet since pre-historic times and is highly rated among other foods due to its pleasurable consumption experience and high nutritional value (Aboah & Lees, 2020; Leroy & Praet, 2015; Ruby et al., 2016). However, in the last three decades, animal production and meat consumption has received negative publicity in most developed countries including Canada due to issues relating to environmental, animal welfare and food safety concerns (Belcher, Germann, & Schmutz, 2007; Hoffman & Wiklund, 2006; MacRae, O'Reilly, & Morgan, 2005). This has resulted in changing consumer behavior towards meat ranging from flexitarianism, to vegetarianism or veganism (Corallo, Latino, & Spennato, 2019; Verbeke & Vackier, 2004). These factors, together with the recommendations of World Health Organization (WHO) and World Cancer Research to limit intake of red meat due to its saturated fat content and association with negative health outcomes (Bo et al., 2013; Ranabhat, Park, & Kim, 2020; World Health Organization, 2004) has contributed to a decline in red meat consumption.

The changing meat consumption pattern may generate consumer interest in red meats from alternative animal species. These are meats derived from game or non-domesticated animals or animals considered unusual for the purpose of consumption (Maheswarappa & Kiran, 2014; Schupp, Gillespie, & Reed, 1998). Some of these alternative red meats contain lower fat and good proportion of polyunsaturated fatty acids (Polawska, Cooper, Jozwik, & Pomianowski, 2013). Examples of such alternative red meats produced in Canada are bison and horse meats. As of 2017, there were 975 bison farmers in Canada, 80% of which are in Western Canada raising almost 145,000 bison (Agriculture and Agri-Food Canada, 2019a; Canadian Bison Association, 2020). Also, Canada is the third largest exporter of horse meat after Belgium and Argentina (Belaunzaran et al., 2015; Canadian Meat Council, 2013). In addition to nutritional benefit and local availability, production of both bison and horse meat offer some environmental benefits as bison feed on indigenous grasses rather than grains, and horse being a non-ruminant

generates lower enteric methane than ruminants (Agriculture and Agri-Food Canada, 2019b; Belaunzaran et al., 2015).

Despite the benefits of these meats, familiarity and consumption is still low as they are confined to niche market. As of 2017, the per capita consumption of 'other meats' in Canada including wild game, horse and rabbit meats was 0.01% (FAOSTAT, 2020; Ritchie & Roser, 2019). Only 15% of horse meat produced in Canada is consumed in the country, mainly in the province of Quebec (Canadian Meat Council, 2013; Government of Alberta, 2017). Horse meat consumption is uncommon in other parts of Canada including the province of Alberta in Western Canada where 2 out of the 4 of the federally inspected horse meat slaughterhouses are located. Also, popularity and consumption of bison meat among consumers in Canada is low as it is only available in specialty meat stores. The extent to which the changing consumer behavior towards meat may provide opportunity for these meats is unknown. Very little is known about consumers responses to these meats and the contributing factors.

While low level of familiarity and limited accessibility to horse and bison meats are factors limiting consumption, consumer perception of these meats and other consumer-related factors are also contributing factors. Moreover, oftentimes, these meats are sold in frozen making it difficult for consumers to evaluate the appearance of the meats, which is an important factor in purchase decision. Research about consumer perception and response to bison and horse meat is limited among North American consumers. Majority of the previous studies were focused on identifying consumer market segment and not on understanding consumer response to these meats and the contributing factors (Sanderson, Hobbs, Shand, & Kerr, 2002; Torok, Bradley, Phillips, & Bernateau, 1996; Torok, Mittelstaedt, May, Tatsch, & Bradley, 1998). Moreover, these studies are dated and there is need for more current information, considering the changing trends in meat consumption. Hence, this study is aimed at determining consumer response to these unfamiliar red meats from alternative animal species relative to familiar alternative (beef).

Food choice is a complex interplay of sensory (appearance, taste, flavor, texture and aroma) and non-sensory factors including food related expectations and attitudes, nutritional quality, interest in health, ethical concerns, price, convenience, familiarity, social, economics, cultural and political factors (Johansen, Naes, & Hersleth, 2011; Narine & Badrie, 2007; Prescott, Young,

O'Neill, Yau, & Stevens, 2002). These factors have been broadly classified into product-related, consumer-related and environment-related factors (Jaeger, Bava, Worch, Dawson, & Marshall, 2011; Wadolowska, Babicz-Zielinska, & Czarnocinska, 2008). The consumer-related factors are rooted in consumers' preferences, personality traits, socio-demographic characteristics, psychological and physiological needs (Eertmans, Victoir, Vansant, & Van den Bergh, 2005) .

Consumers' tendency to avoid unfamiliar foods is attributed to distaste for the sensory attributes, fear of negative consequences that may arise from consumption, a sense of repulsion for the source of the food and consumers' mental classification of the appropriateness of the item as food (Derinalp Çanakçı & Birdir, 2020; Fallon & Rozin, 1983). Consumers oftentimes have associations or perception about a food which influences their decision to either accept or reject the food. Based on the expectancy-value theory of Ajzen & Fishbein (1980) the most salient associations or perception that consumers have about an object are the best predictors of their behavior (Roininen, Arvola, & Lähteenmäki, 2006). To assess consumer perception of an object and ascertain reasons behind their behavior, the Free Word Association (FWA) method is used (Rojas-Rivas, Espinoza-Ortega, Thome-Ortiz, & Moctezuma-Perez, 2019). This qualitative technique entails asking consumers to provide the first few images, associations thoughts or feelings that came to their minds when presented with a target stimuli (de Andrade, Sobral, Ares, & Deliza, 2016; Guerrero et al., 2010). Unlike close-ended questionnaires, face-to-face interviews and focus group discussions that are restrictive, the FWA method provides a more spontaneous response thereby allowing consumers to express themselves beyond the rational and providing unrestricted access to mental representation of an object in the mind of the consumer (Ares, Gimenez, & Gambaro, 2008; Gambaro, 2018; Rebollar, Lidon, Gil-Perez, & Martin, 2019). Although the FWA method has found application in the meat research domain (Ruby et al., 2016) it is yet to be applied for the understanding of consumer perception of unfamiliar meats. Moreover, it is widely believed consumers have both positive and negative perceptions of an object, with the most salient perception being the best predictor of behavior (Conner & Armitage, 2006; Holdershaw & Gendall, 2008; Roininen et al., 2006), this relationship is yet to be empirically investigated. Although Ruby et al. (2016) attempted to understand consumer attitude towards beef by classifying consumers responses into positive,

ambivalent, neutral and negative, the study did not quantitatively link these perceptions to the liking scores.

In addition to influence of consumer perception, food-related personality traits are important psychological variables that play a significant role in consumers behavior towards food (Mak, Lumbers, Eves, & Chang, 2012). Food-related personality traits that have an impact on consumer behavior towards unfamiliar food is food neophobia (reluctance to try or avoidance of new food and food) variety seeking (tendency to seek variety in food choice) (Pliner & Hobden, 1992; van Trijp & Steenkamp, 1992). Evaluation of the content validity of both scales by Lenglet (2018) showed that the variety seeking scale is more suitable for predicting willingness to try unfamiliar foods as the questionnaire items are more rooted in unfamiliarity. Despite the importance of these traits in determining consumers behavior towards unfamiliar foods, their impact on consumer response to unfamiliar meats from alternative animal species is yet to be investigated.

Another personality trait known to influence food choice is food involvement which is defined as the degree to which food plays an important role in a person's life, evidenced by the extent to which a person talks about, thinks about and is involved in food related activities (Bell & Marshall, 2003; Eertmans et al., 2005). Increasing consumer interest in environmental, animal welfare and healthy eating makes the role of food involvement on meat consumption worth investigating (Verbeke & Vackier, 2004). Few researchers have investigated the role of involvement in explaining consumer behavior towards meat (Borgogno, Favotto, Corazzin, Cardello, & Piasentier, 2015; Ripoll & Panea, 2019; Verbeke & Vackier, 2004). However, the studies were in the context of product involvement i.e. involvement with meat itself and not in the context of food involvement as a personality trait. So far, limited information exists about the impact of involvement as a personality trait on consumer response to unfamiliar meats like horse and bison.

The changing consumer behavior towards meat, particularly red meat, may provide opportunity for unfamiliar red meats from alternative animal species, but the extent is not known. Also, FWA, variety seeking and food involvement are yet to be applied to the understanding of consumer response to unfamiliar meats. Past studies using FWA did not quantitatively link consumers' most salient perception to their behavior towards the food. This information is

necessary for the identification of the strength of consumer perception on their behavior towards the food. The objective of this study was to investigate the influence of consumer perception and food-related personality traits of variety seeking and food involvement on their liking of familiar and willingness to try (WTT) unfamiliar meats.

5.2. Materials and methods

5.2.1. Online survey

An online survey was conducted between September 2019 and January 2020 using Compusense® Cloud (Guelph, ON, Canada) data collection tool. The survey was divided into 6 parts, (1) FWA (2) familiarity, WTT and liking (3) Variety seeking (4) Food involvement (5) Meat consumption pattern (6) socio-demographics. A schematic presentation of the survey is presented in Fig. 5.1. For the FWA, participants were presented with the names of the meats (beef, bison, horse meats and food products derived from insects) and were asked to write the first four words, images, associations, thoughts or feelings that came to their minds. The names of meats were presented one at a time and the order of presentation randomized across participants while questions about insect products were presented last and was excluded for use in a separate study. Next, participants answered questions about their level of familiarity with each of the meats on a 5-point Likert scale ranging from 1 = "very unfamiliar" to 5 = "very familiar". Participants who responded "very unfamiliar" or "unfamiliar" to the familiarity question were directed to the WTT question on a 5-point scale ranging from 1 = "very unlikely" to 5 = "very likely". Participants who responded, "somewhat familiar", "familiar" or "very familiar" were directed to the liking questions on a 5-point Likert scale, which ranged from 1 = "dislike very much" to 5 = "like very much". Participants then answered questions about their variety-seeking and level of food involvement on a 5-point scale (l = "completely agree" to 5 = "completely agree") using the 8-item variety seeking scale and 11-item food involvement scale developed by van Trijp & Steenkamp (1992) and Bell & Marshall (2003), respectively. Next, participants answered questions about their meat consumption preference (vegan, vegetarian, pescatarian or meat consumer) and their frequency of consuming specific types of meat including beef, poultry, lamb, horse, bison and other types of meats. Finally, participants

answered questions about their socio-demographic characteristics including age, gender, income, education, country of birth and how long they have lived in Canada (for non-Canadians).

5.2.2. Participants

A convenience sampling approach was used in this study (Lavrakas, 2020). Participants were recruited from the mailing list of the University of Alberta and by distributing handbills and fliers with the survey link around the University campus, grocery stores and specialty meat stores in Edmonton, Alberta Canada. The study protocol was approved by the University of Alberta Research Ethics Board (Pro00091071). The only criterion for participation was that participants should be above 18 years of age; the study was opened to all consumers regardless of their meat consumption preference. Participation was voluntary and anonymous and no compensation was given. To avoid bias, no indication of the meats to be evaluated was provided at the recruitment stage. One hundred and seventy-six participants started the survey but 31 dropped out after the completion of the FWA part and were excluded from this study, leaving a total of 145 completed surveys for analysis. This sample size is comparable to the size used by previous FWA authors. Ares et al. (2008) and Polizer Rocha, Lapa-Guimaraes, de Noronha, Regina Lucia F., & Trindade (2018) conducted FWA studies whereby consumers were clustered based on their responses to attitudinal questionnaire using 50 and 120 participants, respectively.

5.2.3. Statistical analysis

5.2.3.1. Variety seeking and food involvement

Participants' responses to the 8-item variety seeking and the 11-item food involvement questionnaires were summed up separately to determine the levels of variety-seeking and food involvement of the participants. The combined variety seeking and food involvement questionnaire items were subjected to agglomerative hierarchical cluster analysis based on Ward's method with Euclidean distance (Ares et al., 2008; Polizer Rocha et al., 2018) to identify homogeneous respondent groups. The variety seeking and food involvement scores across the clusters were compared using one-way Analysis of Variance (ANOVA) to establish the basis for cluster membership. Participants' responses across the clusters to each of the questionnaire items was also compared using one-way ANOVA while a chi-square test was used

to compare participants' meat consumption pattern and socio-demographic characteristics across the clusters.

5.2.3.2. Familiarity, liking and willingness to try

Familiarity scores for all three meats, WTT scores for horse and bison meats and liking scores for beef were subjected to one-way ANOVA with the meats being the independent variable. Impact of personality traits on liking for familiar meat were tested using a one-way ANOVA with liking dependent on cluster. Impact of personality trait on WTT unfamiliar meats was tested using non-parametric Kruskal-Wallis test at 0.05 significant level with WTT dependent on cluster.

5.2.3.3. Free word association

Initial sorting of the FWA data was conducted using the "one word" sorting option of the Compusense software, whereby words with similar meaning grouped into the same category. All the words, including the original associations generated by each participant, were downloaded into an Excel file, and manually assessed to determine the context of usage and then recategorized. A contingency table of the word categories used by each participant was created for each meat with the word categories in the columns and participants on rows. Categorization and naming of the categories was developed by the first author and finalized by consensus with two other authors. The categories for each meat type were compared and merged (Ares et al., 2008); only categories mentioned by at least 5% of the participants in total across all three meat types were retained for further analysis (Soares et al., 2017). A chi-square test was conducted to determine significant differences in consumer perception across meats while another chi-square test was used to compare perception of the meats across the clusters. The latter information was visually presented by correspondence analysis (Guerrero et al., 2010) and the analysis was based on categories mentioned for each meat with total citation above 5 across all the clusters in order to increase clarity of the correspondence plot (Nielsen, Bech-Larsen, & Grunert, 1998).

To quantitatively analyze the FWA data, the word categories were separated into positive, neutral and negative statements (Roininen, Arvola, & Lahteenmaki, 2006; Ruby et al., 2016). This classification was based on consumption related context only. For instance, association of

horse meat with pets was labelled negative because people do not consider a pet as food, while association of horse meat with delicacy was labelled positive. This classification was done by another co-author and finalized by consensus with two other authors. For each meat, the proportion of positive or negative associations were then determined by dividing the number of positive or negative word categories by the total number of word categories used by each participant. The proportion of positive associations for beef was categorized into 3 based on the 33^{rd} and 67^{th} percentile i.e. values between 0 and 0.33 were classified into low, 0.34 and 0.67 classified into intermediate, while values between 0.68 and 1 classified into high. Although this approach is novel in the FWA data analysis, classification of consumer groups into low, medium and high response group based on 33 and 67 percentiles has been applied in the literature (van Trijp, Lahteenmaki, & Tuorila, 1992). The combined influence of personality traits and positive association on liking for beef was tested using a two-way ANOVA with liking dependent on the proportion of positive association and cluster. The influence of negative associations and personality traits on WTT unfamiliar meats was tested by correlation and regression analyses. For the regression analysis, the clusters were dummy coded before inclusion in the model.

Analyses were carried out using SPSS version 23 except for the correspondence analysis which was conducted using XLSTAT® version 2020.1.3 software (Addinsoft, Boston, USA). Statistical significance for all the tests was determined at $p < 0.05$ and where necessary, multiple comparisons were done using Tukey posthoc test.

5.3. Results and discussion

5.3.1. Participants' socio-demographics and meat consumption pattern

Details of participants' socio-demographic characteristics and meat consumption is presented in Tables 5.1 and 5.2, respectively. Most participants were females with 60% of the participants born in Canada and 34% born outside Canada. Slightly over 50% of the participants have a graduate degree which is higher than the national average of 8% (Statistics Canada, 2017). The majority were meat consumers followed by flexitarians while only 2%, 5% and 9% were pescatarian, vegan and vegetarian, respectively. The percentage of vegans and vegetarians in this study is consistent with the results of a cross Canada survey where approximately 3-4% and 5-

7% Canadians identified as vegans and vegetarians, respectively (von Massow & Weersink, 2019). The most frequently consumed meat was poultry, followed by beef and pork, while only a small proportion of participants consumed lamb frequently (Table 5.2).

5.3.2. Familiarity, liking and willingness to try

Significant differences existed in the participants' level of familiarity with the meats with beef being the most familiar (mean ± SD = 4.66 ± 0.77) followed by bison meat (mean ± SD = 2.63 ± 1.29) while horse meat was the least familiar (mean ± SD = 1.74 ± 0.93). The limited consumption and availability of both horse and bison meats may have contributed to its significantly lower familiarity scores. Participants showed high liking for beef (mean ± SD = 4.27 ± 1.24) while WTT was low for both bison (mean ± SD = 2.63 ± 1.42) and horse meats (mean ± SD = 2.40 ± 1.30). The mean WTT score below 3 on a 5-point scale indicated low consumer interest in consuming these meats. This is similar to results obtained by Schupp et al. (2005) where only about 30 percent of the participants showed willingness to purchase meats that were considered exotic.

5.3.3. Identification of homogenous consumer clusters based on variety seeking and food involvement

Reliability of the variety seeking and food involvement scales as determined by Cronbach's Alpha showed good internal consistency (0.874 and 0.718 for variety seeking and food involvement scales, respectively). Across all participants, variety seeking scores ranged between 8 and 39 (mean ± SD = 28.14 ± 6.66) while the food involvement scores ranged between 28 and 55 (mean ± SD = 44.31 ± 6.24). The average variety seeking was close to 29 reported by Lahteenmaki & van Trijp (1995) and Marshall & Bell (2004) among Finnish consumers and consumers in the United Kingdom, respectively while the average food involvement score was similar to the more than moderately food involved score reported by Eertmans et al. (2005) among students in Belgium.

Four clusters were identified by agglomerative hierarchical cluster analysis. Details of the average variety seeking and food involvement scores for each cluster are presented in Table 5.3. The clusters were named using the median values of the variety seeking and food involvement

scores as cut off (Lahteenmaki & van Trijp, 1995). Clusters with average scores ≤ 29 and ≤ 46 for variety seeking and food involvement were classified as low variety seeking (LVS) and low food involvement (LFI), respectively, while clusters with average scores > 29 and > 46 were classified as high variety seeking (HVS) and high food involvement (HFI) clusters, respectively. Although clusters 1 and 4 both had average variety seeking score <29, their average variety seeking scores differed significantly, hence, cluster 1 was classified as medium variety seeking (MVS) cluster while cluster 4 was classified as LVS. The medium variety seeking, high food involvement cluster (MVS-HFI) was the largest cluster, which constituted 37.2% of the participants followed by the high variety seeking, high food involvement (HVS-HFI) cluster which constituted 31% of the participants. The high variety seeking, low food involvement (HVS-LFI) cluster and low variety seeking, low food involvement cluster (LVS-LFI) constituted 22.1% and 9.7% of the participants, respectively.

Average scores of the clusters on each item of the variety seeking and food involvement questionnaires are presented in Table 5.4. The two HVS clusters scored significantly higher than the other two clusters on all the variety seeking questionnaire items except for 'trying out new recipes when preparing foods or snacks', which was not significantly different from the MVS cluster. Regarding food involvement, all four clusters did not differ significantly on questions relating to food disposal i.e. cleaning up after eating (questions 6 and 11), an indication that these items are either not a measure of food involvement or these are activities carried out by participants regardless of their level of involvement with food. The HVS cluster scored significantly higher than the other two clusters on items relating to thinking about and cooking food (questions 1, 2 and 7). While this reflects involvement from the perspective of food preparation, however, the involvement scale does not reflect the perspective of consumers who manifest keen interest in food through other means without necessarily preparing food themselves. Sociodemographic characteristics and meat preference did not differ significantly among the clusters ($\chi 2 = 18.337$, $p = 0.245$).

5.3.4. Consumers perception of the meats

A total of 1195 valid words were obtained from the FWA, an approximation of 2.75 words per participant for each meat. The words were grouped into 50 categories (Table 5) out of which 17 were positive, 19 neutral and 14 negative. The large number of categories was due to the difference in consumer perception of each of the meats which made it impossible to merge some categories together. A similarly large category size (55 categories) was reported by Guerrero et al (2010).

Significant differences existed in associations across the meats ($\chi^2 = 1168.62$, $p < 0.0001$). The most frequently cited category was the "live animal" (i.e. cow, cattle, horse, bison, animal or livestock), 67% of which was for beef while 17% and 15% were for horse and bison meats, respectively. The next most cited category was the "yummy" category (delicious, tasty, yum). A larger proportion of this citation was for beef (50%) followed by bison meat (43.3%) while 6.7% was for horse meat. The next most frequently cited category was "cruelty" (death, killing, inhuman and pain) which was more cited for horse than beef. The "aversion" category (wouldn't, off-limits, shouldn't) was also more frequently cited for horse meat but beef had zero citations while "burger or barbecue" was more frequently cited for beef (63%) followed by bison (37%) while horse had zero citation in this category. The low/no citations for horse meat on the categories relating to consumption and high citations on the "aversion" and "cruelty" category suggest that consumers did not associate horse meat with food or consumption-related activities. However, the high association of beef with both consumption-related activities and the live animal show that participants were able to dissociate beef from its animal origin (Benningstad & Kunst, 2020) and had mental classification of the animal origin as suitable for consumption. Only beef was associated with environmental concerns (methane, carbon emission, unsustainable) while bison and horse had zero citations in this category. This is consistent with reports on consumer concerns about environmental impact of beef production which is reflected in their willingness to pay more for beef with positive environmental attributes (Belcher et al., 2007; Zanoli et al., 2013). On the contrary, bison had the highest citation for "sustainable" followed by horse meat while beef had only 1 citation in this category. This is an indication that

participants considered production of bison to be good for the environment despite the information on whether the bison is farmed raised or wild caught not being provided.

5.3.5. Influence of variety seeking and food involvement on consumer perception

Variety seeking and food involvement had significant impact on perception of both familiar and unfamiliar meats. Significant differences existed among the clusters in the "Western Canada" (χ^2 = 9.385, p = 0.022), "no clue" (χ^2 = 8.405, p = 0.038), "lean" (χ^2 = 20.114, p = 0.000) categories of bison meat and in the "delicacy" category of horse meat (χ^2 = 8.213, p = 0.047). For bison meat, the HVS-HFI cluster had the most frequent citation on "Western Canada" (57.1%) and "lean" (60%) categories while HVS-LFI cluster had the highest citation (41.2%) in "no clue" category (no idea, unknown and never tried it). The HVS-HFI cluster had the most frequent citations in the "delicacy" category for horse meat.

A graphical representation of consumer perception of each meat on cluster basis is shown in Fig 5.2. The first two dimensions explained 87.15%, 84.92% and 84.14% for beef, bison and horse meats, respectively. For beef, the two HVS clusters were positioned close to each other and on the same axis while the MVS and LVS clusters were positioned close to each other and were on the same axis. Participants in all clusters perceived beef both positively and negatively. This supports the notion of consumer ambivalence towards meat explained by the "meat paradox" whereby meat is associated with both sensory pleasure and moral, environmental or health concerns (Benningstad & Kunst, 2020; Buttlar & Walther, 2018; Ruby et al., 2016). Manifestation of this ambivalence differed across the clusters. The LVS-LFI cluster associated beef with both "dietary diseases" (cancer, diabetes, obesity) and "liking" (love, nice, like, excellent). These groups of consumers are similar to the "indifferent meat consumers" or "straight forward meat lovers" of Verbeke & Vackier (2004). Although a different classification scale was used by these authors, the indifferent meat consumers and straight forward meat lovers both had low involvement scores and were less concerned about the perceived risk or negative consequences of poor meat choice. Consumers in the HVS-HFI cluster associated beef with "cruelty", "livestock production", "environmental concerns", "tender and juicy", and "source of iron". This group of consumers consider beef consumption as pleasurable and a source of

essential mineral but this conflicts with their moral standard of environmental concern and animal welfare. The HVS-HFI consumer group may be target consumer for beef with animal welfare and environmentally friendly attributes. Although the use of specific scale to assess participants' level of environmental concern was not used in this study, however, this was reflected in participants' mental representation of beef and influenced by their food-related personality traits.

With respect to the 2 unfamiliar meats, the LVS-LFI cluster was located far from the other 3 clusters on the correspondence plots. This cluster associated bison meat with "aversion" and horse meat with both "lean" and "unappealing", indicating their awareness of the healthiness attribute of horse meat but find it unappealing to consume.

5.3.6 Quantitative evaluation of the combined influence of variety seeking, food involvement and consumer perception on liking and willingness to try

Variety seeking and food involvement did not significantly influence WTT unfamiliar meats but significantly influenced liking for beef with the HVS-HFI cluster scoring significantly lower (mean ± SD = 3.83 ± 1.52) than the LVS-LFI cluster (mean ± SD = 4.92 ± 1.52) while there were no significant differences in liking scores among other clusters. The lack of an impact of variety seeking and food involvement on WTT the unfamiliar meats is contrary to the expectation that some consumer group with high variety seeking tendencies and food involvement may be opened to trying novel or unfamiliar foods (Bell & Marshall, 2003; Pliner & Melo, 1997).The significantly high liking scores for beef among the LVS-LFI cluster shows that these group of consumers make choices based on well-established information and attitudes (Bell & Marshall, 2003) which enhances their interest in familiar, readily available foods such as beef. The association of beef with both "dietary diseases" and "liking" by this this group of consumers together with their significantly high liking score for beef shows the perception of negative health impact does not outweigh their liking for beef. This further reiterates their similarity with "indifferent meat consumers" or "straight forward meat lovers" of Verbeke & Vackier (2004). This consumer group may not be interested in searching for different meat alternatives or information related to meat quality, hence cannot be easily convinced with nutritional or other quality information (Verbeke & Vackier, 2004).

Individual cluster sizes and perceptions of consumers within each cluster is similar to the classification of Verbeke & Vackier (2004) who reported small cluster size of 15.7% and 16.2% for "indifferent meat consumers" and "straight forward meat lovers", respectively as against 36.1% cluster size for "cautious meat lovers" who consider the negative consequences of poor choice and 32% for "concerned meat consumers" who are concerned about both probability and consequences of risk. The lack of influence of variety seeking and food involvement on WTT unfamiliar meats, but significant influence on liking for familiar meat implies that these traits only manifested in low preference for familiar option and not in willingness to try unfamiliar option. Hence, as regards consumer response to meat, HVS-HFI consumers may desire a level of stimulation that can probably be achieved by alternating among familiar options which does not involve as much risk as alternating among unfamiliar options (Lähteenmäki & Arvola, 2001).

Consumer perception of beef had significant impact on its liking ($p = 0.000$) but the interactive effect of both perception and personality traits was not significant ($p = 0.109$). Beef liking was significantly higher when positive perception was more salient (mean ± SD = 4.81 ± 1.15) than when proportion of positive associations was low (mean ± SD = 3.78 ± 1.17). McCarthy, de Boer, O'Reilly, & Cotter (2003) also reported that desire to increase beef consumption was high among consumers with more positive attitude towards beef.

For the unfamiliar meats, negative perceptions had significant impact on WTT ($p = 0.013$ for bison meat and $p = 0.000$ for horse meat) while personality traits had no significant impact. Moreover, correlation analysis shows a moderately strong and significant correlation between proportion of negative perceptions and WTT for both bison ($r_s = -0.577$, $p = 0.002$) and horse meats ($r_s = -0.567$, $p = 0.000$). The significant effect of both positive perceptions on liking for familiar meats and negative perceptions on WTT unfamiliar meats supports the theory that consumers hold both positive and negative associations towards an object with the salient association being the best predictor of behavior (Conner & Armitage, 2006; Holdershaw & Gendall, 2008). The lack of interactive effect shows that the relationship between consumers perception and their attitude towards an object is not moderated (strengthened or weakened) by the personality traits of variety seeking and food involvement. Hence, regardless of the personality traits, positive perception will result in positive behavior towards an object.

The role of consumer perception, and personality traits of variety seeking and food involvement in explaining how consumers respond to familiar and unfamiliar meats were investigated. The limitation of this study lies in the small sample size and use of convenience sampling which limited both the heterogeneity and representativeness of the consumer clusters in terms of their socio-demographic characteristics, especially educational attainment. Perceptions and WTT unfamiliar meats may change for consumer clusters other than LVS-LFS (especially for consumers that do not have animal welfare concerns) when information about quality of the meats is provided, however, this was not investigated in this study. Future studies in this domain should investigate this. Also, it is not evident from this study if the consumer cluster that showed significantly lower liking for beef are seeking alternative among other familiar meats or among non-animal protein alternatives, this can be investigated by future studies. Moreover, aspects of food involvement other than food preparation could be included in future studies on food involvement.

5.4. Conclusion

This research has contributed to the body of knowledge about how consumers perceive meats, particularly unfamiliar meats, how this is influenced by food-related personality traits of variety seeking and food involvement. Moreover, this study contributed to the expansion of the scope of utilization of the FWA by quantitatively linking consumers' perception to liking and WTT. Clustering consumers into homogeneous group based on their variety seeking and food involvement influence consumer perception of meat and liking for familiar meats, hence should be a consideration in future studies relating to meats. Regardless of the personality trait, consumers response to the unfamiliar meats is mostly negative, hence there is need to develop and understand the impact of concerted efforts to communicate quality attributes of these meats to consumers on consumers interest.

5.5. References

Aboah, J., & Lees, N. (2020). Consumers use of quality cues for meat purchase: Research trends and future pathways. *Meat Science, 166*, 108142. doi:https://doi.org/10.1016/j.meatsci.2020.108142

Agriculture and Agri-Food Canada. (2019a). Canada's red meat and livestock industry at a glance. Retrieved from http://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/industry-profile/?id=1415860000002

Agriculture and Agri-Food Canada. (2019b). Canadian bison: The red meat with a difference. Retrieved from http://www.agr.gc.ca/eng/food-products/explore-canadian-food-products/canadian-bison/?id=1425927572578

Ajzen, I., & Fishbein, M. (1980). *Understanding attitude and predicting behaviour* Prentice-Hall. Inc, Engelwood Cliffs, New Jersey.

Ares, G., Gimenez, A., & Gambaro, A. (2008). Understanding consumers' perception of conventional and functional yogurts using word association and hard laddering. *Food Quality and Preference, 19*, 636-643. doi:10.1016/j.foodqual.2008.05.005 ER

Belaunzaran, X., Bessa, R. J. B., Lavín, P., Mantecón, A. R., Kramer, J. K. G., & Aldai, N. (2015). Horse meat for human consumption — current research and future opportunities. *Meat Science, 108*, 74-81. doi:https://doi.org/10.1016/j.meatsci.2015.05.006

Belcher, K., Germann, A., & Schmutz, J. (2007). Beef with environmental and quality attributes: Preferences of environmental group and general population consumers in Saskatchewan, Canada. *Agriculture and Human Values, 24*, 333-342. doi:10.1007/s10460-007-9069-x

Bell, R., & Marshall, D. W. (2003). The construct of food involvement in behavioral research: Scale development and validation. *Appetite, 40*, 235-244. doi:https://doi.org/10.1016/S0195-6663(03)00009-6

Benningstad, N. C. G., & Kunst, J. R. (2020). Dissociating meat from its animal origins: A systematic literature review. *Appetite, 147*, 104554. doi:https://doi.org/10.1016/j.appet.2019.104554

Bo, C. d., Simonetti, P., Gardana, C., Riso, P., Lucchini, G., & Ciappellano, S. (2013). Horse meat consumption affects iron status, lipid profile and fatty acid composition of red blood cells in healthy volunteers. *International Journal of Food Sciences and Nutrition, 64*, 147-154.

Borgogno, M., Favotto, S., Corazzin, M., Cardello, A. V., & Piasentier, E. (2015). The role of product familiarity and consumer involvement on liking and perceptions of fresh meat. *Food Quality and Preference, 44*, 139-147. doi:https://doi.org/10.1016/j.foodqual.2015.04.010

Buttlar, B., & Walther, E. (2018). Measuring the meat paradox: How ambivalence towards meat influences moral disengagement. *Appetite, 128*, 152-158. doi:https://doi.org/10.1016/j.appet.2018.06.011

Canadian Bison Association. (2020). Bison history. Retrieved from https://www.canadianbison.ca/producers/about-bison/bison-history

Canadian Meat Council. (2013). Horse meat production in Canada. Retrieved from https://www.cmc-cvc.com/sites/default/files/files/Horse%20Meat%20Production%20in%20Canada%20Feb%202013.pdf

Conner, M., & Armitage, C. J. (2006). Social psychological models of food choice. In R. Shepherd, & M. Raats (Eds.), *The psychology of food choice* (pp. 41-57). United Kingdom: Frontiers in Nutritional Science.

Corallo, A., Latino, M. E., & Spennato, A. (2019). A survey to discover current food choice behaviors. *Sustainability, 11*, 5041-5057.

de Andrade, J. C., Sobral, L. d. A., Ares, G., & Deliza, R. (2016). Understanding consumers' perception of lamb meat using free word association. *Meat Science, 117*, 68-74. doi:10.1016/j.meatsci.2016.02.039

Derinalp Çanakçı, S., & Birdir, K. (2020). The relation among food involvement, food variety seeking and food neophobia: A study on foreign tourists visiting turkey. *Current Issues in Tourism, 23*, 917-928. doi:10.1080/13683500.2019.1602114

Eertmans, A., Victoir, A., Vansant, G., & Van den Bergh, O. (2005). Food-related personality traits, food choice motives and food intake: Mediator and moderator relationships. *Food Quality and Preference, 16*, 714-726. doi:https://doi.org/10.1016/j.foodqual.2005.04.007

Fallon, A. E., & Rozin, P. (1983). The psychological bases of food rejections by humans. *Ecology of Food and Nutrition, 13*, 15-26. doi:10.1080/03670244.1983.9990728

FAOSTAT. (2020). New food balances. *Food and Agriculture Organization of the United Nations,* Retrieved from http://www.fao.org/faostat/en/#data/FBS

Gambaro, A. (2018). Projective techniques to study consumer perception of food. *Current Opinion in Food Science, 21*, 46-50. doi://doi.org/10.1016/j.cofs.2018.05.004

Government of Alberta. (2017). Alberta horse meat exports by destination. Retrieved from https://open-alberta-ca.login.ezproxy.library.ualberta.ca/dataset/b16b47e6-33aa-4f42-86c5-c2c8f86b0003/resource/65163962-a4ff-4635-b6a6-98b2b66fc408/download/tab-68.xlsx

Guerrero, L., Claret, A., Verbeke, W., Enderli, G., Zakowska-Biemans, S., Vanhonacker, F., . . . Hersleth, M. (2010). Perception of traditional food products in six European regions using free word association. *Food Quality and Preference, 21*, 225-233.

Hoffman, L. C., & Wiklund, E. (2006). Game and venison - meat for the modern consumer. *Meat Science, 74*, 197-208. doi://dx.doi.org/10.1016/j.meatsci.2006.04.005

Holdershaw, J., & Gendall, P. (2008). Understanding and predicting human behaviour. *Power and Place: Refereed Proceedings of the Australian and New Zealand Communication Association Conference, Wellington, New Zealand, July 9-11, 2008*

Jaeger, S. R., Bava, C. M., Worch, T., Dawson, J., & Marshall, D. W. (2011). The food choice kaleidoscope. A framework for structured description of product, place and person as sources of variation in food choices. *Appetite, 56*, 412-423.

Johansen, S. B., Naes, T., & Hersleth, M. (2011). Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. *Appetite, 56*, 15-24.

Lahteenmaki, L., & van Trijp, H. (1995). Hedonic responses, variety-seeking tendency and expressed variety in sandwich choices. *Appetite, 24*, 139-151. doi:10.1016/S0195-6663(95)99358-4

Lähteenmäki, L., & Arvola, A. (2001). Food neophobia and variety seeking —consumer fear or demand for new food products. In L. J. Frewer, E. Risvik & H. Schifferstein (Eds.), *Food, people and society: A European perspective of consumers' food choices* (pp. 161-175). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-662-04601-2_11

Lavrakas, P. (2020). *Encyclopedia of survey research methods*. Thousand Oaks, California: doi:10.4135/9781412963947

Lenglet, F. (2018). FNS or the varseek-scale? proposals for a valid operationalization of neophilia. *Food Quality and Preference, 66*, 76-84. doi:https://doi.org/10.1016/j.foodqual.2018.01.007

Leroy, F., & Praet, I. (2015). Meat traditions. the co-evolution of humans and meat. *Appetite, 90*, 200-211. doi:S0195-6663(15)00116-6 [pii]

MacRae, J., O'Reilly, L., & Morgan, P. (2005). Desirable characteristics of animal products from a human health perspective. *Livestock Production Science, 94*, 95-103. doi:https://doi.org/10.1016/j.livprodsci.2004.11.030

Maheswarappa, N. B., & Kiran, M. (2014). Emu meat: New source of healthier meat towards niche market. *Food Reviews International, 30*, 22-35. doi:10.1080/87559129.2013.853773

Mak, A. H. N., Lumbers, M., Eves, A., & Chang, R. C. Y. (2012). Factors influencing tourist food consumption. *International Journal of Hospitality Management, 31*, 928-936. doi:https://doi.org/10.1016/j.ijhm.2011.10.012

Marshall, D., & Bell, R. (2004). Relating the food involvement scale to demographic variables, food choice and other constructs. *Food Quality and Preference, 15*, 871-879. doi:10.1016/j.foodqual.2004.06.003

McCarthy, M., de Boer, M., O'Reilly, S., & Cotter, L. (2003). Factors influencing intention to purchase beef in the Irish market. *Meat Science, 65*, 1071-1083. doi:https://doi.org/10.1016/S0309-1740(02)00325-X

Narine, T., & Badrie, N. (2007). Influential factors affecting food choices of consumers when eating outside the household in Trinidad, West Indies. *Journal of Food Products Marketing, 13*, 19-29. doi:10.1300/J038v13n01_02

Nielsen, N. A., Bech-Larsen, T., & Grunert, K. G. (1998). Consumer purchase motives and product perceptions: A laddering study on vegetable oil in three countries. *Food Quality and Preference, 9*, 455-466. doi:https://doi.org/10.1016/S0950-3293(98)00022-6

Pliner, P., & Melo, N. (1997). Food neophobia in humans: Effects of manipulated arousal and individual differences in sensation seeking. *Physiology & Behavior, 61*, 331-335. doi:10.1016/S0031-9384(96)00406-4 ER

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120. doi:https://doi.org/10.1016/0195-6663(92)90014-W

Polawska, E., Cooper, R. G., Jozwik, A., & Pomianowski, J. (2013). Meat from alternative species - nutritive and dietetic value, and its benefit for human health - a review. *CyTA -- Journal of Food, 11*, 37-42.

Polizer Rocha, Y. J., Lapa-Guimaraes, J., de Noronha, Regina Lucia F., & Trindade, M. A. (2018). Evaluation of consumers' perception regarding frankfurter sausages with different healthiness attributes. *Journal of Sensory Studies, 33*, e12468. doi:10.1111/joss.12468

Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference, 13*, 489-495.

Ranabhat, L. C., Park, M., & Kim, C. (2020). Influence of alcohol and red meat consumption on life expectancy: Results of 164 countries from 1992 to 2013. *Nutrients, 12* doi:10.3390/nu12020459

Rebollar, R., Lidon, I., Gil-Perez, I., & Martin, J. (2019). How should I tell you this? the effects of the image used to convey that a natural yogurt is sweetened on consumer expectations and willingness to buy. *Food Research International, 126* doi:10.1016/j.foodres.2019.108721 ER

Ripoll, G., & Panea, B. (2019). The effect of consumer involvement in light lamb meat on behavior, sensory perception, and health-related concerns. *Nutrients, 11*, 1200. doi: 10.3390/nu11061200. doi:10.3390/nu11061200 [doi]

Ritchie, H., & Roser, M. (2019). Meat and dairy production. Retrieved from https://ourworldindata.org/meat-production

Roininen, K., Arvola, A., & Lahteenmaki, L. (2006). Exploring consumers' perceptions different qualitative of local food with two techniques: Laddering and word association. *Food Quality and Preference, 17*, 20-30. doi:10.1016/j.foodqual.2005.04.012

Roininen, K., Arvola, A., & Lähteenmäki, L. (2006). Exploring consumers' perceptions of local food with two different qualitative techniques: Laddering and word association. *Food Quality and Preference, 17*, 20-30. doi:https://doi.org/10.1016/j.foodqual.2005.04.012

Rojas-Rivas, E., Espinoza-Ortega, A., Thome-Ortiz, H., & Moctezuma-Perez, S. (2019). Consumers' perception of amaranth in Mexico. *British Food Journal, 121*, 1190-1202. doi:10.1108/BFJ-05-2018-0334 ER

Ruby, M. B., Alvarenga, M. S., Rozin, P., Kirby, T. A., Richer, E., & Rutsztein, G. (2016). Attitudes toward beef and vegetarians in Argentina, Brazil, France, and the USA. *Appetite, 96*, 546-554. doi:https://doi.org/10.1016/j.appet.2015.10.018

Sanderson, K., Hobbs, J. E., Shand, P., & Kerr, W. A. (2002). Consumer preferences in the emerging bison industry: Marketing implications. *Journal of International Food & Agribusiness Marketing, 14*, 57-78. doi:10.1300/J047v14n03_05 ER

Schupp, A., Gillespie, J., O'Neil, C. E., Witoon Prinyawiwatkul, & Makienko, I. (2005). The impact of an "exotic" label on consumer willingness to taste test, purchase, and price a new meat product. *Journal of Food Distribution Research, 36*, 50-60.

Schupp, A., Gillespie, J., & Reed, D. (1998). Consumer choice among alternative red meats. *Journal of Food Distribution Research, 29*, 35-43.

Soares, E. K. B., Esmerino, E. A., Ferreira, M. V. S., da Silva, Maria Aparecida A. P., Freitas, M. Q., & Cruz, A. G. (2017). What are the cultural effects on consumers' perceptions? A case study covering coalho cheese in the Brazilian Northeast and Southeast area using word association. *Food Research International, 102*, 553-558.

Statistics Canada. (2017). Canada at a glance 2017: Education. Retrieved from https://www150.statcan.gc.ca/n1/pub/12-581-x/2017000/edu-eng.htm

Torok, S. J., Bradley, E., Phillips, C., & Bernateau, G. (1996). International market segmentation analysis of a new meat product. *Agribusiness, 12*, 443-459.

Torok, S. J., Mittelstaedt, J., May, G. J., Tatsch, K., & Bradley, E. (1998). Identification of bison consumer characteristic dimensions and restaurant marketing strategies. *Agribusiness : An International Journal, 14*, 33-48.

van Trijp, H. C. M., Lahteenmaki, L., & Tuorila, H. (1992). Variety seeking in the consumption of spread and cheese. *Appetite, 18*, 155-164. doi:10.1016/0195-6663(92)90192-9

van Trijp, H. C. M., & Steenkamp, J. E. M. (1992). Consumers' variety seeking tendency with respect to foods: Measurement and managerial implications, *European Review of Agricultural Economics, 19*, 181-195.

Verbeke, W., & Vackier, I. (2004). Profile and effects of consumer involvement in fresh meat. *Meat Science, 67*, 159-168. doi:https://doi.org/10.1016/j.meatsci.2003.09.017

von Massow, M., & Weersink, A. (2019). Meat consumption is changing but it's not because of vegans. Retrieved from https://news.uoguelph.ca/2019/03/meat-consumption-is-changing-but-its-not-because-of-vegans/

Wadolowska, L., Babicz-Zielinska, E., & Czarnocinska, J. (2008). Food choice models and their relation with food preferences and eating frequency in the Polish population: POFPRES study. *Food Policy, 33*, 122-134. doi:10.1016/j.foodpol.2007.08.001 ER

World Health Organization. (2004). *Global strategy on diet, physical activity and health*. Geneva, Switzerland. Retrieved from https://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf?ua=1

Zanoli, R., Scarpa, R., Napolitano, F., Piasentier, E., Naspetti, S., & Bruschi, V. (2013). Organic label as an identifier of environmentally related quality: A consumer choice experiment on beef in Italy. *Renewable Agriculture and Food Systems, 28*, 70-79. doi:10.1017/S1742170512000026

Table 5.1: Participants' socio-demographic characteristics

Characteristics		Frequency	Percent
Age	18-29years	57	39.3
(n = 145)	30-39years	59	40.7
	40-49years	16	11.0
	50-59years	8	5.5
	60-69years	5	3.4
Gender	Male	42	30.4
(n = 138)	Female	95	68.8
	Others	1	0.7
Education	High School/trade certificate/technical school	4	2.8
(n = 138)	Some College/ university undergraduate degree	63	45.7
	University graduate degree (e.g. Masters, PhD, MD)	71	51.4
Employment	Employed - full-time (30 hours or more per week)	63	45.7
(n = 138)	Employed - part-time (less than 30 hours per week)	15	10.9
	Student	42	30.4
	Parent/ homemaker/retired/not currently employed/self-employed	18	13.1
Household income	Less than $40,000	42	30.4
(n = 138)	$40,000 to $79,999	38	27.5
	$80,000 to $124,999	28	20.3
	$125,000 to $164,999	18	13.0
	more than $165,000	12	8.7
Country of birth	Canada	83	60.1
(n = 138)	Others	47	34.1
	Prefer not to answer	8	5.8
Number of years in Canada	1 -10 years	40	85.1
(n = 47)	> 10 years	7	14.9

Table 5.2: Participants' meat consumption behavior

	Meat preference	Frequency	Percent
	Vegan	7	5.1
	Vegetarian	12	8.7
	Pescatarian	3	2.2
	Flexitarian	25	18.1
	Meat Consumers	88	63.8
	Others	3	2.2
Consumption of specific kinds of meat			
Beef/veal	Frequently (daily/at least 2-3 times a week)	54	39.2
	Monthly/multiple times a month	42	30.4
	Less often/special occasions	19	13.8
	Never	23	16.7
Poultry	Frequently (daily/at least 2-3 times a week)	75	54.3
	Monthly/multiple times a month	39	28.2
	Less often/special occasions	7	5
	Never	17	12.3
Pork	Frequently (daily/ at least 2-3 times a week)	21	15.2
	Monthly/multiple times a month	55	39.9
	Less often/special occasions	30	4.3
	Never	32	23.2
Lamb	Frequently (daily/ at least 2-3 times a week)	4	2.9
	Monthly/multiple times a month	10	7.3
	Less often /special occasions	68	49.3
	Never	56	40.6
Bison, elk, venison, horse	Frequently (daily/ at least 2-3 times a week)	5	3.6
	Monthly/multiple times a month	5	3.6
	Less often /special occasions	53	38.4
	Never	75	54.3
Fish	Frequently (daily/ at least 2-3 times a week)	19	13.7
	Monthly/multiple times a month	72	52.1
	Less often/special occasions	26	18.9
	Never	21	15.2

Table 5.3: Mean variety seeking and food involvement scores for the four identified clusters

Cluster name	Cluster size	Variety seeking Mean (SD)	Food involvement Mean (SD)
MVS-HF1 (Medium Variety Seeking, High Food Involvement)	54	24.39[a] (6.61)	46.13[a] (6.80)
HVS-LFI (High Variety Seeking, Low Food Involvement)	32	32.31[b] (8.58)	38.22[b] (8.83)
HVS-HFI High (Variety Seeking, High Food Involvement)	45	33.11[b] (7.24)	48.93[a] (7.45)
LVS-LFI (Low Variety Seeking, Low Food Involvement)	14	17.07[c] (12.97)	36.36[b] (13.35)

Values with different superscripts within a column indicate mean scores for the clusters differ significantly according to Tukey's test ($p<0.05$). Values were based on the sum of responses to the 8-item variety seeking scale (maximum score = 40) and 11-item food involvement scale (maximum score = 55) with higher scores indicating greater extent of variety seeking and food involvement.

Table 5.4: Mean scores and standard deviation for individual items of the variety seeking and food involvement questionnaires for each of the identified clusters.

	Mean (SD)			
	MVS-HFI (N=54)	HVS-LFI (N=32)	HVS-HFI (N=45)	LVS-LFI (N=14)
Variety seeking items				
1. When I eat out, I like to try the most unusual items, even if I am not sure I would like them	1.81[a] (0.80)	3.91[b] (1.00)	3.84[b] (0.74)	1.29[a] (0.61)
2. When preparing foods or snacks, I like to try out new recipes	4.13[a,b] (0.83)	3.63[b] (1.04)	4.36[a] (0.74)	2.29[c] (1.14)
3. I think it is fun to try out food items no one is familiar with	2.83[a] (1.23)	4.31[b] (0.59)	4.18[b] (0.72)	2.14[c] (1.23)
4. I am eager to know what kind of foods people from other countries eat	3.76[a] (1.13)	4.69[b] (0.47)	4.78[b] (0.42)	2.43[c] (1.28)
5. I like to eat exotic foods	3.06[a] (1.17)	4.31[b] (0.86)	4.40[b] (0.58)	3.00[a] (1.41)
6. Items on the menu I am not familiar with make me curious	3.30[a] (1.06)	4.28[b] (0.63)	4.27[b] (0.75)	2.07[c] (1.00)
7. I prefer to eat food products I am used to (R)	1.91[a] (0.78)	2.94[b] (0.98)	2.89[b] (0.94)	1.50[a] (0.86)
8. I am curious about food products I am not familiar with	3.59[a] (0.79)	4.25[b] (0.67)	4.40[b] (0.54)	2.36[c] (1.45)
Food Involvement items				
1. I don't think much about food each day (R)	4.31[a] (0.77)	3.31[b] (1.26)	4.51[a] (0.59)	3.57[b] (1.56)
2. Cooking or barbequing is not much fun (R)	4.28[a] (0.81)	2.84[b] (1.25)	4.58[a] (0.75)	3.36[b] (1.50)
3. Talking about what I ate or am going to eat is something I like to do	3.63[a,b] (1.22)	2.88[b] (1.24)	4.13[a] (0.97)	3.29[b] (1.27)
4. Compared with other daily decisions, my food choices are not very important (R)	4.02[a,b] (0.96)	3.28[b] (1.14)	4.24[a] (1.05)	3.29[b] (1.27)
5. When I travel, one of the things I anticipate most is eating the food there	4.19[a] (0.70)	4.22[a] (1.01)	4.44[a] (1.01)	2.07[b] (1.27)
6. I do most or all of the cleaning after eating	4.09[a,b] (1.01)	3.50[a,b](1.30)	3.80[a,b] (1.08)	3.29[b] (1.33)
7. I enjoy cooking for others and myself	4.15[a] (0.90)	2.94[b] (1.37)	4.56[a] (0.69)	3.21[b] (1.42)
8. When I eat out, I don't think or talk much about how the food taste (R)	4.02[a] (1.00)	3.75[a] (1.05)	4.76[b] (0.44)	3.43[a] (1.40)
9. I do not like to mix or chop food (R)	4.17[a,c,d] (0.89)	3.56[b,c] (1.13)	4.69[a] (0.60)	3.29[b,d] (1.49)
10. I do most or all of my own food shopping	4.52[a] (0.89)	3.72[b] (1.30)	4.49[a] (0.92)	3.21[b] (1.37)
11. I do not wash dishes or clean the table (R)	4.76[a] (0.70)	4.22[a] (1.21)	4.73[a] (0.54)	4.36[a] (1.15)

(R) indicates reversed scale. Values with different superscript within the same row indicate mean scores for the clusters differ significantly according to Tukey's test ($p<0.05$)

Table 5.5: Word categories and examples of words used, classification into positive, neutral and negative, and citation frequency in individual categories for beef, bison and horse meats

Word categories	Examples of words	Classification	Beef	Bison	Horse	Total
Source of iron	iron	Positive	7	0	0	7
Beefy	beefy flavor, beef-like (bison)	Positive	2	5	0	7
Minced	minced, ground	Positive	4	2	1	7
Delicacy	beshbarmak, delicacy, kazy, lasagna	Positive	0	1	6	7
Natural	No anti-biotics, natural	Positive	0	6	1	7
Sustainable	sustainable	Positive	3	5	1	9
Liking	nice, love, like, good, better, excellent	Positive	11	4	0	15
Interest	probably, interested, interesting, try, tried, sure, maybe, would consider	Positive	0	5	10	15
Cooking methods	cook, cooked, cooking, fried, grilled, recipes, smoked, stew, soup, curry	Positive	15	0	1	16
Nutritious or healthy	nutrients, nutritious, vitamins, minerals	Positive	7	10	1	18
Source of protein	protein	Positive	17	1	2	20
Tender or juicy	juicy, tender, soft	Positive	17	5	0	22
Meat cuts	steak, roast, chops, rib, ribs	Positive	35	4	0	39
Lean	lean, leaner, less fat, lower in fat	Positive	1	35	10	46
Food	food, meal, meat	Positive	30	14	5	49
Burgers or barbecue	barbecue, burger, sausage, jerky	Positive	33	20	0	53
Yummy	delicious, tasty, yummy, yum	Positive	30	26	4	60
Tourism	tourism, elk island park	Neutral	0	8	0	8
Asia & Quebec	China, Asian, Japan, Mongolia, Quebec	Neutral	0	0	9	9
Buffalo	buffalo	Neutral	0	9	0	9
pet food	dog food, pet food, dogs	Neutral	0	0	10	10
Gelatin	glue, gelatin	Neutral	0	0	12	12
Gamey flavor	gamey flavor	Neutral	0	11	2	13
Entertainment	cowboy hats, rodeo, horseback, sport, entertainment, equestrian, riding, cowboy	Neutral	2	1	14	17
No clue	no idea, unknown, nothing, don’t know, never tried	Neutral	0	17	0	17
Red	red, reddish	Neutral	13	3	2	18
Physical features	bigger, big, large, massive, hairy, majestic, rich, respect, fur	Neutral	1	18	0	19
Red meat	Red meat	Neutral	14	7	1	22
Indigenous	aboriginal, indigenous, traditional, native, rustic, first nation	Neutral	0	24	0	24

Expensive	expensive, extravagant, gourmet, high-end, fancy, restaurant	Neutral	5	19	2	26
Europe	Belgium, France, Sweden, Europe, Dutch, Germany, Iceland	Neutral	0	0	26	26
Western Canada	Canadian, Saskatoon, Alberta, Prairies	Neutral	15	14	0	29
Wildlife	wild, wildlife, hunting, game	Neutral	0	38	3	41
Livestock production	pasture, agriculture, farm, farming, feedlot, grain, grass, grass-fed, grassland, grazing, ranch, rangeland	Neutral	23	15	6	44
Unconventional	abnormal, exotic, different, rare, weird, unpopular, mystery, unique, uncommon, unconventional, unusual, specialty	Neutral	0	25	24	49
Live animal	cow, cattle, cows, livestock, horse, bison, animal	Neutral	67	15	17	99
Scarce	not available, hard to find, scarce	Negative	0	6	1	7
Endangered	endangered, extinction, conservation, species at risk, protected species	Negative	0	8	0	8
Fat	fat, marbled, marbling	Negative	9	2	0	11
Bad	bad, not good, dangerous	Negative	3	1	6	10
Unappealing	unappealing, unacceptable, unpleasant, unremarkable, unfun	Negative	0	2	10	12
Dietary diseases	cancer, cholesterol, diabetes, obesity	Negative	9	3	3	15
Blood	blood, raw, flesh, butcher, slaughterhouse, bloody	Negative	12	1	2	15
Pets	pet, friend, beautiful, gentle, love horses, domesticated, intelligent animal	Negative	0	0	16	16
Environmental concerns	methane, carbon, carbon-intensive, deforestation, degradation, environment, emissions, unsustainable, intensive	Negative	21	0	0	21
Unethical	ethically, awful, horrible, wrong, worse, taboo, unethical, controversial, haram, scandal, illegal	Negative	0	0	25	25
Tough texture	tough, hard, chewy, tough, gristle, hard, stringy, tendons, sinew	Negative	2	3	21	26
Disgust	gross, disgust, stinky, slimy, distaste, repulsive, yuck, gross, stinky, nasty	Negative	4	1	26	31
Aversion	don't, non-edible, couldn't, wouldn’t impossible, off-limits, shouldn't	Negative	0	7	46	53
Cruelty	death, killing, inhuman, injustice, murder, pain, slaughter, cruelty, suffering, unfriendly, dead, sadness, bounded, unkind, bizarre, bothersome, pain, scary, abuse, anger, guilt injustice, suffering, cannibalism	Negative	15	9	32	56
Total words						1195

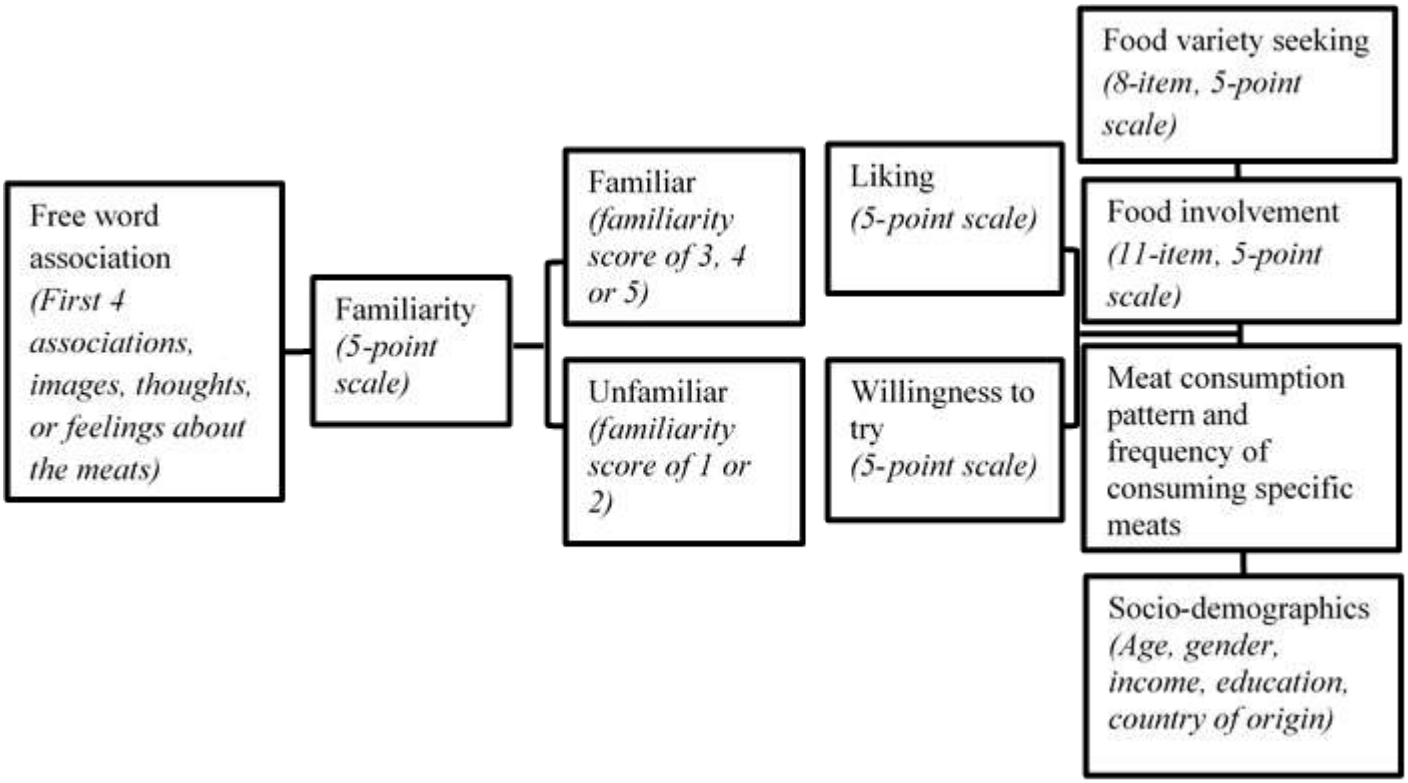
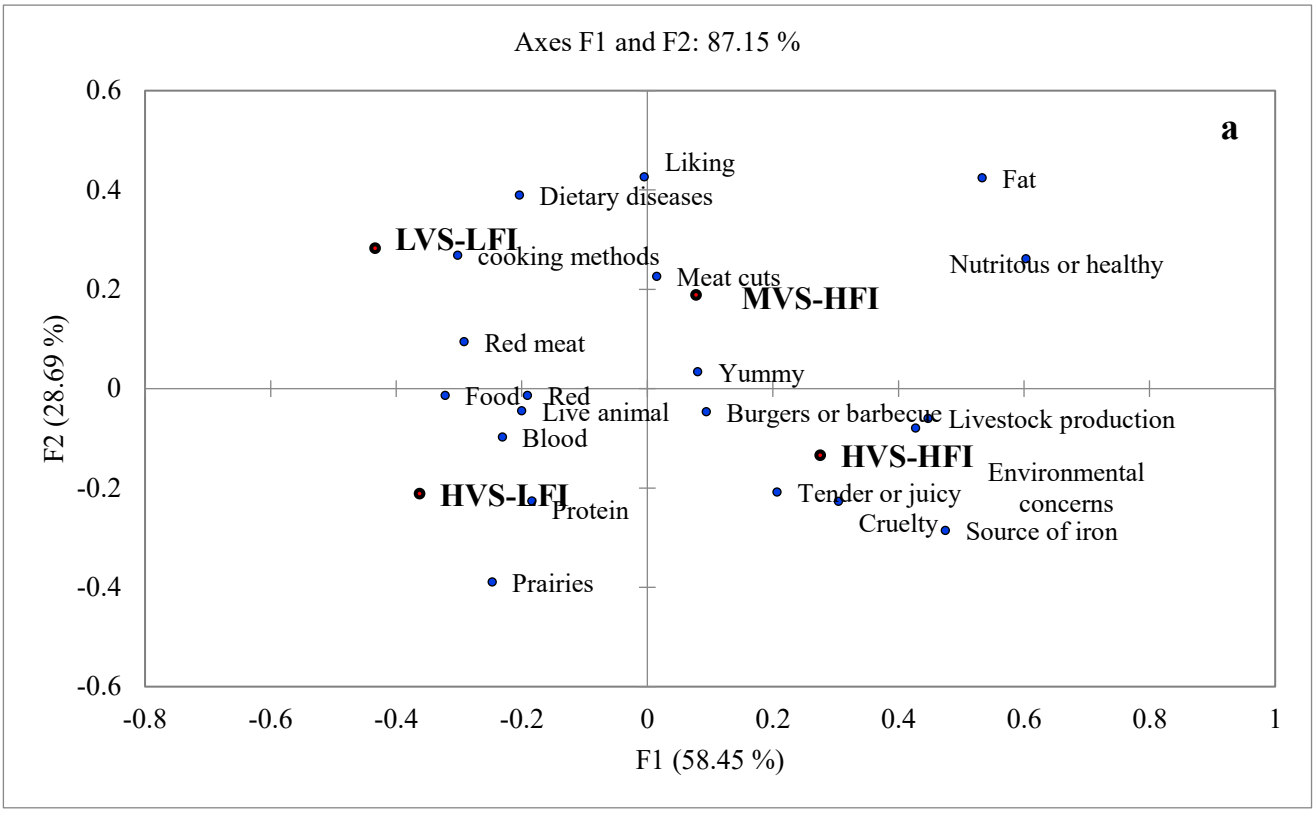
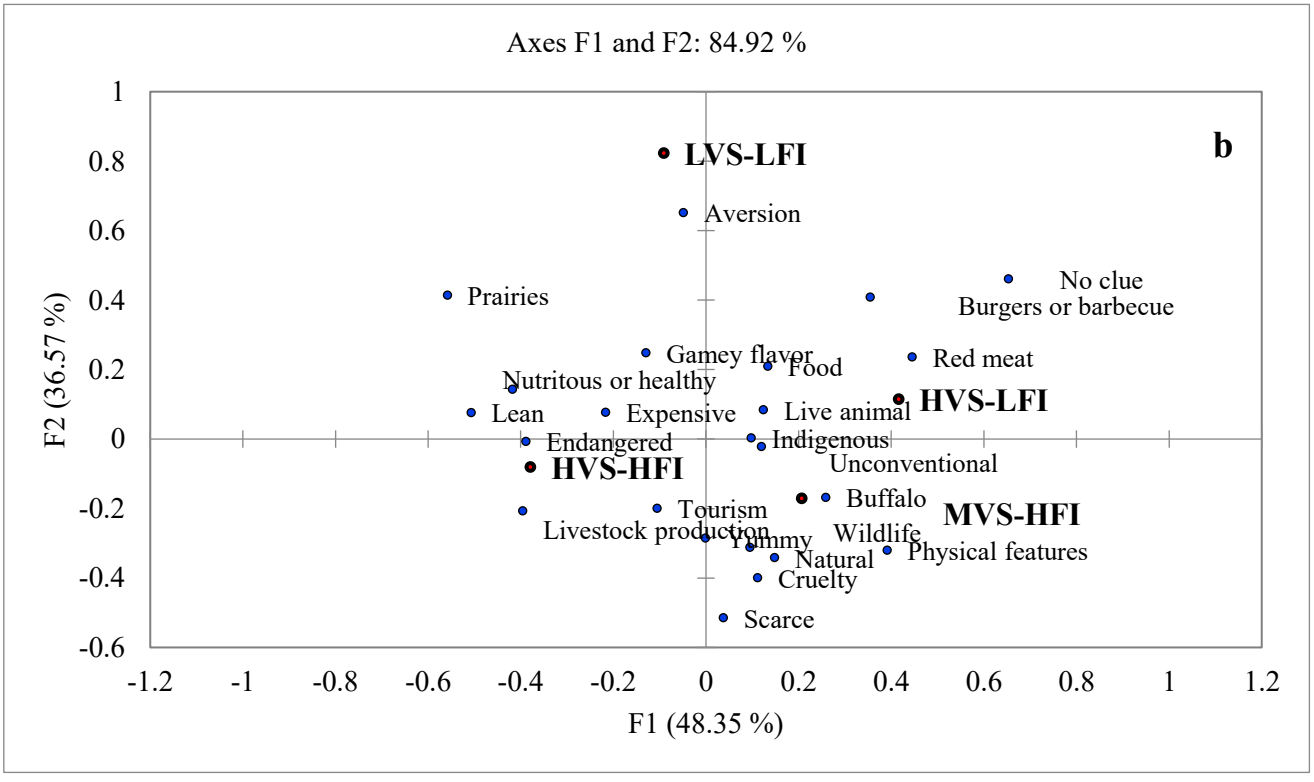


Fig. 5.1: Schematic presentation of the survey flow.


Axes F1 and F2: 87.15 %
a
Liking
Fat
Dietary diseases
LVS-LFI
cooking methods
Nutritous or healthy
Meat cuts
MVS-HFI
Red meat
Yummy
Food
Red
Live animal
Burgers or barbecue
Livestock production
Blood
HVS-HFI
Environmental concerns
HVS-LFI
Protein
Tender or juicy
Cruelty
Source of iron
Prairies
F2 (28.69 %)
F1 (58.45 %)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


Axes F1 and F2: 84.92 %
b
LVS-LFI
Aversion
No clue
Prairies
Burgers or barbecue
Gamey flavor
Food
Red meat
Nutritous or healthy
HVS-LFI
Lean
Expensive
Live animal
Endangered
Indigenous
Unconventional
HVS-HFI
Buffalo
Tourism
MVS-HFI
Livestock production
Yummy
Wildlife
Physical features
Natural
Cruelty
Scarce
F2 (36.57 %)
F1 (48.35 %)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2

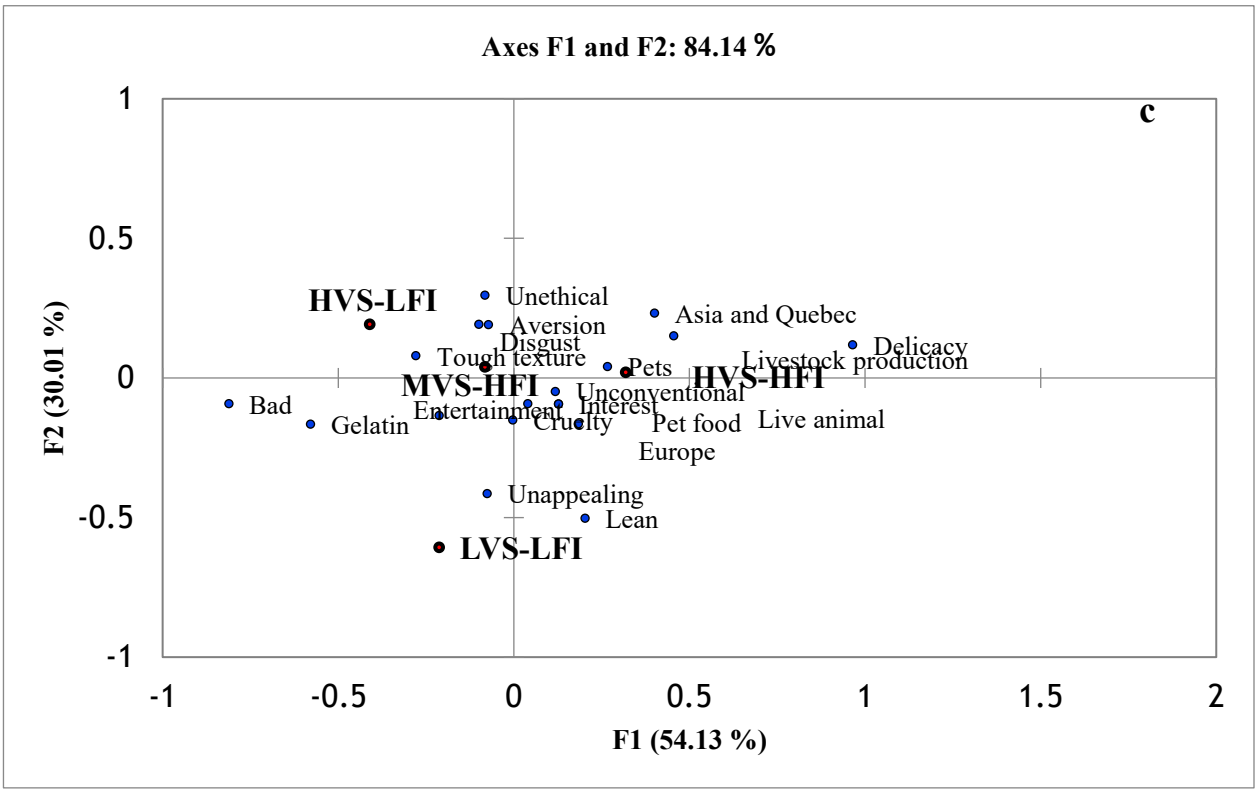


Fig. 5.2: correspondence analysis plot of categories associated with (a) beef, (b) bison meat, and (c) horse meat based on consumer cluster.

Chapter 6. General discussion and conclusions

Increasing consumer health consciousness and concerns about the environmental impact of meat production, animal welfare concerns and concerns about meat safety due to meat-related disease outbreaks, are major factors contributing to changing consumer behavior towards meat, particularly red meats (Cheah, Sadat Shimul, Liang, & Phau, 2020; Hartmann & Siegrist, 2017). Although red meats from alternative species such as horse, bison and elk are healthier alternatives to conventional red meats, their consumption is very low and still confined to niche markets. While the global consumption of horse meat is low, some countries have a tradition of eating horse meat, and Canada represents the third largest exporter to these countries. This PhD research incorporated a variety of methods in sensory and consumer research to contribute to the advancement of the alternative red meat industry by: (i) identifying the influence of cost reduction efforts through reduced carcass chilling duration on existing consumer acceptance of horse meat (Chapter 3), and (ii) identifying the sensory (Chapter 4) and non-sensory consumer-related (Chapter 5) factors contributing to consumer acceptance/ rejection of horse meat and other alternative red meats. Some methods which were novel to the domain of meat research, especially the alternative meat research, were employed which not only served to achieve the objectives of this research but also broadened the scope of the utilization of these methods.

6.1 Carcass chilling and consumer acceptance of horse meat

In the study described in Chapter 3, the use of the JAR method together with CLT and HUT allowed evaluation of the impact of reduced carcass chilling on ideal sensory attributes for horse meat, the extent to which liking drops when sensory attributes deviated from the ideal and how acceptance differs when consumers evaluated the meat samples under controlled conditions against home conditions. With reduced carcass chilling duration from 30 to 17 h, horse meat can be harvested at internal temperature of 12.6ºC ± 0.7 which is higher than the 7ºC stipulated by the CFIA without significant impact on consumer acceptance. Although harvesting at higher internal temperature resulted in a lighter colored horse meat, this did not result in a significant drop in mean overall liking, whereas harvesting at the stipulated internal temperature resulted in horse meat perceived to be too dark by some consumers, which resulted in a higher drop in mean

overall liking. This provided an indication that horse meat is more acceptable when perceived to be too light than too dark and harvesting at 17 h resulted in horse meat of desirable color. Harvesting at higher internal temperature resulted in horse meat with similar tenderness to standard duration, although regardless of the chilling duration, horse meat samples evaluated in this study were perceived to be too tough, which was attributed to the influence of the anatomical location of the muscle used in this study (Lorenzo et al., 2014). While the *Semimembranosus* muscle used in this study has been shown to be among the least tender muscle types (Lorenzo, Pateiro, & Franco, 2013), it is the only muscle best suited for the objective of this study as it is located deep in the hip of the animal and thus takes the longest to chill (Walker, 2017). Beyond the primary objective of this study, the need to substantiate acceptability ratings for meat obtained under controlled condition with home use testing was identified as liking improved significantly when consumers had the freedom to prepare samples to their preference, consume an unrestricted amount and evaluate the samples under more relaxed conditions (Boutrolle, Arranz, Rogeaux, & Delarue, 2005).

6.2 Sensory dissimilarities between conventional (beef) and alternative red meats (bison, horse and elk) and its impact on consumer acceptance

In the study described in Chapter 4, combining rapid descriptive profiling of beef, bison, elk and horse meats together with hedonic ratings for these meats allowed the identification of both sensory dissimilarities among these meat types, and specific sensory attributes with the most impact on liking. Identification of homogeneous groups of consumers based on their overall liking for each of the meats provided an indication of the size of the market segment for these meats from the sensory perspective. Comparing results from CATA, a rapid method that has found wide application in meat research with PAE, and a relatively novel method with limited application, provided information about the suitability of the latter in the domain of meat research and expansion of its scope of utilization.

The alternative red meats were described by unique sensory attributes which differentiated them from conventional meat (beef). Color is an important quality factor for both raw and cooked meat as it indicates freshness and wholesomeness in fresh meat and doneness in cooked meat

(Mancini & Hunt, 2005; Suman & Joseph, 2013). Due to their higher myoglobin content and negligible intramuscular fat content, red meats from alternative species are darker than conventional red meats (Dhanda, Pegg, & Shand, 2003; Neethling, Hoffman, & Muller, 2016). Although agreement on the intensity of dark color differed across the 3 different panellist groups (2 PAE and 1 CATA), bison, horse and elk meats were all perceived to be darker than beef. Nonetheless, the dark color did not influence acceptance of these alternative red meats across all 3 panellist groups, an indication that consumers will consume these meats regardless of the color. The influence of color difference on purchase decision (which is beyond the scope of this research) may however be different as consumers often perceive the quality of darker colored meats as being inferior to bright red colored meats (Neethling et al., 2016).

Unlike the influence of color differences, differences in type and intensity of flavor and aroma had an impact on consumer acceptance of alternative red meats. Beef was associated with mild beefy flavor and aroma, which were indicated as important attributes for consumers' meat choice across the 3 panellist groups. Elk meat was associated with musky, urine/ammonia aroma and bloody, metallic, livery, fishy flavor while bison meat was associated with intense fishy/bloody/metallic and livery aroma. The unique flavor attributes have been attributed to the differences in fatty acid composition of the meats, particularly a high proportion of polyunsaturated fatty acids which gives different flavor profile, and makes the meats more susceptible to oxidation and development of off-flavors (Neethling et al., 2016). Horse meat contrasted with elk and bison but was located close to beef in all 3 sensory maps. A similar observation was made by Rodbotten, Kubberod, Lea, & Ueland (2004) in their evaluation of meat from 15 different species of animals. Horse meat was distinguished mainly based on appearance and dryness attributes with its association with dryness being a significant driver of dislike, while livery flavor, associated with elk meat, was a significant driver of dislike.

Differences exist in consumers' acceptance of the unique sensory attributes of the alternative red meats, with some consumers (especially existing consumers) considering the unique flavor attributes a positive factor driving acceptance (Demartini, Vecchiato, Tempesta, Gaviglio, & Vigano, 2018; Hoffman, Crafford, Muller, & Schutte, 2003; Wassenaar, Kempen, & van Eeden, 2019), while others consider this a major driver of dislike (Bodnar, Benak, & Skobrak, 2010;

Hoffman, Muller, Schutte, Calitz, & Crafford, 2005; Radder & Grunert, 2009). This study identified a consumer group that showed high overall liking for elk, horse and bison meats which may present a target market for these meat types. Although the consumer segment that showed liking for horse and elk meats represents only 19% of the total participants

6.3 Consumer response to familiar and unfamiliar meats: the role of perception, variety seeking and food involvement

In the study described in Chapter 5, the use of a qualitative consumer research method (FWA) for the investigation of consumers' perception of beef, bison and horse meats provided access to consumers' mental representation of these meats. Quantitative evaluation of this representation was a novel approach that allowed the evaluation of the impact of the salient associations in the mind of the consumer on liking of beef and willingness to try horse and bison meats. In addition, the consumer study was used to identify homogeneous groups of consumers based on personality traits relating to the central role of food in the life of consumers and their tendency to seek variety in their food choice.

Consumers in this study do not have a mental classification of horses as food, hence they do not hold predominantly food-related associations for horse meat but relate consumption of horse meat more with something cruel and unethical. Evaluation of consumers based on food-related personality traits of variety-seeking and food involvement showed that the predominant personality traits among consumers in this study is medium variety-seeking and high food involvement (37.2%), followed by high variety-seeking and high food involvement (31%), and high variety seeking and low food involvement (22.1%), while the least predominant personality trait is the low variety-seeking and low food involvement (9.7%). The significant impact of this classification on beef liking but not on willingness to try horse and bison meat, showed that these personality traits are manifested in preference for familiar alternatives and not in choosing unfamiliar alternatives. The smallest cluster (low variety seeking and low food involvement cluster) consist of consumers similar to indifferent meat consumers or straightforward meat lovers of Verbeke & Vackier (2004) who liked beef despite their awareness of the negative consequences of its consumption.

Regardless of personality traits, consumers' perception of beef was mostly ambivalent, while perception of horse and bison meats was mostly negative with correspondingly low willingness to try scores. In line with the theory that the most salient association held by consumers about an object is the best predictor of consumers' behavior towards the object (Ajzen & Fishbein, 1980; Holdershaw & Gendall, 2008), this study reveals that when positive perception is more salient for beef, liking is significantly higher. Conversely, a significant negative correlation between willingness to try and proportion of negative perceptions was observed for bison and horse meats. The mostly negative perception of horse and bison meats, together with the low willingness to try scores show that the potential for expansion of the alternative red meat industry beyond a niche market may be slim unless concerted effort is put into communicating quality attributes of these meats to variety-seeking and highly food involved consumers that showed a significantly low liking for beef.

6.5 Conclusions

Overall, this research has demonstrated that the Canadian horse meat industry can be more profitable when an important cost factor (carcass chilling) is modified, as this does not significantly affect consumer acceptance. This research has also identified the factors that could potentially contribute to the expansion of the alternative red meat industry from the perspective of attributes of the "product" (sensory factors) and the "person" making the choice (non-sensory/consumer-related factors). From the sensory perspective, the relatively small size of consumer cluster that showed liking for the sensory attributes of these meats implies that consumption of these meats will likely be limited to a small segment of consumers who showed liking for their unique sensory attributes. This information, together with the low willingness to try scores reported for these meats among clusters that showed low liking for beef, indicated that consumers would seek variety among known alternatives and not switch to an unfamiliar alternative. The potential for growth of the alternative red meat industry, however, lies in provision of information about quality attributes of these meats which may increase interest among consumers that showed significantly lower liking for beef. Another option is to increase availability of the meats for consumers who showed liking for these meat types by making these meats available in conventional grocery stores.

6.5 Limitations and future research

Except for the study conducted among existing consumers of horse meat (Chapter 3), the other studies (Chapter 4 and 5) were conducted among consumers regardless of their level of consumption of these meat types. While this was necessary in order to identify potential consumers for these meat types, the impact of information about nutritional benefits on consumer perception and liking was not explored in this research. The possibility of identifying a homogeneous consumer segment for alternative red meats based on both sensory preference and consumer-related factors (personality traits and perceptions) can be explored in future studies by conducting taste-driven consumer studies. Another limitation of this research was that its scope was limited to the influence of sensory attributes of these meat and the attributes of the person making the choice, but did not cover the potential impact of the "place" (eating occasion or context) on the possibility of expansion of the alternative meat industry. While results of a few studies have indicated these meats as mainly suitable for special occasions (Chausson, Rowcliffe, Escouflaire, Wieland, & Wright, 2019; Sanderson, Hobbs, Shand, & Kerr, 2002), information about consumers' motive behind this classification, and the context or occasions that they consider these meats appropriate for, is lacking. With respect to the influence of reduced carcass chilling on sensory quality of horse meat (Chapter 3), although identification of consumers' ideal sensory attribute for horse meat was not the main goal of the research, consumers perceived horse meat to be too tough regardless of the carcass chilling duration and preparation method. This was attributed to the anatomical location of the muscle used for this study. While this suits the purpose of the present research as it is the muscle that takes the longest to chill (Walker, 2017), future studies on ideal sensory attributes of horse meat should include other muscle cuts in order to determine the extent to which deviation from ideal is penalized for different muscle types. Moreover, the influence of ante-mortem factors of age, breed, gender, and diet, which could have influenced the sensory attributes of the meat, could be investigated in the future.

6.6. References

Ajzen, I., & Fishbein, M. (1980). *Understanding attitude and predicting behavior.* Prentice-Hall. Inc, Engelwood Cliffs, New Jersey.

Bodnar, K., Benak, A., & Skobrak, E. B. (2010). Analyses of consumer preferences and attitudes on Hungarian game meat market (preliminary report). *Lucrari Stiintifice, Universitatea De Stiinte Agricole Si Medicina Veterinara "Ion Ionescu De La Brad" Iasi, Seria Agronomie, 53*, 9-12.

Boutrolle, I., Arranz, D., Rogeaux, M., & Delarue, J. (2005). Comparing central location test and home use test results: Application of a new criterion. *Food Quality and Preference, 16*, 704-713. doi:https://doi.org/10.1016/j.foodqual.2005.03.015

Chausson, A. M., Rowcliffe, J. M., Escouflaire, L., Wieland, M., & Wright, J. H. (2019). Understanding the sociocultural drivers of urban bushmeat consumption for behavior change interventions in Pointe Noire, Republic of Congo. *Human Ecology, 47*, 179-191. doi:10.1007/s10745-019-0061-z ER

Cheah, I., Sadat Shimul, A., Liang, J., & Phau, I. (2020). Drivers and barriers toward reducing meat consumption. *Appetite, 149*, 104636.

Demartini, E., Vecchiato, D., Tempesta, T., Gaviglio, A., & Vigano, R. (2018). Consumer preferences for red deer meat: A discrete choice analysis considering attitudes towards wild game meat and hunting. *Meat Science, 146*, 168-179. doi:10.1016/j.meatsci.2018.07.031 ER

Dhanda, J. S., Pegg, R. B., & Shand, P. J. (2003). Tenderness and chemical composition of elk (*Cervus elaphus*) meat: Effects of muscle type, marinade composition, and cooking method. *Journal of Food Science, 68*(5), 1882-1888. doi:10.1111/j.1365-2621.2003.tb12347.x

Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science & Technology, 61*, 11-25. doi:https://doi.org/10.1016/j.tifs.2016.12.006

Hoffman, L. C., Crafford, K., Muller, N., & Schutte, D. W. (2003). Perceptions and consumption of game meat by a group of tourists visiting South Africa. *South African Journal of Wildlife Research, 33*, 125-130.

Hoffman, L. C., Muller, M., Schutte, D. W., Calitz, F. J., & Crafford, K. (2005). Consumer expectations, perceptions and purchasing of South African game meat. *South African Journal of Wildlife Research, 35*, 33-42.

Hoffman, L. C., & Wiklund, E. (2006). Game and venison - meat for the modern consumer. *Meat Science, 74*, 197-208. doi://dx.doi.org/10.1016/j.meatsci.2006.04.005

Holdershaw, J., & Gendall, P. (2008). Understanding and predicting human behaviour. *Power and Place: Refereed Proceedings of the Australian and New Zealand Communication Association Conference, Wellington, New Zealand, July 9-11, 2008.*

Lorenzo, J. M., Victoria Sarries, M., Tateo, A., Polidori, P., Franco, D., & Lanza, M. (2014). Carcass characteristics, meat quality and nutritional value of horsemeat: A review. *Meat Science, 96*, 1478-1488. doi:https://doi.org/10.1016/j.meatsci.2013.12.006

Lorenzo, J. M., Pateiro, M., & Franco, D. (2013). Influence of muscle type on physicochemical and sensory properties of foal meat. *Meat Science, 94*, 77-83. doi:https://doi.org/10.1016/j.meatsci.2013.01.001

Mancini, R. A., & Hunt, M. C. (2005). Current research in meat color. *Meat Science, 71*, 100-121. doi:10.1016/j.meatsci.2005.03.003 ER

Neethling, J., Hoffman, L. C., & Muller, M. (2016). Factors influencing the flavor of game meat: A review. *Meat Science, 113*, 139-153. doi:10.1016/j.meatsci.2015.11.022 ER

Radder, L., & Grunert, K. G. (2009). Consumers' perceptions of African wildlife meat: A laddering study. *Journal of Food Products Marketing, 15*, 164-174. doi:10.1080/10454440802317022 ER

Rodbotten, M., Kubberod, E., Lea, P., & Ueland, O. (2004). A sensory map of the meat universe. sensory profile of meat from 15 species. *Meat Science, 68*, 137-144. doi:10.1016/j.meatsci.2004.02.016

Sanderson, K., Hobbs, J. E., Shand, P., & Kerr, W. A. (2002). Consumer preferences in the emerging bison industry: Marketing implications. *Journal of International Food & Agribusiness Marketing, 14*, 57-78. doi:10.1300/J047v14n03_05 ER

Suman, S. P., & Joseph, P. (2013). Myoglobin chemistry and meat color. *Annual Review of Food Science and Technology, Vol 4,* 79-99. doi:https://doi.org/10.1146/annurev-food-030212-182623

Verbeke, W., & Vackier, I. (2004). Profile and effects of consumer involvement in fresh meat. *Meat Science, 67*, 159-168. doi:https://doi.org/10.1016/j.meatsci.2003.09.017

Walker, B. (2017). *Impact of Carcass Chill Time on the Microbiology of Horse Meat.* Retrieved from https://era.library.ualberta.ca/items/502543e7-6ddc-4f59-90fb-b786ad9cfee9/view/fd5ba37d-3bca-48c0-ab81-3a4150e49074/Walker_Brian_D_201709_MSc.pdf

Wassenaar, A., Kempen, E., & van Eeden, T. (2019). Exploring South African consumers' attitudes towards game meat-utilizing a multi-attribute attitude model. *International Journal of Consumer Studies, 43*(5), 437-445. doi:10.1111/ijcs.12523

BIBLIOGRAPHY

Aalhus, J. L., Janz, J. A. M., Tong, A. K. W., Jones, S. D. M., & Robertson, W. M. (2001). The influence of chilling rate and fat cover on beef quality. *Canadian Journal of Animal Science, 81*(3), 321-330. doi:https://doi.org/10.4141/A00-084

Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., & Best, D. R. (2002). Very fast chilling of beef carcasses. *Canadian Journal of Animal Science, 82*, 59-67. doi:https://doi.org/10.4141/A01-020

Aboah, J., & Lees, N. (2020). Consumers use of quality cues for meat purchase: Research trends and future pathways. *Meat Science, 166*, 108142. doi:https://doi.org/10.1016/j.meatsci.2020.108142

Adams, J., Williams, A., Lancaster, B., & Foley, M. (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. *Paper Presented at 7th Pangborn Sensory Science Symposium, Minneapolis, USA, 12–16 August, 2007.*

Aganga, A. A., Aganga, A. O., Thema, T., & Obocheleng, K. O. (2003). Carcass analysis and meat composition of the donkey. *Pakistan Journal of Nutrition, 2*, 138-147.

Agriculture and Agri-Food Canada. (2019a). Canada's red meat and livestock industry at a glance. Retrieved from http://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/industry-profile/?id=1415860000002

Agriculture and Agri-Food Canada. (2019b). Canadian bison: The red meat with a difference. Retrieved from http://www.agr.gc.ca/eng/food-products/explore-canadian-food-products/canadian-bison/?id=1425927572578

Ajzen, I., & Fishbein, M. (1980). *Understanding attitude and predicting behavior.* Prentice-Hall. Inc, Engelwood Cliffs, New Jersey.

Alexi, N., Nanou, E., Lazo, O., Guerrero, L., Grigorakis, K., & Byrne, D. V. (2018). Check-all-that-apply (CATA) with semi-trained assessors: Sensory profiles closer to descriptive analysis or consumer elicited data? *Food Quality and Preference, 64*, 11-20. http://doi:10.1016/j.foodqual.2017.10.009ER.

Ali, J., & Pappa, E. (2011). Understanding structural changes in global meat sector: A comparative analysis across geographical regions. Paper presented at the *21st Annual International Food and Agribusiness Management Association (IFAMA) World Forum and Symposium:* On the Road to 2050: Sustainability as a Business Opportunity, Frankfurt, Germany, 22-23 June, 2011.

Almeida, M. A. d., Villanueva, N. D. M., Saldana, E., Pinto, J. S. D. S., Fadda, S. G., & Castillo, C. J. C. (2016). The use of just-about-right (JAR) scales to identify drivers of customer acceptance for low-sodium Italian salami. *Meat Science, 112* doi:https://doi.org/10.1016/j.meatsci.2015.08.032

AMSA. (2016). *Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness of Meat* (2nd ed.). Champaign, Illinois, USA: American Meat Science Association.

Antunez, L., Machin, L., Ares, G., & Jaeger, S. R. (2019). Visual attention to rate-all-that-apply (RATA) questions: A case study with apple images as food stimuli. *Food Quality and Preference, 72*, 136-142. doi:10.1016/j.foodqual.2018.10.007 ER

Aqueveque, C. (2015). Intention to try unfamiliar food: The role of level and type of unfamiliarity, food neophobia, and ethnocentrism. *Journal of Food Products Marketing, 21*, 244-254. doi:10.1080/10454446.2013.807414

Arcos-Garcia, G., Totosaus, A., Guerrero, I., & Perez-Chabela, M. d. L. (2002). Physicochemical, sensory, functional and microbial characterization of horse meat. *Revista Brasileira De Agrociência, 8*, 43-46.

Ares, G., & Deliza, R. (2010). Identifying important package features of milk desserts using free listing and word association. *Food Quality and Preference, 21*, 621-628. doi:10.1016/j.foodqual.2010.03.010

Ares, G., Andrade, J. C. d., Antunez, L., Alcaire, F., Swaney-Stueve, M., Gordon, S., & Jaeger, S. R. (2017). Hedonic product optimisation: CATA questions as alternatives to JAR scales. *Food Quality and Preference, 55*, 67-78. doi:https://doi.org/10.1016/j.foodqual.2016.08.011

Ares, G., Antúnez, L., Bruzzone, F., Vidal, L., Giménez, A., Pineau, B., . . . Jaeger, S. R. (2015). Comparison of sensory product profiles generated by trained assessors and consumers using CATA questions: Four case studies with complex and/or similar samples. *Food Quality and Preference, 45,* 75-86. https://doi.org/10.1016/j.foodqual.2015.05.007.

Ares, G., Cecilia, B., Rosires, D., Gimenéz, A., & Gámbaro, A. (2010). Application of a check-all-that-apply question to the development of chocolate milk desserts. *Journal of Sensory Studies, 25,* 67-86. https://doi:10.1111/j.1745-459X.2010.00290.x.

Ares, G., Dauber, C., Fernández, E., Giménez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. *Food Quality and Preference, 32*, 65-76. doi:https://doi.org/10.1016/j.foodqual.2013.05.014

Ares, G., de Andrade, J. C., Antunez, L., Alcaire, F., Swaney-Stueve, M., Gordon, S., & Jaeger, S. R. (2017). Hedonic product optimisation: CATA questions as alternatives to JAR scales. *Food Quality and Preference, 55*, 67-78. doi:https://doi.org/10.1016/j.foodqual.2016.08.011

Ares, G., Gimenez, A., & Gambaro, A. (2008). Understanding consumers' perception of conventional and functional yogurts using word association and hard laddering. *Food Quality and Preference, 19*, 636-643. doi:10.1016/j.foodqual.2008.05.005 ER

Ares, G., Tárrega, A., Izquierdo, L., & Jaeger, S. R. (2014). Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-

that-apply (CATA) questions. *Food Quality and Preference, 31,* 135-141. https://doi.org/10.1016/j.foodqual.2013.08.012.

Balowski, M., Sobczak, M., Zochowska-Kujawska, J., Pytel-Zajac, O., & Niedzwiedz, M. (2015). Comparison of meat quality of selected exotic animal species. *Folia Pomeranae Universitatis Technologiae Stetinensis, Agricultura, Alimentaria, Piscaria Et Zootechnica, 322*, 5-13.

Barone, M., Turroni, S., Rampelli, S., Soverini, M., D'Amico, F., Biagi, E., . . . Candela, M. (2019). Gut microbiome response to a modern paleolithic diet in a western lifestyle context. *PLoS ONE, 14*, 503-514 doi:10.1371/journal.pone.0220619 ER

Bartoň, L., Bureš, D., Kotrba, R., & Sales, J. (2014). Comparison of meat quality between eland (*Taurotragus oryx*) and cattle (*Bos taurus*) raised under similar conditions. *Meat Science, 96*, 346-352. doi://doi.org/10.1016/j.meatsci.2013.07.016

Beaton, A. J. W., Spiegel, N. B., Thompson, J. M., & Wynn, P. (2002). Sensory evaluation of kangaroo meat. *Animal Production Australia, 24*, 21-24.

Belaunzaran, X., Bessa, R. J. B., Lavín, P., Mantecón, A. R., Kramer, J. K. G., & Aldai, N. (2015). Horse meat for human consumption — current research and future opportunities. *Meat Science, 108*, 74-81. doi:https://doi.org/10.1016/j.meatsci.2015.05.006

Belcher, K., Germann, A., & Schmutz, J. (2007). Beef with environmental and quality attributes: Preferences of environmental group and general population consumers in Saskatchewan, Canada. *Agriculture and Human Values, 24*, 333-342. doi:10.1007/s10460-007-9069-x

Beldarrain, L. R., Etaio, I., Morán, L., Sentandreu, M. Á, Barron, L. J. R., & Aldai, N. (2020). Effect of ageing time on consumer preference and sensory description of foal meat. *Food Research International, 129* doi:10.1016/j.foodres.2019.108871

Bell, R., & Marshall, D. W. (2003). The construct of food involvement in behavioral research: Scale development and validation. *Appetite, 40*, 235-244. doi:https://doi.org/10.1016/S0195-6663(03)00009-6

Benningstad, N. C. G., & Kunst, J. R. (2020). Dissociating meat from its animal origins: A systematic literature review. *Appetite, 147*, 104554. doi:https://doi.org/10.1016/j.appet.2019.104554

Bo, C. d., Simonetti, P., Gardana, C., Riso, P., Lucchini, G., & Ciappellano, S. (2013). Horse meat consumption affects iron status, lipid profile and fatty acid composition of red blood cells in healthy volunteers. *International Journal of Food Sciences and Nutrition, 64*, 147-154.

Bodnar, K., Benak, A., & Skobrak, E. B. (2010). Analyses of consumer preferences and attitudes on Hungarian game meat market (preliminary report). *Lucrari Stiintifice, Universitatea De Stiinte Agricole Si Medicina Veterinara "Ion Ionescu De La Brad" Iasi, Seria Agronomie, 53*, 9-12.

Bodnar, K., Bodnarne, S. E., Tanacs, L., & Pinnyey, S. (2011). Consumers' opinion about the hygienic risks of the meat of wild ungulates. *Lucrari Stiintifice, Universitatea De Stiinte Agricole Si Medicina Veterinara a Banatului, Timisoara, Seria I, Management Agricol, 13*, 31-36.

Boles, J. A., & Shand, P. J. (2008). Effect of muscle location, fiber direction, and slice thickness on the processing characteristics and tenderness of beef stir-fry strips from the round and chuck. *Meat Science, 78,* 369-374. https://doi://doi.org/10.1016/j.meatsci.2007.06.024.

Bordi, P. L., Lambert, C. U., Smith, J., Hollender, R., & Borja, M. E. (2001). Acceptability of soy protein in oatmeal muffins. *Foodservice Research International, 13*, 101-110. doi:https://doi.org/10.1111/j.1745-4506.2001.tb00034.x

Borgogno, M., Favotto, S., Corazzin, M., Cardello, A. V., & Piasentier, E. (2015). The role of product familiarity and consumer involvement on liking and perceptions of fresh meat.

Food Quality and Preference, 44, 139-147. doi:https://doi.org/10.1016/j.foodqual.2015.04.010

Bouton, P. E., Harris, P. V., & Shorthose, W. R. (1976). Factors influencing cooking losses from meat. *Journal of Food Science, 41*, 1092-1095. https://doi:10.1111/j.1365-2621.1976.tb14394.x

Boutrolle, I., Arranz, D., Rogeaux, M., & Delarue, J. (2005). Comparing central location test and home use test results: Application of a new criterion. *Food Quality and Preference, 16*, 704-713. doi:https://doi.org/10.1016/j.foodqual.2005.03.015

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M., & Köster, E. P. (2007). Central location test vs. home use test: Contrasting results depending on product type. *Food Quality and Preference, 18*, 490-499. doi:https://doi.org/10.1016/j.foodqual.2006.06.003

Brittin, H. C., Armes, C. L., Ramsey, C. B., & Simpson, C. D. (1981). Palatability of meat from mule deer. *Journal of Food Science, 46*, 1805-1807. doi:10.1111/j.1365-2621.1981.tb04490.x ER

Bureš, D., Bartoň, L., Kotrba, R., & Hakl, J. (2015). Quality attributes and composition of meat from red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and Aberdeen angus and Holstein cattle (*Bos taurus*). *Journal of the Science of Food and Agriculture, 95*, 2299-2306. doi:10.1002/jsfa.6950

Buttlar, B., & Walther, E. (2018). Measuring the meat paradox: How ambivalence towards meat influences moral disengagement. *Appetite, 128*, 152-158. doi:https://doi.org/10.1016/j.appet.2018.06.011

Canadian Bison Association. (2019). Bison market and supply update. Retrieved from https://www.canadianbison.ca/resources/resources/industry-reports/bison-market-and-supply-update

Canadian Bison Association. (2020). Bison history. Retrieved from https://www.canadianbison.ca/producers/about-bison/bison-history

Canadian Food Inspection Agency. (2017). Refrigeration of carcasses and carcass parts. Retrieved from http://www.inspection.gc.ca/food/meat-and-poultry-products/manual-of-procedures/chapter-17/eng/1367723343665/1367723573062?chap=12

Canadian Meat Council. (2013). Horse meat production in Canada. Retrieved from https://www.cmc-cvc.com/sites/default/files/files/Horse%20Meat%20Production%20in%20Canada%20Feb%202013.pdf

Cerjak, M., Haas, R., Brunner, F., & Tomic, M. (2014). What motivates consumers to buy traditional food products? evidence from Croatia and Austria using word association and laddering interviews. *British Food Journal, 116*, 1726-1747. doi:10.1108/BFJ-02-2014-0090

Charles, D. D. (1982). Meat tenderness and palatability of swamp buffalo and four breeds of cattle. *Animal Production, 34*(1), 79-84.

Chausson, A. M., Rowcliffe, J. M., Escouflaire, L., Wieland, M., & Wright, J. H. (2019). Understanding the sociocultural drivers of urban bushmeat consumption for behavior change interventions in pointe noire, Republic of Congo. *Human Ecology, 47*, 179-191. doi:10.1007/s10745-019-0061-z ER

Cheah, I., Sadat Shimul, A., Liang, J., & Phau, I. (2020). Drivers and barriers toward reducing meat consumption. *Appetite, 149*, 104636.

Conner, M., & Armitage, C. J. (2006). Social psychological models of food choice. In R. Shepherd, & M. Raats (Eds.), *The psychology of food choice* (pp. 41-57). United Kingdom: Frontiers in Nutritional Science.

Corallo, A., Latino, M. E., & Spennato, A. (2019). A survey to discover current food choice behaviors. *Sustainability, 11*, 5041-5057.

Corbin, C. H., O'Quinn, T. G., Garmyn, A. J., Legako, J. F., Hunt, M. R., Dinh, T. T. N., . . . Miller, M. F. (2015). Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments. *Meat Science, 100*, 24-31. doi:S0309-1740(14)00298-8 [pii]

Costa, M. P., Monteiro, M. L. G., Frasao, B. S., Silva, V. L. M., Rodrigues, B. L., Chiappini, C. C. J., & Conte-Junior, C. A. (2017). Consumer perception, health information, and instrumental parameters of cupuassu (T*heobroma grandiflorum*) goat milk yogurts. *Journal of Dairy Science, 100*, 157-168. doi:https://doi.org/10.3168/jds.2016-11315

Cranfield, J. (2013). Impact of beef quality on Canadian beef demand. Retrieved from https://www.beefresearch.ca/factsheet.cfm/impact-of-beef-quality-on-canadian-beef-demand-166

da Silva, V. M., Rodrigues Minim, V. P., Marques Ferreira, M. A., de Paula Souza, Pedro Henrique, da Silva Moraes, Liliane Elen, & Minim, L. A. (2014). Study of the perception of consumers in relation to different ice cream concepts. *Food Quality and Preference, 36*, 161-168. doi:10.1016/j.foodqual.2014.04.008

Dahlan, I., & Norfarizan Hanoon, N. A. (2008). Chemical composition, palatability and physical characteristics of venison from farmed deer. *Animal Science Journal, 79*, 498-503. doi:10.1111/j.1740-0929.2008.00555.x

Darke, P. R., & Chaiken, S. (2005). The pursuit of self-interest: Self-interest bias in attitude judgment and persuasion. *Journal of Personality and Social Psychology, 89*, 864-883.

Daszkiewicz, T., Janiszewski, P., & Wajda, S. (2009). Quality characteristics of meat from wild red deer (*Cervus elaphus L.*) hinds and stags. *Journal of Muscle Foods, 20*, 428-448.

Dawood, A. A. (1995). Physical and sensory characteristics of Najdi-camel meat. *Meat Science, 39*, 59-69. doi:10.1016/0309-1740(95)80007-7

de Andrade, J. C., Nalerio, E. S., Giongo, C., de Barcellos, M. D., Ares, G., & Deliza, R. (2018). Consumer sensory and hedonic perception of sheep meat coppa under blind and informed conditions. *Meat Science, 137*, 201-210. doi:10.1016/j.meatsci.2017.11.026 ER

de Andrade, J. C., Sobral, L. d. A., Ares, G., & Deliza, R. (2016). Understanding consumers' perception of lamb meat using free word association. *Meat Science, 117*, 68-74. doi:10.1016/j.meatsci.2016.02.039

Deerfarmer. (2016). Farmed deer statistics – UK and Canada. Retrieved from http://deerfarmer.com/wiki/farmed-deer-statistics-canada-united-kingdom

DEFRA. (2010). Fostering the development of technologies and practices to reduce the energy inputs
into the refrigeration of food. *Department for Environment, Food and Rural Affairs*. Retrieved from https://www.grimsby.ac.uk/documents/defra/sectrep-meatchill.pdf

Delgado, C. L. (2003). Rising consumption of meat and milk in developing countries has created a new food revolution. *The Journal of Nutrition, 133*, 3907S-3910S. doi:10.1093/jn/133.11.3907S [doi]

Demartini, E., Vecchiato, D., Tempesta, T., Gaviglio, A., & Vigano, R. (2018). Consumer preferences for red deer meat: A discrete choice analysis considering attitudes towards wild game meat and hunting. *Meat Science, 146*, 168-179. doi:10.1016/j.meatsci.2018.07.031 ER

Derinalp Çanakçı, S., & Birdir, K. (2020). The relation among food involvement, food variety seeking and food neophobia: A study on foreign tourists visiting Turkey. *Current Issues in Tourism, 23*, 917-928. doi:10.1080/13683500.2019.1602114

Dhanda, J. S., Pegg, R. B., & Shand, P. J. (2003). Tenderness and chemical composition of elk (*Cervus elaphus*) meat: Effects of muscle type, marinade composition, and cooking method. *Journal of Food Science, 68,* 1882-1888. https://doi:10.1111/j.1365-2621.2003.tb12347.x.

Dominique, V., Sylvie, C., Lelièvre Maud, & Abdi Hervé. (2012). Quick and dirty but still pretty good: A review of new descriptive methods in food science. *International Journal of Food Science & Technology, 47,* 1563-1578. https://doi:10.1111/j.1365-2621.2012.03022.x.

Dransfield, E. (2001). Consumer issues and acceptance of meat. *Paper Presented at 47th International Congress of Meat Science and Technology, Krakow, Poland,* 27-31 *August, 2001, 72-78.*

Drury, R. (2011). Hungry for success: Urban consumer demand for wild animal products in Vietnam. *Conservation and Society, 9*, 247-257. doi:10.4103/0972-4923.86995 ER

Eertmans, A., Victoir, A., Vansant, G., & Van den Bergh, O. (2005). Food-related personality traits, food choice motives and food intake: Mediator and moderator relationships. *Food Quality and Preference, 16*, 714-726. doi:https://doi.org/10.1016/j.foodqual.2005.04.007

Eldesouky, A., Pulido, A. F., & Mesias, F. J. (2015). The role of packaging and presentation format in consumers' preferences for food: An application of projective techniques. *Journal of Sensory Studies, 30*, 360-369. doi:10.1111/joss.12162

Esmerino, E. A., Ferraz, J. P., Tavares Filho, E. R., Pinto, L. P. F., Freitas, M. Q., Cruz, A. G., & Bolini, H. M. A. (2017). Consumers' perceptions toward 3 different fermented dairy products: Insights from focus groups, word association, and projective mapping. *Journal of Dairy Science, 100*(11), 8849-8860. doi:10.3168/jds.2016-12533

Fallon, A. E., & Rozin, P. (1983). The psychological bases of food rejections by humans. *Ecology of Food and Nutrition, 13*, 15-26. doi:10.1080/03670244.1983.9990728

Fanatico, A. C., Pillai, P. B., Emmert, J. L., Gbur, E. E., Meullenet, J. F., & Owens, C. M. (2007). Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. *Poultry Science, 86*, 2441-2449. doi:https://doi.org/10.3382/ps.2007-00092

FAOSTAT. (2020a). FAO statistical yearbook: Livestock primary. Retrieved from http://www.fao.org/faostat/en/#data/QL

FAOSTAT. (2020b). New food balances. *Food and Agriculture Organization of the United Nations,* Retrieved from http://www.fao.org/faostat/en/#data/FBS

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing, 24*, 230-235.

Font-i-Furnols, M., & Guerrero, L. (2014). Consumer preference, behavior and perception about meat and meat products: An overview. *Meat Science, 98*, 361-371.

Food Navigator-USA. (2020). Want to stay competitive in the growing protein space? look no further than consumer preferences. Retrieved from https://www.foodnavigator-usa.com/News/Promotional-Features/Discover-Insights-Into-What-Drives-Consumer-Protein-Choice?source=3&utm_source=newsletter_daily&utm_medium=email&utm_campaign=20-May-2020

Forss, D. A., & Manley, T. R. (1978). An evaluation of the eating qualities of venison from farmed and feral red deer. *Advances in Deer Farming.,*25-26.

Franco, D., & Lorenzo, J. M. (2014). Effect of muscle and intensity of finishing diet on meat quality of foals slaughtered at 15 months. *Meat Science, 96*, 327-334. doi:https://doi.org/10.1016/j.meatsci.2013.07.018

Franco, D., Rodriguez, E., Purrinos, L., Crecente, S., Bermudez, R., & Lorenzo, J. M. (2011). Meat quality of "Galician mountain" foals breed. Effect of sex, slaughter age and livestock production system. *Meat Science, 88*, 292-298. doi:https://doi.org/10.1016/j.meatsci.2011.01.004

Gambaro, A. (2018). Projective techniques to study consumer perception of food. *Current Opinion in Food Science, 21*, 46-50. doi://doi.org/10.1016/j.cofs.2018.05.004

Garcia-Diez, J., Alheiro, J., Pinto, A. L., Soares, L., Falco, V., Fraqueza, M. J., & Patarata, L. (2017). The impact of essential oils on consumer acceptance of chourico de vinho - a dry-cured sausage made from wine-marinated meat - assessed by the hedonic scale, JAR intensity scale and consumers' "will to consume and purchase". *Journal of Food Processing and Preservation, 41*. doi:https://doi.org/10.1111/jfpp.13056 ER

Gere, A., Szabo, Z., Pasztor-Huszar, K., Orban, C., Kokai, Z., & Sipos, L. (2017). Use of JAR-based analysis for improvement of product acceptance: A case study on flavored kefirs. *Journal of Food Science, 82*, 1200-1207. doi:https://doi.org/10.1111/1750-3841.13701 ER

Gill, C. O. (2005). Safety and storage stability of horse meat for human consumption. *Meat Science, 71*, 506-513. doi:https://doi.org/10.1016/j.meatsci.2005.04.030

Government of Alberta. (2017). Alberta horse meat exports by destination. Retrieved from https://Open.Alberta.Ca/Dataset/Alberta-Horse-Meat-Exports-by-Destination-2005-2014/Resource/65163962-A4ff-4635-B6a6-98b2b66fc408

Government of Canada. (2019a). Annual game report by species in Canada. Retrieved from https://www.agr.gc.ca/eng/animal-industry/red-meat-and-livestock/red-meat-and-livestock-market-information/supply-sheets-by-species/annual-game-report-by-species/?id=1415860000117

Government of Canada. (2019b). Canadian total exports - horse and other equine production. Retrieved from https://www.ic.gc.ca/app/scr/tdst/tdo/crtr.html?grouped=INDIVIDUAL&searchType=BL&naArea=9999&countryList=TOP&toFromCountry=CDN&reportType=TE&customYears=2019&timePeriod=%7CCustom+Years&currency=CDN&productType=NAICS&hSelectedCodes=%7C11292&runReport=true

Graça, J. (2016). Towards an integrated approach to food behaviour: Meat consumption and substitution, from context to consumers. *Psychology, Community & Health, 5*, 152-169. doi:http://dx.doi.org/10.5964/pch.v5i2.169

Grunert, K. G. (2006). Future trends and consumer lifestyles with regard to meat consumption. *Meat Science, 74*, 149-160. doi:https://doi.org/10.1016/j.meatsci.2006.04.016

Grygorczyk, A., Lesschaeve, I., Corredig, M., & Duizer, L. (2013). Extraction of consumer texture preferences for yogurt: Comparison of the preferred attribute elicitation method to conventional profiling. *Food Quality and Preference, 27,* 215-222. https://doi.org/10.1016/j.foodqual.2012.02.017.

Guerrero, L., Claret, A., Verbeke, W., Enderli, G., Zakowska-Biemans, S., Vanhonacker, F., . . . Hersleth, M. (2010). Perception of traditional food products in six European regions using free word association. *Food Quality and Preference, 21*, 225-233.

Ha, M., McGilchrist, P., Polkinghorne, R., Huynh, L., Galletly, J., Kobayashi, K., . . . Warner, R. D. (2019). Effects of different ageing methods on color, yield, oxidation and sensory qualities of Australian beef loins consumed in Australia and Japan. *Food Research International, 125*, 108528. doi:https://doi-org.login.ezproxy.library.ualberta.ca/10.1016/j.foodres.2019.108528

Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science & Technology, 61*, 11-25. doi:https://doi.org/10.1016/j.tifs.2016.12.006

Hartung, J., Nowak, B., & Springorum, A. C. (2009). 27 - animal welfare and meat quality. In J. P. Kerry, & D. Ledward (Eds.), *Improving the sensory and nutritional quality of fresh meat* (pp. 628-646) Woodhead Publishing. doi:https://doi.org/10.1533/9781845695439.4.628 Retrieved from http://www.sciencedirect.com/science/article/pii/B9781845693435500273

Hassan, M. A., Abdel-Naeem, H. H. S., Mohamed, H. M. H., & Yassien, N. A. (2018). Comparing the physico-chemical characteristics and sensory attributes of imported Brazilian beef meat and imported Indian buffalo meat. *Journal of Microbiology Biotechnology and Food Sciences, 8*, 672-677. doi:10.15414/jmbfs.2018.8.1.672-677

Hayes, J. E., Raines, C. R., Depasquale, D. A., & Cutter, C. N. (2014). Consumer acceptability of high hydrostatic pressure (HHP)-treated ground beef patties. *LWT -- Food Science and Technology, 56*, 207-210.

Henchion, M. M., McCarthy, M., & Resconi, V. C. (2017). Beef quality attributes: A systematic review of consumer perspectives. *Meat Science, 128*, 1-7. doi://doi.org/10.1016/j.meatsci.2017.01.006

Henchion, M. M., McCarthy, M., Resconi, V. C., & Troy, D. (2014). Meat consumption: Trends and quality matters. *Meat Science, 98*, 561-568. doi://doi.org/10.1016/j.meatsci.2014.06.007

Hirsh, K. W., & Tree, J. J. (2001). Word association norms for two cohorts of British adults. *Journal of Neurolinguistics, 14*, 1-44. doi:10.1016/S0911-6044(00)00002-6

Hobbs, J. E., Sanderson, K., & Haghiri, M. (2006). Evaluating willingness-to-pay for bison attributes: An experimental auction approach. *Canadian Journal of Agricultural Economics, 54*, 269-287. doi:10.1111/j.1744-7976.2006.00049.x ER

Hoffman, L. C., & Wiklund, E. (2006). Game and venison - meat for the modern consumer. *Meat Science, 74*, 197-208. doi://dx.doi.org/10.1016/j.meatsci.2006.04.005

Hoffman, L. C., Crafford, K., Muller, N., & Schutte, D. W. (2003). Perceptions and consumption of game meat by a group of tourists visiting South Africa. *South African Journal of Wildlife Research, 33*, 125-130.

Hoffman, L. C., Muller, M., Schutte, D. W., Calitz, F. J., & Crafford, K. (2005). Consumer expectations, perceptions and purchasing of South African game meat. *South African Journal of Wildlife Research, 35*, 33-42.

Holdershaw, J., & Gendall, P. (2008). Understanding and predicting human behaviour. *Power and Place: Refereed Proceedings of the Australian and New Zealand Communication Association Conference, Wellington, New Zealand, July 9-11, 2008.*

Hovardas, T., & Korfiatis, K. J. (2006). Word associations as a tool for assessing conceptual change in science education. *Learning and Instruction, 16*, 416-432. doi:https://doi.org/10.1016/j.learninstruc.2006.09.003

Huff-Lonergan, E., & Lonergan, S. M. (2005). Mechanisms of water-holding capacity of meat: The role of post-mortem biochemical and structural changes. *Meat Science, 71*, 194-204. doi:https://doi.org/10.1016/j.meatsci.2005.04.022

Hutchison, C. L., Mulley, R. C., Wiklund, E., & Flesch, J. S. (2012). Effect of concentrate feeding on instrumental meat quality and sensory characteristics of fallow deer venison. *Meat Science, 90*, 801-806. doi:10.1016/j.meatsci.2011.11.018

Irurueta, M., Cadoppi, A., Langman, L., Grigioni, G., & Carduza, F. (2010). Effect of aging on meat characteristics from water buffalo grown in Delta del Parana in Argentina. *Revista Veterinaria, 21*, 499-505.

Jaeger, S. R., & Porcherot, C. (2017). Consumption context in consumer research: Methodological perspectives. *Current Opinion in Food Science, 15*, 30-37. doi:https://doi.org/10.1016/j.cofs.2017.05.001

Jaeger, S. R., Bava, C. M., Worch, T., Dawson, J., & Marshall, D. W. (2011). The food choice kaleidoscope. A framework for structured description of product, place and person as sources of variation in food choices. *Appetite, 56*, 412-423. doi://doi.org/10.1016/j.appet.2011.01.012

Janz, J. A. M., Aalhus, J. L., Robertson, W. M., Dugan, M. E. R., Larsen, I. L., & Landry, S. (2004). The effects of modified carcass chilling on beef carcass grade and quality of several muscles. *Canadian Journal of Animal Science, 84*, 377-384. doi:https://doi.org/10.4141/A03-067

Jarvis, N., Clement, A. R., O'Bryan, C. A., Babu, D., Crandall, P. G., Owens, C. M., . . . Ricke, S. C. (2012). Dried plum products as a substitute for phosphate in chicken marinade. *Journal of Food Science, 77*, S253-S257.

Jastrzebska, E., Daszkiewicz, T., Gorecka-Bruzda, A., & Felis, D. (2019). Current situation and prospects for the horse meat market in Poland and the world. *Medycyna Weterynaryjna, 75*, 196-202.

Johansen, S. B., Naes, T., & Hersleth, M. (2011). Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. *Appetite, 56*, 15-24.

Jorge, E. d. C., Mendes, A. C. G., Auriema, B. E., Cazedey, H. P., Fontes, P. R., Ramos, A. de L. S., & Ramos, E. M. (2015). Application of a check-all-that-apply question for evaluating and characterizing meat products. *Meat Science, 100*, 124-133.

Joseph, R. L. (1996). Very fast chilling of beef and tenderness—a report from an EU concerted action. *Meat Science, 43*, 217-227. doi:https://doi.org/10.1016/0309-1740(96)00067-8

Juárez, M., Basarab, J. A., Baron, V. S., Valera, M., Larsen, I. L., & Aalhus, J. L. (2012). Quantifying the relative contribution of ante- and post-mortem factors to the variability in beef texture. *Animal, 6*, 1878-1887. doi:10.1017/S1751731112000572

Kaic, A., & Potocnik, K. (2019). Tenderness of horsemeat. *Meso, 21*, 71-78.

Kangaroo Industry Association. (2018). Economic benefits of the kangaroo industry. Retrieved from http://www.kangarooindustry.com/industry/economic/

Knaapila, A. J., Sandell, M. A., Vaarno, J., Hoppu, U., Puolimatka, T., Kaljonen, A., & Lagström, H. (2015). Food neophobia associates with lower dietary quality and higher BMI in Finnish adults. *Public Health Nutrition, 18*(12), 2161-2171. doi:10.1017/S1368980014003024

Koch, R. M., Crouse, J. D., & Seideman, S. C. (1988). Bison, Hereford and Brahman growth and carcass characteristics. *Beef Research Progress Report, Roman L. Hruska US Meat Animal Research Center.* 3, 26-28.

Koch, R. M., Jung, H. G., Crouse, J. D., Varel, V. H., & Cundiff, L. V. (1995). Growth, digestive capability, carcass, and meat characteristics of *Bison bison*, *Bos taurus,* and bos x bison.*73*, 1271-1281.

Kurtu, M. Y. (2004). An assessment of the productivity for meat and the carcass yield of camels (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. *Tropical Animal Health and Production, 36*, 65-76. doi:TROP.0000009520.34657.35

Kwiecinska, K., Kosicka-Gebska, M., Gebski, J., & Gutkowska, K. (2017). Prediction of the conditions for the consumption of game by Polish consumers. *Meat Science, 131*, 28-33. doi:10.1016/j.meatsci.2017.04.038 ER

Lähteenmäki, L., & Arvola, A. (2001). Food neophobia and variety seeking — consumer fear or demand for new food products. In L. J. Frewer, E. Risvik & H. Schifferstein (Eds.), *Food, people and society: A European perspective of consumers' food choices* (pp. 161-175). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-662-04601-2_11

Lahteenmaki, L., & van Trijp, H. (1995). Hedonic responses, variety-seeking tendency and expressed variety in sandwich choices. *Appetite, 24*, 139-151. doi:10.1016/S0195-6663(95)99358-4

Lavrakas, P. (2020). *Encyclopedia of survey research methods*. Thousand Oaks, California: doi:10.4135/9781412963947

Lebert, I., Rousset, S., Lebert, A., & Talon, R. (2003). MEAT | eating quality. In B. Caballero (Ed.), *Encyclopedia of food sciences and nutrition (second edition)* (pp. 3777-3785). Oxford: Academic Press. doi:https://doi.org/10.1016/B0-12-227055-X/00753-7 "

Lenglet, F. (2018). FNS or the varseek-scale? proposals for a valid operationalization of neophilia. *Food Quality and Preference, 66*, 76-84. doi:https://doi.org/10.1016/j.foodqual.2018.01.007

Leroy, F., & Praet, I. (2015). Meat traditions. the co-evolution of humans and meat. *Appetite, 90*, 200-211. doi:S0195-6663(15)00116-6 [pii]

Leygonie, C., Britz, T. J., & Hoffman, L. C. (2012). Impact of freezing and thawing on the quality of meat: Review. *Meat Science, 91,* 93-98. https://doi.org/10.1016/j.meatsci.2012.01.013.

Li, B., Hayes, J. E., & Ziegler, G. R. (2014). Just-about-right and ideal scaling provide similar insights into the influence of sensory attributes on liking. *Food Quality and Preference, 37*, 71-78. doi:https://doi.org/10.1016/j.foodqual.2014.04.019

Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., . . . Bugeon, J. (2016). How muscle structure and composition influence meat and flesh quality. *The Scientific World Journal, 16* doi:https://doi.org/10.1155/2016/3182746

Liu, Y., Youssef, M. K., & Yang, X. (2016). Effects of dry chilling on the microflora on beef carcasses at a Canadian beef packing plant. *Journal of Food Protection, 79*, 538-543. doi:10.4315/0362-028X.JFP-15-476 ER

Lorenzo, J. M., Pateiro, M., & Franco, D. (2013). Influence of muscle type on physicochemical and sensory properties of foal meat. *Meat Science, 94*, 77-83. doi:https://doi.org/10.1016/j.meatsci.2013.01.001

Lorenzo, J. M., Purrinos, L., & Carballo, J. (2016). A survey on the effect of livestock production system and finishing diet on sensory characteristics of foal meat using Generalized Procrustes Analysis. *The Scientific World Journal,* 1-6. doi:https://doi.org/10.1155/2016/8729053

Lorenzo, J. M., Sarries, M. V., & Franco, D. (2013). Sex effect on meat quality and carcass traits of foals slaughtered at 15 months of age. *Animal, 7,* 1199-11207. http://doi:10.1017/S1751731113000189.

Lorenzo, J. M., Victoria Sarries, M., Tateo, A., Polidori, P., Franco, D., & Lanza, M. (2014b). Carcass characteristics, meat quality and nutritional value of horsemeat: A review. *Meat Science, 96*, 1478-1488. doi:https://doi.org/10.1016/j.meatsci.2013.12.006

Luiselli, L., Hema, E. M., Segniagbeto, G. H., Ouattara, V., Eniang, E. A., Vittorio, M. d., . . . Fa, J. E. (2019). Understanding the influence of non-wealth factors in determining bushmeat consumption: Results from four West African countries. *Acta Oecologica, 94*, 47-56. doi:10.1016/j.actao.2017.10.002 ER

MacRae, J., O'Reilly, L., & Morgan, P. (2005). Desirable characteristics of animal products from a human health perspective. *Livestock Production Science, 94*, 95-103. doi:https://doi.org/10.1016/j.livprodsci.2004.11.030

Maheswarappa, N. B., & Kiran, M. (2014). Emu meat: New source of healthier meat towards niche market. *Food Reviews International, 30*, 22-35. doi:10.1080/87559129.2013.853773

Mak, A. H. N., Lumbers, M., Eves, A., & Chang, R. C. Y. (2012). Factors influencing tourist food consumption. *International Journal of Hospitality Management, 31*, 928-936. doi:https://doi.org/10.1016/j.ijhm.2011.10.012

Mallikarjunan, P., & Mittal, G. S. (1996). Selection criteria for beef carcass chilling. *Food Research International, 29*(7), 661-666. doi:https://doi.org/10.1016/S0963-9969(96)00064-6

Mancini, R. A., & Hunt, M. C. (2005). Current research in meat color. *Meat Science, 71,* 100-121. http://doi:10.1016/j.meatsci.2005.03.003 ER.

Marescotti, M. E., Caputo, V., Demartini, E., & Gaviglio, A. (2019). Discovering market segments for hunted wild game meat. *Meat Science, 149*, 163-176. doi:10.1016/j.meatsci.2018.11.019 ER

Marques, C. S. S., Oaigen, R. P., Moraes, C. M. d., Santos, M A S dos, Lourenco Junior, J de B, & Abel, I. (2016). Segmentation of the buffalo meat consumer market in Belem, Para, Brazil. *Revista Brasileira De Zootecnia, 45*, 336-344.

Marshall, D., & Bell, R. (2004). Relating the food involvement scale to demographic variables, food choice and other constructs. *Food Quality and Preference, 15*, 871-879. doi:10.1016/j.foodqual.2004.06.003

Marshall, T., & McIntyre, B. L. (1989). A preliminary evaluation of the eating quality of meat derived from red kangaroos. *Australian Zoologist, 25*, 88-90. doi://dx.doi.org/10.7882/AZ.1989.009

Martinez-Navarrete, N., Camacho, M. M., Agudelo, C., & Salvador, A. (2018). Sensory characterization of juice obtained via rehydration of freeze-dried and spray-dried grapefruit. *Journal of the Science of Food and Agriculture, 99*, 244-252. doi:https://doi.org/10.1002/jsfa.9166 ER

Marzan, E. G.,Jr. (1982). Socio-economic factors and marketability of carabeef in Central Luzon. *CLSU Scientific Journal, 2*, 1-8.

Masson, M., Delarue, J., Bouillot, S., Sieffermann, J., & Blumenthal, D. (2016). Beyond sensory characteristics, how can we identify subjective dimensions? A comparison of six qualitative methods relative to a case study on coffee cups. *Food Quality and Preference, 47*, 156-165. doi:10.1016/j.foodqual.2015.01.003

McCarthy, M., de Boer, M., O'Reilly, S., & Cotter, L. (2003). Factors influencing intention to purchase beef in the Irish market. *Meat Science, 65*, 1071-1083. doi:https://doi.org/10.1016/S0309-1740(02)00325-X

McClenahan, J. M., & Driskell, J. A. (2002). Nutrient content and sensory characteristics of bison meat: *Historical Materials from University of Nebraska-Lincoln Extension, 144.* Retrieved from http://digitalcommons.unl.edu/extensionhist/144

McDaniel, J., Askew, W., Bennett, D., Mihalopoulos, J., Anantharaman, S., Fjeldstad, A. S., . . . Richardson, R. S. (2013). Bison meat has a lower atherogenic risk than beef in healthy men. *Nutrition Research, 33*, 293-302.

McGeehin, B., Sheridan, J. J., & Butler, F. (2002). Optimising a rapid chilling system for lamb carcasses. *Journal of Food Engineering, 52,* 75-81. doi:https://doi.org/10.1016/S0260-8774(01)00088-7

McGinnis, D. S., Aalhus, J. L., Chabot, B., Gariepy, C., & Jones, S. D. M. (1994). A modified hot processing strategy for beef: Reduced electrical energy consumption in carcass chilling. *Food Research International, 27*, 527-535. doi:10.1016/0963-9969(94)90138-4 ER

McLean-Meyinsse, P. (1999). An analysis of factors affecting consumers' decisions to shop at stores offering specialty meat. *Journal of Food Distribution Research, 30*, 134-139.

McSweeney, M. B., Duizer, L. M., Seetharaman, K., & Dan Ramdath, D. (2016). Assessment of important sensory attributes of millet-based snacks and biscuits. *Journal of Food Science, 81*, S1203-S1209.

McSweeney, M. B., Sisopha, A., T'ien, C., Rector, M., & Duizer, L. M. (2017). Comparing preferred attribute elicitation to trained panelists' evaluations using a novel food product. *Journal of Sensory Studies, 32* doi:10.1111/joss.12300 ER

Meiselman, H. L., Johnson, J. L., Reeve, W., & Crouch, J. E. (2000). Demonstrations of the influence of the eating environment on food acceptance. *Appetite, 35*, 231-237. doi:https://doi.org/10.1006/appe.2000.0360

Merle, S., Sencleer, J., Rodas-Gonzalez, A., Gonzalez, J., Mansutti, D., & Huerta-Leidenz, N. (2004). Comparison of water buffalo (*Bubalus bubalis*) vs zebu-type intact male bovines in slaughter characteristics, carcass traits, cutability and longissimus palatability. *Archivos Latinoamericanos De Produccion Animal, 12*, 110-118.

Miller, R. (2020). Drivers of consumer liking for beef, pork, and lamb: A review. *Foods (Basel, Switzerland), 9*, 428. doi: 10.3390/foods9040428. doi:10.3390/foods9040428 [doi]

Moussaoui, K. A., & Varela, P. (2010). Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis. *Food Quality and Preference, 21,* 1088-1099. http://doi://doi.org/10.1016/j.foodqual.2010.09.005.

Muggah, E. M., & McSweeney, M. B. (2017). Using preferred attribute elicitation to determine how males and females evaluate beer. *Journal of Food Science, 82*, 1916-1923. doi:10.1111/1750-3841.13799 ER

Muir, P. D., Deaker, J. M., & Bown, M. D. (1998). Effects of forage- and grain-based feeding systems on beef quality: A review. *New Zealand Journal of Agricultural Research, 41*, 623-635. doi:10.1080/00288233.1998.9513346

Mullen, A. M. (2002). New techniques for analysing raw meat quality. In J. Kerry, J. Kerry & D. Ledward (Eds.), *Meat processing* (pp. 394-416) Woodhead Publishing. doi:https://doi.org/10.1533/9781855736665.3.394

Narine, T., & Badrie, N. (2007). Influential factors affecting food choices of consumers when eating outside the household in Trinidad, West Indies. *Journal of Food Products Marketing, 13*, 19-29. doi:10.1300/J038v13n01_02

National Research Council of Canada. (2019). *Plant-based protein market: Global and Canadian market analysis*. Retrieved from https://nrc.canada.ca/en/research-development/research-collaboration/programs/plant-based-protein-market-global-canadian-market-analysis

Naveena, B. M., & Kiran, M. (2014). Buffalo meat quality, composition, and processing characteristics: Contribution to the global economy and nutritional security. *Animal Frontiers, 4*, 18-24. doi:10.2527/af.2014-0029 ER

Neely, T. R., Lorenzen, C. L., Miller, R. K., Tatum, J. D., Wise, J. W., Taylor, J. F., . . . Savell, J. W. (1998). Beef customer satisfaction: Role of cut, USDA quality grade, and city on in-home consumer ratings. *Journal of Animal Science, 76*, 1027-1033. doi:10.2527/1998.7641027x [doi]

Neethling, J., Hoffman, L. C., & Muller, M. (2016). Factors influencing the flavor of game meat: A review. *Meat Science, 113*, 139-153. doi:10.1016/j.meatsci.2015.11.022 ER

Nganje, E. W., & Kaitibie, S. (2003). *Food safety risk perception and consumer choice of specialty meats.* Agribusiness and Applied Economics Miscellaneous Report - Department of Agribusiness and Applied Economics, North Dakota State University, 193, 1-24.

Nganje, E. W., Kaitibie, S., & Taban, T. (2005). Multinomial logit models comparing consumers' and producers' risk perception of specialty meat. *Agribusiness (New York), 21*, 375-390. doi:10.1002/agr.20053 ER

Ngapo, T. M., Berge, P., Culioli, J., Dransfield, E., De Smet, S., & Claeys, E. (2002). Perimysial collagen crosslinking and meat tenderness in Belgian blue double-muscled cattle. *Meat Science, 61*, 91-102. doi:https://doi.org/10.1016/S0309-1740(01)00169-3

Nielsen, N. A., Bech-Larsen, T., & Grunert, K. G. (1998). Consumer purchase motives and product perceptions: A laddering study on vegetable oil in three countries. *Food Quality and Preference, 9*, 455-466. doi:https://doi.org/10.1016/S0950-3293(98)00022-6

Nosworthy, M. G., & House, J. D. (2017). Factors influencing the quality of dietary proteins: Implications for pulses. *Cereal Chemistry, 94*, 49-57. doi:10.1094/CCHEM-04-16-0104-FI

OECD. (2020). Meat consumption (indicator). Retrieved from https://data.oecd.org/agroutput/meat-consumption.htm.

Oloo, B., Mahungu, S., & Kahi, A. (2018). Descriptive sensory quality of Kenya's indigenous chicken meat from different ecotype-clusters reared under an intensive system. *African Journal of Food, Agriculture, Nutrition and Development, 18*, 13202-13225. doi:https://doi.org/10.18697/ajfand.81.16900 ER

O'Mahony, P. J. (2013). Finding horse meat in beef products—a global problem. *QJM: An International Journal of Medicine, 106*, 595-597. doi:10.1093/qjmed/hct087

Oxana, L., Anna, C., & Luis, G. (2016). A comparison of two methods for generating descriptive attributes with trained assessors: check-all-that-apply (CATA) vs. free choice profiling (FCP). *Journal of Sensory Studies, 31*, 163-176. http://doi:10.1111/joss.12202.

Pawshe, M., Khedkar, C., & Pundkar, C. (2016). Horse meat. In B. Caballero, P. Finglas & F. Toldrá (Eds.), *Reference module in food and health* (pp. 353-356). London: Elsevier.

Piaskowska, N., Daszkiewicz, T., Kubiak, D., & Janiszewski, P. (2015). The effect of gender on meat (*Longissimus lumborum* muscle) quality characteristics in the fallow deer (*Dama dama L.*). *Italian Journal of Animal Science, 14*, 3845. doi:10.4081/ijas.2015.3845

Pinto Neto, M., Beraquet, N. J., & Cardoso, S. (2013). Effects of chilling methods and hot-boning on quality parameters of *M. Longissimus lumborum* from *Bos indicus nelore* steer. *Meat Science, 93*, 201-206. doi:https://doi/10.1016/j.meatsci.2012.08.024

Pinto, Leticia de Paula F., Silva, H. L. A., Kuriya, S. P., Macaira, P. M., Cyrino Oliveira, F. L., Cruz, A. G., . . . Freitas, M. Q. (2018). Understanding perceptions and beliefs about different types of fermented milks through the application of projective techniques: A case study using Haire's shopping list and free word association. *Journal of Sensory Studies, 33*, e12326. doi:10.1111/joss.12326

Piqueras-Fiszman, B., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study

involving jam jars. *Food Quality and Preference, 28*, 328-338. doi:10.1016/j.foodqual.2012.10.006

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*, 105-120. doi:https://doi.org/10.1016/0195-6663(92)90014-W

Pliner, P., & Melo, N. (1997). Food neophobia in humans: Effects of manipulated arousal and individual differences in sensation seeking. *Physiology & Behavior, 61*, 331-335. doi:10.1016/S0031-9384(96)00406-4 ER

Polawska, E., Cooper, R. G., Jozwik, A., & Pomianowski, J. (2013). Meat from alternative species - nutritive and dietetic value, and its benefit for human health - a review. *CyTA -- Journal of Food, 11*, 37-42.

Polizer Rocha, Y. J., Lapa-Guimaraes, J., de Noronha, Regina Lucia F., & Trindade, M. A. (2018). Evaluation of consumers' perception regarding frankfurter sausages with different healthiness attributes. *Journal of Sensory Studies, 33*, e12468. doi:10.1111/joss.12468

Popoola, I. O., Bruce, H. L., McMullen, L. M., & Wismer, W. V. (2019). Consumer sensory comparisons among beef, horse, elk, and bison using preferred attributes elicitation and check-all-that-apply methods. *Journal of Food Science, 84*, 3009-3017. doi:10.1111/1750-3841.14780

Postolache, A. N., Boisteanu, P. C., & Lazar, R. (2011). Red deer meat (*Cervus elaphus L.*): Between hunting and necessity. *Lucrari Stiintifice - Universitatea De Stiinte Agricole Si Medicina Veterinara, Seria Zootehnie, 56*, 265-269.

Prabhakar, K., & Rao, N. P. L. (1986). Comparison of organoleptic and related characters of buffalo meat with beef. *Journal of Food Science and Technology, India, 23*, 90-93.

Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference, 13*, 489-495.

R Core Team. (2018). R: A language and environment for statistical computing. R foundation for statistical computing [computer software]. Vienna, Austria:

Radder, L. (2002). Restaurants and venison marketing: A South African experience. *Food Service Technology, 2*, 109-114. doi://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1471-5740/issues

Radder, L., & Grunert, K. G. (2009). Consumers' perceptions of African wildlife meat: A laddering study. *Journal of Food Products Marketing, 15*(2), 164-174. doi:10.1080/10454440802317022 ER

Radder, L., & Le Roux, R. (2005). Factors affecting food choice in relation to venison: A South African example. *Meat Science, 71*, 583-589.

Rahman, M. M., Walker, B., Roy, B. C., McMullen, L., & Bruce, H. L. (2017). Effects of chilling and ageing period on horse meat quality. *Proceedings of the 63rd International Congress of Meat Science and Technology, Cork, Ireland, 13-18, August, 2017, 212-213.*

Ranabhat, L. C., Park, M., & Kim, C. (2020). Influence of alcohol and red meat consumption on life expectancy: Results of 164 countries from 1992 to 2013. *Nutrients, 12* doi:10.3390/nu12020459

Rao, V. A., Thulasi, G., & Ruban, S. W. (2009). Effect of age and sex on meat quality characteristics of South Indian non-descript buffalo. *Buffalo Bulletin, 28*, 138-147.

Realini, C. E., Font i Furnols, M., Guerrero, L., Montossi, F., Campo, M. M., Sañudo, C., . . . Oliver, M. A. (2009). Effect of finishing diet on consumer acceptability of Uruguayan beef in the European market. *Meat Science, 81*, 499-506. doi:https://doi.org/10.1016/j.meatsci.2008.10.005

Rebollar, R., Lidon, I., Gil-Perez, I., & Martin, J. (2019). How should I tell you this? the effects of the image used to convey that a natural yogurt is sweetened on consumer expectations

and willingness to buy. *Food Research International, 126* doi:10.1016/j.foodres.2019.108721 ER

Resurreccion, A. V. A. (2003). Sensory aspects of consumer choices for meat and meat products. *Meat Science, 66*, 11-20. doi://doi.org/10.1016/S0309-1740(03)00021-4

Rincker, P. J., Bechtel, P. J., Finstadt, G., Van Buuren, R., Killefer, J., & McKeith, F. K. (2006). Similarities and differences in composition and selected sensory attributes of reindeer, caribou and beef. *Journal of Muscle Foods, 17*, 65-78. doi:10.1111/j.1745-4573.2006.00036.x

Ripoll, G., & Panea, B. (2019). The effect of consumer involvement in light lamb meat on behavior, sensory perception, and health-related concerns. *Nutrients, 11*, 1200. doi: 10.3390/nu11061200. doi:10.3390/nu11061200 [doi]

Ritchie, H., & Roser, M. (2019). Meat and dairy production. Retrieved from https://ourworldindata.org/meat-production

Robertson, J., Bouton, P. E., Harris, P. V., Shorthose, W. R., & Ratcliff, D. (1983). A comparison of some properties of beef and buffalo (*Bubalus bubalis*) meat. *Journal of Food Science, 48*, 686-690,. doi:10.1111/j.1365-2621.1983.tb14876.x ER

Rodbotten, M., Ueland, O., Lea, P., & Kubberod, E. (2004). A sensory map of the meat universe. sensory profile of meat from 15 species. *Meat Science, 68,* 137-144. https://doi.org/10.1016/j.meatsci.2004.02.016.

Rodrigues, I., Goncalves, L. A., Carvalho, F. A., Pires, M., Rocha, Y. J. P., Barros, J. C., . . . Trindade, M. A. (2020). Understanding salt reduction in fat-reduced hot dog sausages: Network structure, emulsion stability and consumer acceptance. *Food Science and Technology International, 26*, 123-131. doi:10.1177/1082013219872677 ER

Roininen, K., Arvola, A., & Lahteenmaki, L. (2006). Exploring consumers' perceptions different qualitative of local food with two techniques: Laddering and word association. *Food Quality and Preference, 17*, 20-30. doi:10.1016/j.foodqual.2005.04.012

Rojas-Rivas, E., Espinoza-Ortega, A., Thome-Ortiz, H., & Moctezuma-Perez, S. (2019). Consumers' perception of amaranth in Mexico. *British Food Journal, 121*, 1190-1202. doi:10.1108/BFJ-05-2018-0334 ER

Rossier, E. (2003). Horse meat. In B. Caballero (Ed.), *Encyclopedia of Food Sciences and Nutrition (second edition)* (pp. 3174-3178). Oxford: Academic Press. doi:https://doi.org/10.1016/B0-12-227055-X/00607-6

Roth, D. M., Brewer, M. S., Bechtel, P. J., Kline, K. H., & McKeith, F. K. (1995). Sensory, color, and composition characteristics of young and mature chevaline. *Journal of Muscle Foods, 6*, 83-89. doi:10.1111/j.1745-4573.1995.tb00559.x ER

Roy, B. C., Walker, B., Rahman, M. M., Bruce, H. L., & McMullen, L. (2018). Role of myofibers, perimysium and adipocytes in horse meat toughness. *Meat Science, 146*, 109-121. doi:https://doi.org/10.1016/j.meatsci.2018.08.005

Rozin, P. (2006). The integration of biological, social, cultural and psychological influences on food choice. In R. Shepherd, & M. Raats (Eds.), *The psychology of food choice* (pp. 19-39). Oxfordshire: CAB International.

Rubio, B., Vieira, C., Martinez, B., & Fernandez, A. M. (2013). Effect of different post-mortem temperatures on carcass quality of suckling lamb. *Food Science and Technology International, 19*, 351-356.

Ruby, M. B., Alvarenga, M. S., Rozin, P., Kirby, T. A., Richer, E., & Rutsztein, G. (2016). Attitudes toward beef and vegetarians in Argentina, Brazil, France, and the USA. *Appetite, 96*, 546-554. doi:https://doi.org/10.1016/j.appet.2015.10.018

Ruicong Zhi, Lei Zhao, & Jingye Shi. (2016). Improving the sensory quality of flavored liquid milk by engaging sensory analysis and consumer preference. *Journal of Dairy Science, 99*, 5305-5317. doi:https://doi.org/10.3168/jds.2015-10612 ER

Rule, D. C., Broughton, K. S., Shellito, S. M., & Maiorano, G. (2002). Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. *Journal of Animal Science, 80*, 1202-1211.

Saha, A., Lee, Y., Meullenet, J. F., & Owens, C. M. (2009). Consumer acceptance of broiler breast fillets marinated with varying levels of salt. *Poultry Science, 88*, 415-423. doi:10.3382/ps.2008-00230 ER

Sanderson, K., Hobbs, J. E., Shand, P., & Kerr, W. A. (2002). Consumer preferences in the emerging bison industry: Marketing implications. *Journal of International Food & Agribusiness Marketing, 14*, 57-78. doi:10.1300/J047v14n03_05 ER

Sarin, H. V., Taba, N., Fischer, K., Esko, T., Kanerva, N., Moilanen, L., . . . Perola, M. (2019). Food neophobia associates with poorer dietary quality, metabolic risk factors, and increased disease outcome risk in population-based cohorts in a metabolomics study. *American Journal of Clinical Nutrition, 110*, 233-245. doi:10.1093/ajcn/nqz100 ER

Sarries, M. V., & Beriain, M. J. (2005). Carcass characteristics and meat quality of male and female foals. *Meat Science, 70*, 141-152. doi:10.1016/j.meatsci.2004.12.006

Savell, J. W., Mueller, S. L., & Baird, B. E. (2005). The chilling of carcasses. *Meat Science, 70*, 449-459. doi:https://doi.org/10.1016/j.meatsci.2004.06.027 ER

Schmitt, N. (1998). Quantifying word association responses: What is native-like? *System, 26*, 389-401. doi:https://doi.org/10.1016/S0346-251X(98)00019-0

Schouteten, J. J., Gellynck, X., & Slabbinck, H. (2019). Influence of organic labels on consumer's flavor perception and emotional profiling: Comparison between a central

location test and home-use-test. *Food Research International, 116*, 1000-1009. doi:https://doi.org/10.1016/j.foodres.2018.09.038

Schupp, A., Gillespie, J., & Reed, D. (1998). Consumer choice among alternative red meats. *Journal of Food Distribution Research, 29*, 35-43.

Schupp, A., Gillespie, J., O'Neil, C. E., Witoon Prinyawiwatkul, & Makienko, I. (2005). The impact of an "exotic" label on consumer willingness to taste test, purchase, and price a new meat product. *Journal of Food Distribution Research, 36*, 50-60.

Segato, S., Cozzi, G., & Andrighetto, I. (1999). In Piva, G. Bertoni, G. Masoero, F. Bani, P. Calamari,L. (Ed.), *Effect of animal morphotype, sex and age on quality of horse meat imported from Poland.* Recent progress in animal production science. Proceedings of the A.S.P.A XIII Congress, Piacenza, Italy, 21-24 June, 1999.

Seong PilNam, Park KuyngMi, Cho SooHyun, Kang GeunHo, Chae HyunSeok, Park BeomYoung, & Hoa Van Ba. (2016). Effect of cut type and post-mortem ageing on the technological quality, textural profile and sensory characteristics of horse meat. *Animal Production Science, 56*, 1551-1559.

Seong PilNam, Park KyoungMi, Cho SooHyun, Kang GeunHo, Kang SunMun, Park BeomYoung, & Ba HoaVan. (2014). Effect of post-mortem ageing time on quality characteristics of horse meat. *Archivos Latinoamericanos De Produccion Animal, 22*, 69-71.

Serrano-Cruz, M. R., Espinoza-Ortega, A., Sepulveda, W. S., Vizcarra-Bordi, I., & Thome-Ortiz, H. (2018). Factors associated with the consumption of traditional foods in Central Mexico. *British Food Journal, 120*, 2695-2709. doi:10.1108/BFJ-11-2017-0663

Sester, C., Dacremont, C., Deroy, O., & Valentin, D. (2013). Investigating consumers' representations of beers through a free association task: A comparison between packaging and blind conditions. *Food Quality and Preference, 28*, 475-483. doi:10.1016/j.foodqual.2012.11.005

Shan, L. C., Henchion, M., De Brún, A., Murrin, C., Wall, P. G., & Monahan, F. J. (2017). Factors that predict consumer acceptance of enriched processed meats. *Meat Science, 133*, 185-193. doi:https://doi.org/10.1016/j.meatsci.2017.07.006

Sheng-Hang Chan, Moss, B. W., Farmer, L. J., Gordon, A., & Cuskelly, G. J. (2013). Comparison of consumer perception and acceptability for steaks cooked to different endpoints: Validation of photographic approach. *Food Chemistry, 136*, 1597-1602. doi:10.1016/j.foodchem.2012.04.069 ER

Sheridan, J. J. (1990). The ultra-rapid chilling of lamb carcasses. *Meat Science, 28*, 31-50. doi:https://doi.org/10.1016/0309-1740(90)90018-2

Sinesio, F., Saba, A., Peparaio, M., Saggia Civitelli, E., Paoletti, F., & Moneta, E. (2019). Reprint of "capturing consumer perception of vegetable freshness in a simulated real-life taste situation". *Food Research International, 117*, 2-9. doi:https://doi.org/10.1016/j.foodres.2018.10.084

Soares, E. K. B., Esmerino, E. A., Ferreira, M. V. S., da Silva, Maria Aparecida A. P., Freitas, M. Q., & Cruz, A. G. (2017). What are the cultural effects on consumers' perceptions? A case study covering coalho cheese in the Brazilian Northeast and Southeast area using word association. *Food Research International, 102*, 553-558.

Soriano, A., Montoro, V., Vicente, J., Sanchez-Migallon, B. F., Benitez, S., Utrilla, M. C., & Garcia Ruiz, A. (2016). Influence of evisceration time and carcass ageing conditions on wild venison quality. preliminary study. *Meat Science, 114*, 130-136. doi:10.1016/j.meatsci.2015.12.021 ER

Spanier, A. M., Flores, M., McMillin, K. W., & Bidner, T. D. (1997). The effect of post-mortem aging on meat flavor quality in brangus beef. correlation of treatments, sensory, instrumental and chemical descriptors. *Food Chemistry, 59*, 531-538. doi:https://doi.org/10.1016/S0308-8146(97)00003-4

Statista. (2016). Meat consumption habits in Canada from 2013 to 2015. Retrieved from https://www.statista.com/statistics/521135/meat-consumption-canada/

Statista. (2019a). Consumption of beef per capita in Canada from 2000 to 2020. Retrieved from https://www.statista.com/statistics/735166/consumption-of-milk-per-capita-canada/

Statista. (2019b). Per capita meat consumption in Canada from 1998 to 2018, by type. Retrieved from https://www.statista.com/statistics/442461/per-capita-meat-consumption-by-type-canada/

Statistics Canada. (2017). Canada at a glance 2017: Education. Retrieved from https://www150.statcan.gc.ca/n1/pub/12-581-x/2017000/edu-eng.htm

Steiner, B., Gao Fei, & Unterschultz, J. (2010). Alberta consumers' valuation of extrinsic and intrinsic red meat attributes: A choice experimental approach. *Canadian Journal of Agricultural Economics, 58*, 171-189. doi:10.1111/j.1744-7976.2009.01177.x ER

Stelick, A., & Dando, R. (2018). Thinking outside the booth—the eating environment, context and ecological validity in sensory and consumer research. *Current Opinion in Food Science, 21*, 26-31. doi:https://doi.org/10.1016/j.cofs.2018.05.005

Strydom, P., Luhl, J., Kahl, C., & Hoffman, L. C. (2016). Comparison of shear force tenderness, drip and cooking loss, and ultimate muscle pH of the loin muscle among grass-fed steers of four major beef crosses slaughtered in Namibia. *South African Journal of Animal Science, 46*, 348-359. doi:https://doi.org/10.4314/sajas.v46i4.2 ER

Suman, S. P., & Joseph, P. (2013). Myoglobin chemistry and meat color. *Annual Review of Food Science and Technology, Vol 4,* 79-99. doi:https://doi.org/10.1146/annurev-food-030212-182623

Sveinsdottir, K., Martinsdottir, E., Thorsdottir, F., Schelvis-Smit, A. A. M., Kole, A., & Thorsdottir, I. (2010). Evaluation of farmed cod products by a trained sensory panel and

consumers in different test settings. *Journal of Sensory Studies, 25*, 280-293. doi:https://doi.org/10.1111/j.1745-459X.2009.00257.x

Tateo, A., De Palo, P., Ceci, E., & Centoducati, P. (2008). Physicochemical properties of meat of Italian heavy draft horses slaughtered at the age of eleven months. *Journal of Animal Science, 86*, 1205-1214. doi:https://doi.org/10.2527/jas.2007-0629

Tolusic, Z., Florijancic, T., Kralik, I., Sesar, M., & Tolusic, M. (2006). Game meat market in Eastern Croatia. *Poljoprivreda, 12*, 58-63.

Tomasevic, I., & Rajkovic, A. (2015). The sensory quality of meat, game, poultry, seafood and meat products as affected by intense light pulses: A systematic review. *Procedia Food Science, 5*, 285-288. doi:10.1016/j.profoo.2015.09.081 ER

Tomasevic, I., Novakovica, S., Solowiej, B., Zdolec, N., Skunca, D., Krocko, M., . . . Djekic, I. (2018). Consumers' perceptions, attitudes and perceived quality of game meat in ten European countries. *Meat Science, 142*, 5-13. doi:10.1016/j.meatsci.2018.03.016

Torok, S. J., Bradley, E., Phillips, C., & Bernateau, G. (1996). International market segmentation analysis of a new meat product. *Agribusiness, 12*, 443-459.

Torok, S. J., Mittelstaedt, J., May, G. J., Tatsch, K., & Bradley, E. (1998). Identification of bison consumer characteristic dimensions and restaurant marketing strategies. *Agribusiness: An International Journal, 14*, 33-48.

Tuorila, H., & Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Current Opinion in Food Science, 33*, 1-8. doi:https://doi.org/10.1016/j.cofs.2019.09.004

Umberger, W. J., Feuz, D. M., Calkins, C. R., & Killinger-Mann, K. (2002). U.S. consumer preference and willingness-to-pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction. *Agribusiness, 18*, 491-504. doi:10.1002/agr.10034

Vaca, S. I., & Mesias, F. J. (2014). Spanish consumer perceptions towards fruits from Ecuador: A preliminary qualitative approach with projective techniques. *Itea-Informacion Tecnica Economica Agraria, 110*, 89-101.

van Trijp, H. C. M., & Steenkamp, J. E. M. (1992). Consumers' variety seeking tendency with respect to foods: Measurement and managerial implications, *European Review of Agricultural Economics, 19*, 181-195.

van Trijp, H. C. M., Lahteenmaki, L., & Tuorila, H. (1992). Variety seeking in the consumption of spread and cheese. *Appetite, 18*, 155-164. doi:10.1016/0195-6663(92)90192-9

Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. *Food Research International, 48,* 893-903. http://doi://doi.org/10.1016/j.foodres.2012.06.037.

Verbeke, W., & Vackier, I. (2004). Profile and effects of consumer involvement in fresh meat. *Meat Science, 67*, 159-168. doi:https://doi.org/10.1016/j.meatsci.2003.09.017

Viana, M. M., dos Santos Silva, Vivian Lara, & Trindade, M. A. (2014). Consumers' perception of beef burgers with different healthy attributes. *Lwt-Food Science and Technology, 59*(2), 1227-1232. doi:10.1016/j.lwt.2014.05.009

Vidal, L., Ares, G., & Gimenez, A. (2013). Projective techniques to uncover consumer perception: Application of three methodologies to ready-to-eat salads. *Food Quality and Preference, 28*, 1-7. doi:10.1016/j.foodqual.2012.08.005

von Massow, M., & Weersink, A. (2019). Meat consumption is changing but it's not because of vegans. Retrieved from https://news.uoguelph.ca/2019/03/meat-consumption-is-changing-but-its-not-because-of-vegans/

Wadolowska, L., Babicz-Zielinska, E., & Czarnocinska, J. (2008). Food choice models and their relation with food preferences and eating frequency in the Polish population: POFPRES study. *Food Policy, 33*, 122-134. doi:10.1016/j.foodpol.2007.08.001 ER

Waitt, G. (2014). Embodied geographies of kangaroo meat. *Social & Cultural Geography, 15*(4), 406-426. doi:10.1080/14649365.2014.894113

Waitt, G., & Appleby, B. (2014). 'It smells disgusting': Plating up kangaroo for a changing climate. *Continuum-Journal of Media & Cultural Studies, 28*, 88-100. doi:10.1080/10304312.2013.854863

Walker, B. (2017). *Impact of Carcass Chill Time on the Microbiology of Horse Meat.* Retrieved from https://era.library.ualberta.ca/items/502543e7-6ddc-4f59-90fb-b786ad9cfee9/view/fd5ba37d-3bca-48c0-ab81-3a4150e49074/Walker_Brian_D_201709_MSc.pdf

Walker, B., Bruce, H., & McMullen, L. (2017). Effects of boning time on bacterial load of horse meat. *Journal of Food Protection, 80* doi:https://doi.org/10.4315/0362-028X-80.sp1.1 ER

Wassenaar, A., Kempen, E., & van Eeden, T. (2019). Exploring South African consumers' attitudes towards game meat-utilizing a multi-attribute attitude model. *International Journal of Consumer Studies, 43*, 437-445. doi:10.1111/ijcs.12523

Wiklund, E., Barnier, V. M. H., Smulders, F. J. M., Lundström, K., & Malmfors, G. (1997). Proteolysis and tenderisation in reindeer (*Rangifer tarandus tarandus L.*) bull *Longissimus thoracis* muscle of varying ultimate pH. *Meat Science, 46*, 33-43. doi:https://doi.org/10.1016/S0309-1740(97)00015-6

Wiklund, E., Dobbie, P., Stuart, A., & Littlejohn, R. P. (2010). Seasonal variation in red deer (*Cervus elaphus*) venison (M. longissimus dorsi) drip loss, calpain activity, color and tenderness. *Meat Science, 86*, 720-727. doi:https://doi.org/10.1016/j.meatsci.2010.06.012

Wiklund, E., Johansson, L., & Malmfors, G. (2003). Sensory meat quality, ultimate pH values, blood parameters and carcass characteristics in reindeer (*Rangifer tarandus tarandus L.*) grazed on natural pastures or fed a commercial feed mixture. *Food Quality and Preference, 14*, 573-581. doi://doi.org/10.1016/S0950-3293(02)00151-9

Wiklund, E., Manley, T. R., Littlejohn, R. P., & Stevenson-Barry, J. M. (2003). Fatty acid composition and sensory quality of musculus longissimus and carcass parameters in red deer (*Cervus elaphus*) grazed on natural pasture or fed a commercial feed mixture. *Journal of the Science of Food and Agriculture, 83*, 419-424. doi:10.1002/jsfa.1384

Wilson, G., & Edwards, M. (2019). Professional kangaroo population control leads to better animal welfare, conservation outcomes and avoids waste. *Australian Zoologist, 40*, 181-202. doi:10.7882/AZ.2018.043

Wood, J. D., & Enser, M. (2017). Manipulating the fatty acid composition of meat to improve nutritional value and meat quality. In P. P. Purslow (Ed.), *New aspects of meat quality* (pp. 501-535) Woodhead Publishing. doi://doi.org/10.1016/B978-0-08-100593-4.00023-0

Wood, J. D., Richardson, R. I., Nute, G. R., Fisher, A. V., Campo, M. M., Kasapidou, E., . . . Enser, M. (2004). Effects of fatty acids on meat quality: A review. Meat Science, *66,* 21-32*,* http://doi://doi.org/10.1016/S0309-1740(03)00022-6.

World Health Organization. (2004). *Global strategy on diet, physical activity and health*. Geneva, Switzerland. Retrieved from https://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf?ua=1

Wu, W., Fu, Y., Therkildsen, M., Li, X., & Dai, R. (2015). Molecular understanding of meat quality through application of proteomics. *Food Reviews International, 31*, 13-28. doi:10.1080/87559129.2014.961073

Wynn, P., Beaton, A., & Spiegel, N. (2004). Meat quality of kangaroos. *Rural Industries Research and Development Corporation, 4,* 1-71.

Yancey, E. J., Grobbel, J. P., Dikeman, M. E., Smith, K. A., Hachmeister, E. C., Chambers IV, E. C., . . . Dressler, E. A. (2006). Effects of total iron, myoglobin, hemoglobin, and lipid oxidation of uncooked muscles on livery flavor development and volatiles of cooked beef steaks. *Meat Science*, *73*, 680-686.

Youngseung Lee, Rui Xiong, & Meullenet, J. F. (2014). Prediction of sensory texture of broiler breast meat using instrumental spectral stress-strain analysis. *International Journal of Food Science & Technology, 49*, 2269-2275.

Yung Hung, & Verbeke, W. (2018). Sensory attributes shaping consumers' willingness-to-pay for newly developed processed meat products with natural compounds and a reduced level of nitrite. *Food Quality and Preference, 70*, 21-31. doi:https://doi.org/10.1016/j.foodqual.2017.02.017 ER

Zanoli, R., Scarpa, R., Napolitano, F., Piasentier, E., Naspetti, S., & Bruschi, V. (2013). Organic label as an identifier of environmentally related quality: A consumer choice experiment on beef in Italy. *Renewable Agriculture and Food Systems, 28*, 70-79. doi:10.1017/S1742170512000026

Zhu, L., Gao, S., & Luo, X. (2011). Rapid chilling has no detrimental effect on the tenderness of low-voltage electrically stimulated *M. longissimus* in Chinese bulls. *Meat Science, 88*, 597-601. doi:https://doi.org/10.1016/j.meatsci.2011.02.005

APPENDICES

Appendix 1: Database search string for Chapter 2

1. Search string for sensory studies: (((("unconventional meat") OR ("exotic meat") OR ("less common meat") OR ("unusual meat") OR ("alternate meat") OR ("alternate meat specie*") OR ("squirrel meat") OR ("horse meat") OR ("kangaroo meat") OR ("camel meat") OR ("donkey meat") OR ("rabbit meat") OR ("seal meat") OR ("bison meat") OR ("beefalo meat") OR ("buffalo meat") OR ("yak meat") OR ("deer meat") OR ("venison") OR ("elk meat") OR ("moose meat") OR ("caribou meat") OR ("antelope meat") OR ("game meat"))) & ((("sensory profil*") OR ("textur* profil*") OR ("flavor profil*") OR ("flavor profil*") OR ("sensory attribute*") OR ("sensory test*") OR ("sensory qualit*") OR ("sensory character*") OR ("eating qualit*") OR (palatability) OR (taste) OR (tenderness) OR (juiciness) OR ("sensory evaluation") OR ("sensory propert*") OR (texture) OR ("textur* qualit*") OR ("textur* character*") OR ("textur* propert*") OR ("organoleptic propert*") OR ("organoleptic character*") OR ("sensory analysis")))) .

2. Search string for consumer studies: (((("unconventional meat") OR ("exotic meat") OR ("less common meat") OR ("unusual meat") OR ("alternate meat") OR ("alternate meat specie*") OR ("squirrel meat") OR ("horse meat") OR ("kangaroo meat") OR ("camel meat") OR ("donkey meat") OR ("rabbit meat") OR ("seal meat") OR ("bison meat") OR ("beefalo meat") OR ("buffalo meat") OR ("yak meat") OR ("deer meat") OR ("venison") OR ("elk meat") OR ("moose meat") OR ("caribou meat") OR ("antelope meat") OR ("game meat"))) & ((("consumer* attitude*") OR ("consumer* percept*") OR ("consumer* opinion*") OR ("consumer* belief*") OR ("consumer* factor*") OR ("consumer* accept*") OR ("consumer* prefer*") OR ("consumer* behaviour") OR ("consumer* behavior") OR ("consumer* concern*") OR ("consumer* response*")))) .