Sensory Acceptability of Buffalo Meat and Beef in Young Consumers

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Abstract: *Background*: The aim of this study was to evaluate the sensory acceptability of buffalo meat compared to beef, as well as to evaluate the perception of buffalo meat.

Methods: The study was conducted with young meat consumers, who responded to a questionnaire with four sections: 1) sociodemographic aspects, 2) consumer preferences, 3) hedonic acceptability, and 4) perception of buffalo meat consumption. Three 2.5 cm thick steaks (*Longissimus thoracis et lumborum*) were compared: 1) select beef (slight marbling); 2) select buffalo meat (slight marbling); 3) prime beef (abundant marbling). The samples were evaluated by 76 young meat consumers (non-trained panelists). A seven-point hedonic scale was used to assess appearance, odor, flavor, tenderness, juiciness, and overall acceptability.

Results: The results indicated that prime beef presented a better appearance (P=0.0042) and tenderness (P<0.0001) compared to select buffalo and select beef, respectively. Similarly, a higher score was observed in juiciness for prime beef (5.52±0.19 points), but a better score for buffalo meat compared to beef select was identified (4.52±0.18 points vs. 3.86±0.19 points, respectively; P<0.001). Most of the panelists indicated that prior to the study, they had not consumed buffalo meat (89.00%/n=68). However, they noted that buffalo meat was like select beef (71.00%/n=54). The panelist highlighted various reasons why buffalo meat is not commonly consumed, such as there is no information on the buffalo meat (93.42%/n=71), limited availability of buffalo meat products (60.52%/n =46), and unavailability at supermarkets (73.69%/n=56).

Conclusions: Buffalo meat can be a good option for young consumers. However, more information about buffalo meat characteristics (chemical, nutritional, sensory properties, and technological quality) and improved marketing channels that ensure the availability of buffalo products are important.

Keywords: Consumers, beef, buffalo meat, sensory properties, quality, acceptability.

INTRODUCTION

Buffaloes are reared for different purposes (primarily milk, meat, and work). Global buffalo meat production (4.290.212 tons) accounts for approximately 5.86% of total meat production, while buffalo milk accounts for roughly 15.14% of total primary milk production (883.283.663 tons) in the world [1]. It is estimated that just over 208 million buffalo are distributed across 77 countries on five continents [2].

In recent years, buffalo meat has gained popularity due to its nutritional properties [3]. Buffalo meat could be a viable option for meeting future global protein demands [4]. With the increasing demand for safe and healthy foods, coupled with consumers' focus on quality of life, buffalo meat is seen as an attractive alternative protein source [5]. Buffalo meat consumption may offer several cardiovascular benefits, including a reduced carotid atherosclerotic burden and decreased susceptibility to oxidative stress [6]. Furthermore, buffalo meat is like beef in terms of composition, quality, and organoleptic characteristics but has the added advantage of being lower in fat, cholesterol, and calories [7, 8].

Despite its nutritional benefits, buffalo meat consumption is low compared to beef. In most countries, buffalo carcasses are introduced to the market without species differentiation, resulting in few consumers actively choosing buffalo meat [9]. A previous Brazilian study found that buffalo meat is not widely consumed due to a lack of knowledge or

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recognition of the differences between various ruminant meats, even though lean buffalo and beef are often indistinguishable [5]. Various factors influence meat selection, including color, texture, juiciness, flavor, and aroma, as well as psychological and marketing factors, label information, packaging, price, and consumers' sociodemographic and cultural characteristics [10]. Among sociodemographic factors, age is the primary factor that differentiates consumer attitudes toward meat products, with younger consumers prioritizing intrinsic characteristics [11]. Prior to consumption, appearance, color, and shape are primary drivers of purchasing behavior, whereas taste and texture are more important post-consumption [12].

Since consumers are the final link in the production chain, identifying the factors influencing their purchasing decisions is crucial for the meat industry to better meet consumer expectations, demands, and needs [13]. Various tests are employed under different conditions to understand the sensory profiles of foods. The most common method for untrained participants or consumers is the hedonic scale, also known as the consumer acceptability test or subjective analysis. This scale provides information on the overall acceptance or rejection of a product based on specific sensory properties [12]. Studies have indicated that trained sensory panelists can discriminate sensory attributes of meat. However, untrained consumers' sensory evaluations are influenced by the information provided, thus influencing their perceptions and expectations [14]. Consequently, it was hypothesized that withholding information about the origin of meat (buffalo *vs.* beef) would not affect consumers' sensory acceptability. Therefore, this study aimed to evaluate the sensory acceptability of buffalo meat compared to beef and to identify consumer perceptions related to meat consumption.

METHODOLOGY

This study was conducted in the Laboratory of Dietary Techniques of the Universidad del Valle de México-Coyoacán, Mexico City. Seventy-six students (non-trained panelists) enrolled in the Food Quality and Safety course within the Veterinary Medicine and Zootechnics program at UVM participated. Participants were recruited based on the following inclusion criteria: being meat consumers with interest and availability to participate [10]. Informed consent was obtained from all participants in accordance with the Helsinki Declaration [15]. The questionnaire comprised four sections: 1) sociodemographic information, 2) consumer preferences, 3) hedonic acceptability, and 4) perception of buffalo meat consumption. Questionnaire sections were administered at three different times: before (sections 1 and 2), during (section 3), and after (section 4) the sensory evaluation. Following the sensory evaluation, participants were provided with information regarding general buffalo characteristics and the physicochemical and nutritional properties of buffalo meat to avoid influencing the sensory evaluation score before the sensory analysis. Questionnaires were administered using Google Forms®.

Three types of 2.5 cm thick New York steaks (*Longissimus thoracis et lumborum*) were compared: 1) select grade lean beef, 2) select classified buffalo meat, and 3) prime graded beef (Figure **1**), in accordance with NOM-004-SAGARPA-2018 [16]. The

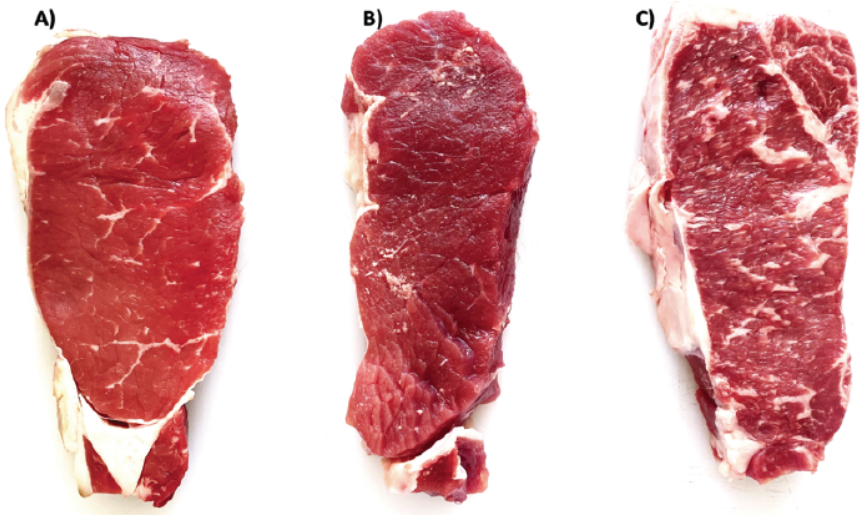

Figure 1: New York steaks samples: **A**) Select beef; **B**) Select buffalo meat; **C**) Prime beef.

meat samples were donated by water buffalo producers. Buffaloes were slaughtered in Federal Inspection Type Establishments (TIF), certified meat processing facilities, following the regulations of the Ministry of Agriculture and Rural Development in Mexico (SADER). Prior to cooking, the steaks were seasoned with 1% sodium chloride. The samples were then pan-cooked until reaching an internal temperature of 71°C (160°F) at the geometric center [11]. After cooking, the steaks were wrapped in aluminum foil for 10 minutes. Each steak was then cut into approximately 1.3 x 1.3 x 1.3 cm cubes, with care taken to avoid excessive fat and connective tissue [17].

Each cooked sample was presented to each panelist on a coded porcelain plate in a blind manner. The samples were coded using three-digit random numbers. Water, unsalted toast, and whole coffee beans were provided at the beginning of the session and between samples to cleanse the palate and neutralize odors, respectively. A seven-point hedonic scale was used to assess appearance, odor, flavor, tenderness, juiciness, and overall acceptability. A score ranged from 1 to 7 with the following ratings: 7 = liked extremely, 6 = liked moderately, 5 = liked slightly, 4 = indifferent, 3 = slightly disliked, 2 = moderately disliked, and 1 = disliked extremely [18].

Statistical Analysis

Analysis of variance (ANOVA) was performed using PROC GLM in JMP®, with sensory characteristics as dependent variables and meat type as independent variables. Where significant differences were detected, a multiple comparison Tukey test was utilized ($P<0.05$). Spearman's correlation was used to assess the association among the sensory variables at a significance level of $P<0.0001$ [11].

RESULTS AND DISCUSSION

Table **1** presents the sociodemographic characteristics of the respondents. The majority were women aged 19–24 years and single. Most respondents were students only and had a weekly income between $50 and $75 USD. The population, with a majority of female participants, aligns with the gender composition of veterinary schools worldwide, which typically ranges from 55 to 78% female students, consistent with the present study [19].

Table **2** shows that panelists indicated that the most consumed meat was chicken, followed by beef. This is consistent with a previous study [20], which found that the three most consumed types of meat in Mexico are chicken (35 kg/person/year), pork (20 kg/person/year), and beef (15 kg/person/year). While our findings agree that chicken is the most popular meat, they differ regarding pork and beef consumption. The high consumption of chicken is likely due to its price and accessibility [20].

Meat consumption was reported to be 1–4 times per week by many respondents. Meat was typically purchased at a butcher shop or supermarket. Refried

Table 1 Sociodemographic Characteristics of Young Meat Consumers

Characteristics	Category	n	%
Gender	Woman	55	72.00
	Man	17	22.00
	Other	4	6.00
Age (years)	19-24	64	84.21
	25-30	8	10.52
	>31	4	5.26
Occupation	Student	69	91.00
	Student and employee	5	7.00
	Student and businessman	2	2.00
Marital status	Single	72	94.73
	Free union	4	5.26
Weekly income (USD)	<1000	36	47.00
	50-75	20	26.00
	76-100	10	13.00
	101-125	3	4.00
	>126	7	9.00

Table 2: Main Meat Consumption Habits of Young Consumers

Characteristics	Category	n	%
Most consumed meat	Chicken	41	54.00
	Beef	30	39.00
	Fish	3	4.00
	Pork	2	3.00
Meat consumption frequency	1-2 times	36	47.00
	2-4 times	24	32.00
	>4 times	3	4.00
	Weekends only	12	16.00
Meat purchase location	Local butcher	14	18.00
	Supermarket	20	26.00
	Butcher and Supermarket	42	55.00
Meat presentation	Frozen	3	4.00
	Refrigerated	39	51.00
	Refrigerated and frozen	26	34.00
	Refrigerated, frozen, and cooked	8	11.00
Preferred cooking term	Rare	5	7.00
	Medium rare	8	11.00
	Medium well	26	34.00
	Well done	37	49.00

meat was the most common form of preparation, followed by refrigerated or frozen meat. The preferred level of doneness was "well done", followed by "medium well". These results differ from those of a Brazilian study, where daily meat consumption was reported by most young participants (57%). However, similar to our findings, a preference for "well done" meat was observed in the Brazilian study (53%) [10].

Table **3** presents the sensory evaluation results for the three meat types. No significant differences were observed for odor (P=0.6763) or flavor (P=0.8821). However, significant differences were found for appearance (P=0.0042), tenderness (P<0.0001), and juiciness (P<0.001), with prime beef rated favorably compared to the other meat cuts.

Sensory evaluation of a product involves assessing its subjective characteristics as perceived by the senses and is a primary determinant of product acceptance [3]. Anyway, several other factors, mainly related to the animal feeding, highly influence meat quality [21].

Previous studies suggest that using untrained participants in research can provide results that are more representative of general population preferences [11]. According to Mammasse and Schlich [22], the recommended number of panelists for a hedonic test typically ranges 50 to 100. Conversely, previous studies [11, 23, 24] have utilized larger panels, with some studies exceeding 400 panelists [24]. Nevertheless, given that the present study did not aim to segment the population, the panel size is deemed adequate [22].

In the present study, prime meat excelled in most sensory attributes. This may be attributed to its fat content, as fat is a key factor influencing other sensory variables and, ultimately, consumer satisfaction [25]. However, growing consumer interest in health and nutrition, driven by a desire for a better quality of life and balanced diets, has increased the demand for lower-calorie and more nutritious foods. Buffalo meat could satisfy this demand [24].

In terms of juiciness, buffalo beef scored higher than select beef (P<0.001). However, in the overall sensory evaluation, only a trend (P=0.0606) was observed, with prime beef receiving the highest numerical score, followed by buffalo meat, and then select beef. This result is similar to other studies that

Table 3: Results of Sensory Evaluation on Beef and Water Buffalo Meat

Samples	Appearance	Odor	Flavor	Tenderness	Juiciness	Overall evaluation
Select beef	4.57±0.16b	5.11±0.16a	4.69±0.17a	4.09±0.18b	3.86±0.19c	4.48±0.15a
Select buffalo	4.65±0.16b	5.00±0.19a	4.81±0.18a	4.38±0.20b	4.52±0.18b	4.63±0.17a
Prime beef	5.32±0.18a	4.86±0.22a	4.84±0.27a	5.77±0.17a	5.52±0.19a	5.10±0.24a
P-value	0.0042	0.6763	0.8821	<0.0001	<0.001	0.0606

Hedonic scale: 7 = liked extremely, 6 = liked moderately, 5 = liked slightly, 4 = indifferent, 3 = slightly disliked, 2 = moderately disliked, and 1 = disliked extremely.
[a,b,c]Different letters in the same column indicate significant differences (P<0.05).

have found few differences between cooked buffalo and beef when animals are raised and processed under similar conditions [26].

To ensure high-quality buffalo meat, young animals (18–24 months old) must be used, and older or culled animals must be avoided. Older animals produce inferior meat, which can negatively impact consumer perception of buffalo meat quality [27]. Meat from older buffalo tends to be less tender and exhibit poorer sensory characteristics than younger animals, particularly those over four years old [28].

Table **4** presents the correlations between the different sensory variables. All variables showed a positive correlation (P<0.0001). These results are consistent with another study [11]. On the other hand, previous studies have consistently identified tenderness, juiciness, and flavor as the three key factors in cooked meat palatability, all of which directly influence overall acceptability and consumer satisfaction [29], which is related to the results of the present study, since the correlations with the highest values were between overall acceptability and flavor (r=0.8519, P<0.0001), juiciness and tenderness (r=0.7442, P<0.0001) and juiciness and overall acceptability (r=0.7063, P<0.0001).

Table **5** presents the results of the post-sensory evaluation questionnaire. Prior to the study, most respondents had never consumed buffalo meat and were unaware of its nutritional properties. Similarly, a recent Brazilian study found that 81% of consumers had never consumed buffalo meat or meat products, citing limited commercial availability as the primary reason [23].

However, a key difference from the present study is that the authors' inclusion criteria required participants to respond affirmatively to the question, 'Would you be willing to consume buffalo meat? [23]. Likewise, research in Brazil [11, 24] included studies with populations comprising both consumers and non-consumers of buffalo meat, who were given prior information about the study. The present study, however, employed a blind study design, withholding prior information from consumers because the primary objective was to ensure expectations did not influence sensory acceptability; rating was based solely on immediate perception. Previous studies on chicken [14] and beef [30] have shown that consumer preference aligns with expectations and increased willingness to pay. Thus, when expectations are either positively (product liking exceeds expectations) or negatively disconfirmed (product is worse than expected), the assimilation model applies hedonic ratings to align with expectations when external information is provided, compared to blind tasting [30].

Most of the participants found the appearance of buffalo meat to be similar beef, both beforeand after cooking. This contrasts with previous studies, which have reported that buffalo meat tends to be darker than beef due to its higher myoglobin content [31, 32]. However, in the present study, most panelists did not observe these differences before cooking; in fact, 14 % rated the appearance of buffalo meat as superior to beef.

In addition, 37% of respondents said they would include buffalo meat in their diet, while 47% indicated they might. Of those willing to consume buffalo meat, 74% preferred a weekly frequency, while 18% preferred twice weekly. A Brazilian study on consumer attitudes found that buffalo meat was particularly well-accepted by young people, who were more willing to purchase it and even pay a premium for quality-certified products, which suggest that certain consumer segments can be attracted by guaranteeing specific quality requirements [24].

In contrast, a study in Bangladesh found that while 48% of consumers preferred buffalo meat ("buffen") among red meats, 65% preferred beef, indicating that "buffen" is not yet as widely accepted [26]. However, a study conducted by Silva, Tavares, Menezes, Freire,

Table 4: Correlations between Different Sensory Variables in Beef and Water Buffalo Meat

	Appearance	Odor	Flavor	Tenderness	Juiciness	Acceptability
Appearance	---	0.5336*	0.5163*	0.4932*	0.5033*	0.5962*
Odor	0.5336*	---	0.5982*	0.3530*	0.3200*	0.5739*
Flavor	0.5163*	0.5982*	---	0.5659*	0.5369*	0.8519*
Tenderness	0.4932*	0.3530*	0.5659*	---	0.7442*	0.6961*
Juiciness	0.5033*	0.3200*	0.5369*	0.7442*	---	0.7063*
Acceptability	0.5962*	0.5739*	0.8519*	0.6961*	0.7063*	---

*Spearman correlation test (P<0.0001).

Table 5: Responses to the Questionnaire were Applied after Sensory Evaluation of the Three Types of Meat Cuts

Characteristic	Category	n	%
Previous consumption of buffalo meat	Yes	8	11.00
	No	68	89.00
Knowledge of the properties of buffalo meat	Yes	13	17.00
	No	63	83.00
Appearance of meat before cooking	Buffalo meat is like beef meat	54	71.00
	Beef looks better than buffalo meat	11	14.00
	Buffalo meat has species-specific characteristics	11	14.00
Appearance of meat after cooking	Buffalo meat is like beef meat	53	70.00
	Beef looks better than buffalo meat	11	14.00
	Buffalo meat has species-specific characteristics	12	16.00
Would you include buffalo meat in your diet?	Yes	28	37.00
	No	12	16.00
	Maybe	36	47.00
How many times would you consume it?	Once a week	56	74.00
	Twice a week	14	18.00
	Three a week	5	7.00
	More than four a week	1	1.00
Why do you think buffalo meat is not commonly consumed?	There is no information on the species at the production level available	71	93.42
	No information on meat characteristics is available	58	73.31
	Not many buffalo meat products available	46	60.52
	Not available in supermarkets	56	73.68
	Sold locally mainly	11	14.47
	There is negativity about the consumption of emerging products	12	15.78
	It is overpriced compared to beef	14	18.42

and Carvalho [23] found that buffalo meat faces minimal rejection, likely due to its similar sensory characteristics to lean beef. This suggests that other factors, such as limited product availability and lack of consumer awareness regarding its benefits, may be influencing purchase decisions [24].

These results are consistent with the present study, which found that around of 90% of respondents reported a lack of information regarding buffalo production systems. Furthermore, 74% were uninformed about the properties of buffalo meat, 74% noted its unavailability in supermarkets, and 60% mentioned the scarcity of known buffalo meat products.

Buffalo meat is comparable to beef in many of its physicochemical, nutritional, functional, and sensory properties. Its use in meat processing is increasing due to its higher lean meat content and lower fat. Additionally, buffalo meat possesses good binding properties, making it useful in manufacturing meat products. Thus, buffalo meat has significant potential that remains largely untapped [33]. Lean buffalo meat products offer clear advantages for consumers and could be easily integrated into modern diets. The significant nutritional and technological potential of buffalo meat needs to be effectively communicated to consumers to create a thriving market [31]. Therefore, buffalo meat has the potential to appeal to consumers when marketed with an emphasis on its nutritional and sensory attributes, such as tenderness and juiciness [10].

CONCLUSIONS

Meat with higher fat content received the highest scores on the hedonic scale. However, buffalo meat is compared favorably to lean beef, particularly in terms of juiciness. Panelists expressed a willingness to incorporate buffalo meat into their diets once or twice a week despite no prior experience with it. Thus, buffalo meat may be a viable alternative for some young consumers. However, broader consumer education regarding buffalo production systems and the sensory attributes of the meat is needed, along with improved marketing strategies to ensure market availability.

APPROVAL FOR PUBLICATION

The authors declare that the panelists gave their informed consent to participate in the present study.

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CONFLICT OF INTEREST

There is no conflict of interest with any financial organization regarding the materials discussed in the manuscript.

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