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Recipe Development and Sensory Evaluation of Bone Broths Prepared from Beef, Chicken, and Chevon

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ABSTRACT

Bone broth is a traditional animal-based liquid food product that is made by prolonged simmering of animal bones, meat, cartilage, and connective tissues. It has gained renewed interest as a nutrient-rich and value-added food product due to its sensory appeal and culinary versatility as well as its potential contribution to dietary protein, mineral, collagen-derived products and flavor-active peptides. The current study was undertaken to formulate bone broth preparations using beef, chicken and chevon and to determine the sensory acceptability of bone broths prepared using different beef, chicken and chevon. Fresh meat-bearing bones of beef, chicken and chevon were purchased from a local market and cleaned, roasted and simmered in water for 24 hours. Apple cider vinegar, vegetables, salt and selected spices were added at the beginning. The ready samples of broth were assessed by a panel of trained ten assessors using a five-point hedonic scale on the color, aroma, taste, texture, and overall acceptability. The overall acceptability score of the broths prepared with chicken bones was the highest, with chevon bone broth following closely, and beef bone broth receiving the lowest score. It was desirable to use chicken broth due to its light golden hue, weak aroma, harmonious flavor and smooth mouthfeel. The chevon broth was averagely acceptable simply because of its unique strong flavor and slightly higher viscosity. Beef broth was not as popular due to their darker color, strong smell, more difficult to taste, and more oily to mouthfeel. The results showed that the chicken bone broth has a relatively higher potential for the further development of the products and consumer- oriented testing in Bangladesh. Nevertheless, more investigations with a larger group of consumers, repeated experiments, measurement of instrumental quality and statistical examination are suggested.

INTRODUCTION

Bone broth is a liquid food that has been traditionally prepared by boiling animal bones, connective tissues, cartilage, and meat in water over an extended period. This slow method of cooking makes it easier to extract soluble animal tissue protein and gelatin, as well as amino acids, minerals, lipids, and flavor-active compounds. Despite its long-standing and commonly used status as a nutritionally enriched and convenient, value-added, and meat-based food in many cultures, bone broth recently has experienced a resurgence of scientific and commercial interest due to its possible application as an easy-to-prepare, nutritionally enriched, convenient, and value-added, meat-based food (Mar-Solís *et al.*, 2021).

Broths and stocks have historically been extensively used as culinary bases in soups, sauces, gravies and in therapeutic foods. Bone broth is considered a restorative food in most traditional diets due to its warming, digestive and nutrient-rich properties. From a modern-day perspective of food science, it is possible to consider bone broth as a complex aqueous extract that contains collagen-derived gelatin, peptides, amino acids such as glycine and proline, minerals such as calcium and phosphorus and volatile compounds that contribute to aroma and flavor (Qi *et al.*, 2022). The animal species, type of bone, proportion of meat to bone, roasting, cooking time, temperature, seasoning, fat content, and handling after cooking affect the sensory quality of bone broth.

Meat and bone by-products are very popular in Bangladesh, and their use in producing value-added food items has been low. The potential creation of acceptable bone broth products offer opportunities for better resource utilization, small-scale entrepreneurship and diversification of ready-to-eat or ready-to-drink types of meat-based products (Rennard *et al.*, 2000). Nonetheless, the sensory characteristics of such products especially appearance, aroma, taste, texture, and overall palatability are the key factors in consumer acceptance of such products. Various animal species can yield broths with different sensory properties. Chicken broth is associated with to a lighter hue and milder flavor, whereas beef broth tends to be darker, stronger meaty smell and have a heavy mouthfeel. The species-specific flavor notes found in chevon broth will determine its acceptability among consumers (Liu *et al.*, 2023).

Although there is an upsurge in the popularity of bone broth, very limited information is available about the comparative sensory quality of beef, chicken and chevon bone broths prepared under local conditions in Bangladesh. Thus, the current research plan was aims to develop bone broths based on these three species and assess their sensory acceptability using a trained panel.

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Objectives of the Study

The objectives of the present study were:

- To formulate bone broth products from beef, chicken, and chevon.
- To evaluate the sensory attributes of the developed broths, including color, aroma, taste, texture, and overall acceptability.
- To identify the most preferred bone broth type based on trained panel evaluation.

To provide preliminary information for future consumer-based and product development studies on bone broth in Bangladesh.

LITERATURE REVIEW

Overview of Bone Broth

Bone broth, stock, meat broth and soup are quite similar types of liquid food products that are made by the heating of animal tissues in water. These terms are often used interchangeably, but they differ in their composition, cooking period and how they are used (Jia *et al.*, 2024). Broth is usually made out of meat and might include bones and connective tissues, whereas stock is typically made by boiling bones and connective tissues. Tipically, bone broth takes more time to cook compared to normal stock, allowing more gelatin, minerals, amino acids, and flavor compounds to be extracted (M. H. Rahman *et al.*, 2014).

The nutritional and sensorial traits of bone broth are based on the characteristics of raw materials and the processing conditions. Animal bones consist of collagen, non-collagenous proteins, marrow lipids, minerals and connective tissue (Lee *et al.*, 2014). In the course of long-term heating, collagen is transformed into gelatin which helps to increase the viscosity and mouthfeel. The level of collagen recovery varies by species, bone structure, age of the animal, cooking temperature, acidity and length of simmering (Cattaneo *et al.*, 2019).

Nutritional and Functional Properties

Bone broth is composed of soluble collagen, gelatin, free amino acids, peptides, minerals and trace amounts of fat-soluble compounds. The key components related to mouthfeel and savory taste, and perceived richness are glycine, proline, hydroxyproline, glutamic acid, and small peptides (De Alcântara *et al.*, 2020). It is also possible to extract minerals like calcium, phosphorus and magnesium by using bones as the source, especially when ingredients used to acidify such as vinegar , are present (Yang *et al.*, 2021).

Even though bone broth is often marketed as having potential health benefits, scientific evidence differs, depending on the assertion (Gawat *et al.*, 2023). According to some studies, collagen peptides and amino acids might potentially play a role in joint, skin , or gut-related functions, but these effects cannot be simply generalized to all bone broth products without any proper biochemical characterization and human clinical evidence (Seki *et al.*, 2024). Thus, studies clinical human elopment must not inflate the health claims to an extent that it can be demonstrated that they are supported by rigorous experimental data.

Flavor Chemistry and Sensory Drivers

The sensorial characteristics of bone broth depend upon the concerted-effects of the amino acids, peptides, nucleotides, lipids, volatile compounds, salts, and spices. Nucleotides and glutamic acid are known to contribute to umami taste, while peptides contribute to kokumii, roundness and mouthfeel (Wang *et al.*, 2019). Bones and meat can be roasted to enhance aroma using the products of the Maillard reaction, although excessive roasting can result in burnt, bitter or excessive aggressive flavor notes (Cao *et al.*, 2022).

Sensory perception is also influenced by the fat content. A moderate degree of lipid-derived flavor might enhance palatability, but an excessive amount of fat can lead to a greasy mouthfeel and decreased acceptability. The lipid composition and volatile compounds that are particular to species are specially important in beef and chevon broths, which can have strongly scented volatile compounds.

Processing and Formulation Considerations

The bone-to-water ratios, roasting time, cooking temperature, simmering time, acidity, seasoning, filtration, cooling, and storage are important processing variables in bone broth production (Aykın-Dinçer *et al.*, 2021). Prolonged simmering might be able to bring out more gelatin and flavor components; however, excess heating or improper management of roasting could result in the development of undesired color, turbidity, and off-flavors (Son & Choi, 2023).

In commercial production, other elements such as microbes safety, shelf stability, packaging, salt level, lipid oxidation, and consumer convenience must also be considered. Bone broth can be sold as refrigerated liquid broth, shelf-stable broth, extract, or powder. Nevertheless, they should be formulated with a discretion, balancing nutritional value, flavor intensity, appearance, texture and safety (A. Rahman *et al.*, 2024).

Sensory Evaluation of Broths

Sensory testing is a necessary assessment of the acceptability of new food products developed. Trained descriptive panels, consumer hedonic tests, or discrimination test can be used to evaluate broths (Bravo *et al.*, 2023). Common attributes to be evaluated include appearance, color, clarity, aroma intensity, meaty flavor, umami taste, saltiness, bitterness, aftertaste, viscosity, greasiness, and overall acceptability (Mar-Solís *et al.*, 2021).

An experienced panel can be used as a preliminary screening of the products and for identifying their attributes. Consumer acceptability, should, however, preferably be tested on a larger and more varied consumer panel (Qi *et al.*, 2022). Statistical analysis is also significant

to ascertain whether the difference between the samples is significant. Descriptive findings in small, preliminary studies might be useful in initial studies, but should be interpreted with caution (Rennard *et al*., 2000).

Comparative Characteristics of Beef, Chicken, and Chevon Broths

Chicken broth tends to be lighter in color, milder in smell and more delicate in taste when compared to red meat broths. These properties could help to make more acceptable consumers who are fond of light and not overly strong liquid food. Broth made from beef is normally darker, richer, as well as being strongly flavored (Jia *et al*., 2024). Although this might be desired in certain culinary uses, excessive fattiness may decrease acceptability. A typical series species-specific aroma of chevon broth typically has been described as gamey or strong. This taste can attract consumers who enjoy goat meat but, it may not be acceptable to those who prefer mild flavors (Wang *et al*., 2019).

With such differences, it is of importance that comparative sensory assessment of broths made from various species should be conducted to identify appropriate formulations to be used in local markets.

MATERIALS AND METHODS

Study Location and Period

This work was done in the Animal Science Laboratory of Patuakhali Science and Technology University, Bangladesh. The experimental work was carried out during July and August.

Collection of Raw Materials

Fresh bones carrying meat of beef, chicken and chevon were procured in a nearby local market. The raw materials were carried to the laboratory in a hygienic environment. At the point of arrival, the manual removal of visible dirt, surface blood and unwanted tissues were done. The meat portions and bones were then properly washed using clean running water and then further processed.

Ingredients Used for Bone Broth Preparation

The samples of bone broth were prepared with the following ingredients:

In the original formulation, food-grade color was an appearance enhancer in the original formulation.

Table 1: The samples of bone broth were prepared with the following ingredients

Ingredient	Quantity	Purpose
Meat with bones	3 kg from each species	Main raw material
Water	6 L	Extraction medium
Carrots	200 g	Flavor and mild sweetness
Onions	6 pieces	Aroma and flavor
Garlic	2 bulbs	Flavor enhancement
Apple cider vinegar	2 tablespoons	Acidification and mineral extraction
Sea salt	15 g	Taste enhancement
Bay leaves	3 leaves	Aroma
Black pepper	5 g	Flavor and spice note
Mint leaves	As required	Garnishing before serving

Nevertheless, to evaluate with rigor sensory evaluation, added color must either be avoided, or strictly standardized across treatments since one of the sensory attributes being evaluated was color.

Preparation of Bone Broth

The cleaned meat-bearing bones of every species were roasted in a heated pan on medium heat until they started to brown. To provide surface browning, roasting was conducted to enhance flavor and aroma. Nevertheless, the over-roasting was discouraged as much as possible since excessive roasting can lead to a burnt taste and texture (Yang *et al*., 2021).

The roasted bones were then placed into stainless-steel stockpots. Carrots, onion, garlic, water and apple cider vinegar were added in a chop. The mixture was left to stand about 30 minutes to enable the extraction of the mineral with the help of acid. This was followed by boiling the contents and then low simmer.

The foam and scum on the surface were taken away in the first cooking period. During simmering, sea salt, bay leaves and crushed black pepper were added. The samples were cooked by keeping them over low heat for 24 hours. The bones were kept in the dish when cooking and were supplemented with hot water as needed to maintain the volume of cooking (Kim *et al*., 2024).

When simmering was complete, the broth was filtered through a fine mesh strainer to eliminate the bones, meat particles, and other solid residues. The filtered broth was cooled to room temperature followed by transfer into airtight containers that had been sterilized and then stored at 4 ° C until a sensory analysis.

The broth samples were warmed again on the day of evaluation and served warm in food-grade serving glasses. Garnishing was done using mint leaves.

Sensory Evaluation

Sensory analysis has been done with the help of trained

panel of ten assessors. The panel consisted of faculty members and postgraduate students; seven males and three females, aged 23-45 years. Prior to sample assessment, the panelists were oriented to the assessment process.

There were 5 sensory attributes that the samples were tested for:

- Color
- Aroma
- Taste
- Texture
- Acceptability

The scale utilized was a five-point hedonic scale where:

The samples were displayed in natural lighting and tested in room temperature or warm serving conditions, depending on the attribute being tested. The panelists were questioned to rate each sample separately, and give the rating based on the perception of the senses.

Table 2: The scale utilized was a five-point hedonic scale where

Score	Category
5	Excellent
4	Good
3	Fair
2	Poor
1	Very poor

Data Interpretation

The sensory results were descriptively interpreted. The findings were only utilized to find initial sensory trends and not to define statistically significant differences. The results can thus be viewed as pilot scale results that can be used to guide future product development.

RESULTS AND DISCUSSION

General Sensory Acceptability

Sensory analysis revealed that there were significant changes between the three bone broth samples. Overall, chicken bone broth was the most acceptably scored, then chevon broth, and lastly beef broth received the lowest score. The ranking of preferences which was shown in this research was:

Chicken bone broth > Chevon bone broth > Beef bone broth

This pattern indicates that lighter flavor, lighter color and smoother texture, and reduced perceived greasiness positively influenced panel acceptability.

Color

Color is a significant quality attribute since it has a strong impact on first impression and perceived freshness of liquid food products. In the current study, the highest-rated chicken bone broth was best in terms of color. The panelists articulated it as being light golden, transparent and aesthetically pleasing to the eyes. This look was probably linked to a lesser pigment intensity, reduced turbidity, and a cleaner look on the surface.

Chevon broth was moderately acceptable with regard to color. It was a bit darker and less transparent than chicken broth, yet it exhibited permissible visual features. The richness of the earthy tone of the chevon broth might have led to a sense of richness.

The lowest score in terms of color score was given to beef broth as compared to the other two samples. It was characterized as a dark brown and somewhat turbid. The dark appearance may have been due to the natural pigments of beef, the presence of more myoglobin, the presence of lipid oxidation products and the possible excessive browning during roasting. The score of color of the beef broth must be taken with caution since the document states that the beef bones could have been over-roasted.

These findings reveal that the color formation in bone broth greatly relies on the species and processing conditions. It is therefore necessary that standardization of the roasting time and temperature be done in future studies.

Aroma

Aroma is one of the most important determinants of broth acceptability since volatile compounds available in the process of heating the broth have significant effects on consumer perception. Broth of chicken was rated positively concerning the smell. The panelists have characterized it as not too intense, mild, pleasant, homely and characterizing it as mild. This does not have a strong aroma and this may have enhanced its overall acceptance. Average scores for aroma were achieved in Chevon broth. Some panelists enjoyed its more character-filled and deeper aroma, but found it strong or gamey. This difference could be connected to the average volatile characteristics of goat meat and compounds of bone. To enhance the wider level of consumer acceptability, adjustments in the formulation of the chevon aroma can be made, such as the incorporation of specific spices, herbs or controlled roasting (Lee *et al.*, 2014).

Beef broth had the lowest rating of aroma. Some of the panelists referred to the aroma being intense, strong or overwhelming. This could have been affected by the more volatile compounds that are characteristic of beef, the higher lipid content and the presence of burnt notes due to over-roasting. As too much roasting may produce unwanted aroma compounds, the beef formulation needs to be repeated under closer control of processing when forming a firm opinion about its acceptability.

Taste

One of the most significant factors of total preference was the taste. The highest taste score was obtained with chicken bone broth. It was characterized as savoury, slightly sweet, balanced and not too greasy. The moderate and moderate taste profile seemed to align in line with the

taste preferences of trained panel.

Chevon broth was fairly well received in flavor. It was said that it was flavorful and was relatively rich, yet some panelists felt that the typical goat-like flavor was too strong. This implies that chevon broth can be adapted for suit consumers who want strong meat flavour, albeit the broth will require additional flavour adjustments to ensure that the broth is accepted by a wider range of consumers in the market.

The lowest score for taste was given to beef broth. It was said to be bulky, intense, greasy and less balanced. Though beef broth could be appreciated because of its robust, meaty taste in certain foodstuff, too much of it might be undesirable due to excessive heaviness in ready-to-drink or light soup-style products. Excessive roasting might have contributed to the lower taste score as well since it may have added burnt or bitter flavors (Gawat *et al*., 2023).

The results indicate that taste optimization must be aimed at a combination of umami intensity, saltiness, fat level, and roasted flavor.

Texture

The texture and mouthfeel are crucial sensory properties of the broth products as they determine perceived richness, smoothness and palatability. The best score for the texture was attributed to chicken broth. It was said to be smooth, silky and homogeneous with a desirable balance between the liquidity and the viscosity. This texture must have helped it to have positive overall assessment.

Chevon broth was moderately to good in terms of texture acceptability. It was a bit fattier than chicken broth, an identification some panelists related to richness. However, some assessors felt that it was a little bit greasy or less uniform and as such, it may have scored lower (Son & Choi, 2023).

The lowest score in texture was given to beef broth. It was also termed as being thicker, fattier and heavier in mouthfeel. Too much fat and viscosity may also decrease acceptability, particularly when consumers desire a light broth. The beef broth might need defatting, better filtration or change of formulation in order to improve the texture.

Acceptability

The overall acceptability results established that the most preferred sample was that of chicken bone broth as compared to both other formulations. Its increased acceptability was linked to its attractive light color, pleasant aroma, balanced taste and smooth texture. All these qualities imply that chicken bone broth could be the most promising formulation that could be further developed as a ready to cook or ready to drink broth product in Bangladesh (Aykın-Dinçer *et al*., 2021).

Chevon broth was the second highest overall in acceptability. It demonstrated itself as a niche product among the consumers who like the meat taste to be stronger and a richer broth texture. Nevertheless, the quality of its characteristic aroma and the intensity of its flavor can be adjusted by using controlled seasoning, defatting or blending.

Beef broth was found to be least acceptable in general. The negative effect it had on panel preference was its darker color, stronger aroma, heavier taste, and fattier texture. However, the results cannot be taken to indicate that beef broth is necessarily unacceptable as the preparation process could have influenced the quality of beef broth. Specifically, excessive roasting of beef bones could have been a contributing factor to the negative sensory attributes (Gawat *et al*., 2023).

Implications of the Study

The results of this research offer initial insights that chicken bone broth could have more to be developed into a product because of the conditions in local Bangladeshi. Its light sensory profile can attract a wide variety of consumers, such as children, older individuals and health-conscious consumers, who are more enticed to consume light and easily digestible foods.

The chevon broth can be offered as a specialty or as a niche product because the broth is much more flavorful. The acceptability of spices, herbs, fat reduction, and cooking conditions can be further refined in order to make it more acceptable.

Beef broth needs to be further formulated. Some of the possible strategies are to reduce the intensity of roasting, controlling fat levels, enhancing filtration, seasoning and improving the conditions of simmering. It takes repeated trials before final conclusions can be drawn on the acceptability of beef broth.

Limitations of the Study

Despite the fact that the study offers some valuable preliminary information, certain limitations should be mentioned.

Firstly, only ten trained panelists were used to carry out the sensory evaluation. This is an appropriate sample size for an initial screening but not enough to cover the whole population of consumers.

Secondly, statistical analysis was not provided in the study. Hence, the differences which were observed between beef, chicken and chevon broths should be viewed as descriptive trends and not statistically significant results.

Thirdly, the preparation process might not have been made completely standardized among all treatments especially in respect to the intensity of roasting. The decrease in the score of beef broth might not have been due to species effect alone but could have been due to excessive roasting.

Fourthly, no instrumental analyses were conducted. Measures of parameters like pH, viscosity, total soluble solids, protein content, fat content, mineral content, color values, lipid oxidation and microbial quality were not taken.

Fifthly, the research lacked the hedonic testing of consumers based on their hedonic behavior. Panel evaluation can be done through training so as to provide

a valuable product profiling, though consumer preference studies are required in order to conduct an analysis of the market potential.

Lastly, the formulation may influence the interpretation of appearance-related appearance-sensory scores because of the use of the food-grade color in the formulation. In future research, the study should not add any artificial color or it should be added homogenously under well-established conditions.

Recommendations for Future Research

Further research is advised to incorporate bigger and more diversified consumer groups in order to confirm the acceptability of bone broth products. Redundant trials are to be run in similar conditions of processing and especially with the controlled roasting time and temperature. This should include instrumental quality measurements that should be used to supplement the sensory findings.

The nutritional content of the developed broths, such as protein, collagen, amino acid profile, mineral content, fat content, and sodium level should also be investigated in further research. Prior to commercial use, microbiological quality and shelf-life stability must be considered. Moreover, defatting, optimization of spices, reduction of salt, and packaging techniques could be used in the formulation trials to enhance the commercial viability of bone broth products.

CONCLUSION

The current research created and assessed beef, chicken as well as chevon bone broth using trained sensory panel. Chicken bone broth was the most acceptable in terms of sensory attributes; the attractive color, slight aroma, balanced taste, and smooth texture of this food made it highly acceptable. Chevon broth was moderately acceptable and could be a good specialty product for consumers who found stronger meat flavor more desirable. Beef broth received the lowest score regarding acceptability, and the main reason is that it is darker, has stronger aroma, is heavier in taste, and its texture is fattier. Nevertheless, this situation could probably be due to the fact that in the preparation of the beef broth, excessive roasting has been conducted which led to the lower acceptability of the beef broth.

All in all, the findings indicate that chicken bone broth has the highest potential for further development as a product in Bangladesh. However, the study is to be considered a predetermined sensory screening. Before commercial recommendations can be made, larger-scale studies in the consumer context, statistical analysis, standardized processing, nutritional profiling, and shelf-life evaluation are required.

Declarations

Ethical Approval

This research entailed sensory assessment of food products, conducted by trained panelists, who are adults. The test was done laboratorily and panelists volunteered.

Conflict of Interest

The authors report that they do not have a conflict of interest.

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Data Availability

The data which prove the findings of this study can be had with the corresponding author under reasonable request.

Author Contributions

A conceptualization, recipe development, sample preparation, sensory evaluation, data interpretation, and manuscript preparation were all the responsibilities of the author.

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