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Fajardo, Crisabel C.[1]
Infortuno, Amylin E.[2]
Gatdula, Michelle M.[3]
Villalobos, Bernard D.[4]
Sta. Cruz, Joy Christine V.[5]

Corresponding Author: *crisabelfajardo1120@gmail.com*

[1-4]*College of Management, Bulacan Agricultural State College, Pinaod, San Ildefonso, Bulacan, Philippines*
[5]*College of Engineering and Technology, Bulacan Agricultural State College, Pinaod, San Ildefonso, Bulacan, Philippines*

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[5]*College of Engineering and Technology, Bulacan Agricultural State College, Pinaod, San Ildefonso, Bulacan, Philippines*

Abstract

Health-conscious consumers are increasingly looking for better meat substitutes for everyday consumption in response to the growing demand for healthier food options. This study evaluated the physicochemical and sensory properties of Lapanuggets (rabbit meat nuggets), a novel product made from rabbit meat. A total of 79 panelists participated in a sensory assessment of the product as part of the study, which used a quantitative research design. Three types of Lapanuggets were created, namely: Treatment A, which contained more texturized vegetable protein (TVP) combined with rabbit meat; Treatment B, which had less TVP and more rabbit meat; and Treatment C, which contained pure rabbit meat. A number of sensory qualities, such as flavor, tenderness, saltiness, meaty aroma, and general acceptability, were impacted by the amount of rabbit meat in each formulation. Treatment C received the highest overall acceptability score, according to sensory evaluation. Nonetheless, there was no statistically significant difference in the scores between Treatment C and Treatment B, indicating that Treatment B might be a good substitute with less meat. According to the physicochemical analysis results, all treatments had high water activity (Aw) and moisture content (% MC), and adding up to 40% TVP had no discernible impact on these parameters. Treatment A's higher TVP content probably contributed to its much lower cooking yield results when compared to Treatments B and C. All samples were found to be free of *Salmonella* and *S. aureus* by microbial testing, indicating that they are safe to eat as long as they are handled and stored correctly.

Keywords: *lapan, lapanuggets, physicochemical, rabbit meat nuggets, sensory evaluation*

Introduction

Rabbits (*Oryctolagus cuniculus*) develop high growth rates. They are categorized as white meat and have no known adverse health effects. They have lower cholesterol levels compared to other meats (Jiang et al., 2020). Rabbit meat is low in fat and protein and contains significant vitamins and minerals essential for human health (Tan, 2020). As cited by Lebas et al. (1997), the tradition of utilization and consumption of rabbit continues in Mediterranean countries to the present day. In the past, rabbit meat and carcasses were usually prepared and consumed on occasional feasts and festivals. Since rabbits are relatively small, the whole carcasses are slaughtered and cut into parts, and they are consumed

immediately.

In the Philippines, a handful of rabbit farms produce meat for local consumption and use different recipes using *lapan*, or rabbit meat (Ozaeta, 2020). Different organizations and government agencies, including the Association of Rabbit Meat Producers (ARAMP), Rabbit Raisers and Meat Producers Cooperative (RRMPC), World Rabbit Science Association (WRSA), Department of Agriculture, Bureau of Animal Industry, National Meat Inspection Service (NMIS), Bulacan Provincial Veterinary Office, and Bulacan Agricultural State College (BASC), have made efforts to widely promote rabbit farming and consumption to Filipinos (Veneracion, 2017). In the province of Bulacan, Bulacan Agricultural State College has entered into a Memorandum of Agreement to collaborate on initiatives aimed at strengthening the rabbit industry in the Philippines. To support this effort, a rabbitry has been established at BASC to serve as a facility for research and extension projects.

Nuggets are processed food products made of deboned and ground chicken meat, coated in batter or breadcrumbs, then deep-fried or baked (deShazo, Bigler, & Skipworth, 2013). Commercially available chicken nuggets usually contain 50% skeletal muscle tissue, while the remaining composition may include fat, soft bone fragments, and connective tissues. It is then combined with various ingredients to create a product (Kravitz, 2016). Due to their palatability and market availability, chicken nuggets have become a popular food choice across ages. They are readily accessible in many fast-food establishments, appealing to mass people (Harrison, 2018). Based on studies, consumers frequently opt for fast food due to its convenience, fast service, and ease of transaction. Common reasons for buying include limited time for meal preparation, dissatisfaction with home-cooked meals, or a preference on fast-food meals. The most frequently cited factor is the lack of time to cook (Hamrick & Okrent, 2014).

Nowadays, more people are focusing on the healthy side of eating and are seeking healthier lifestyle choices and food intake options. According to the study by Dinu et al. (2010), consumers are adopting new lifestyles and eating habits, becoming increasingly mindful of where their food comes from.

Studies reveal that rabbit meat has better nutritional value than chicken. Rabbit meat is richer in essential minerals such as calcium and phosphorus, surpassing chicken in mineral content. Rabbit meat also contains a large amount of good-quality protein. Both chicken and rabbit meat are classified as white meats based on their pale coloration and comparable nutritional characteristics (Nistor et al., 2013). With significant similarities between chicken and rabbit meat, both considered white meat, and the proven fact that rabbit meat is a healthier source of protein compared to chicken, rabbit meat has the potential to replace chicken-based nuggets with rabbit-based ones.

This study aimed to develop Lapanuggets, a novel product made from rabbit meat, by assessing its sensory attributes and physicochemical properties, including water activity (Aw), pH, moisture content, and cooking yield. Microbial analysis was also conducted to identify microbial characteristics influencing product development. The overall objective was to evaluate the acceptability of rabbit meat nuggets.

Materials and Methods

Materials

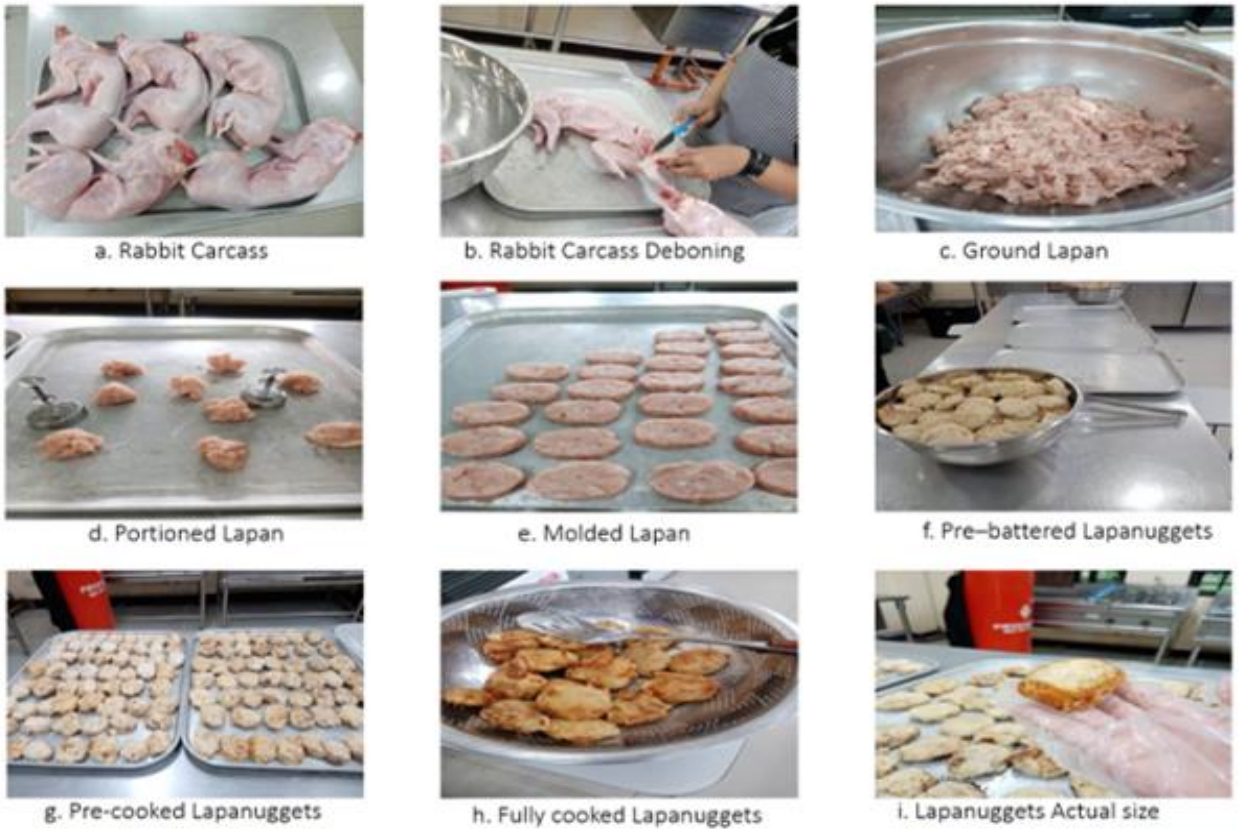
Whole rabbit carcasses of New Zealand white rabbits (*Oryctolagus cuniculus*) were acquired from Bulacan Agricultural State College Rabbitry. Rabbit carcasses were bought and delivered skinless. The Procurement Department of Bulacan Agricultural State College supplied ingredients like iodized salt, ground white pepper, onion powder, texturized vegetable protein (TVP), flour, cornstarch, large eggs, and vegetable oil.

Rabbit Meat Nuggets Preparation and Formulation

The rabbit carcasses were initially washed to eliminate unwanted particles or dirt. Then, the *lapan* (rabbit meat) was manually deboned and washed thoroughly in running water. Sliced *lapan* was processed in a commercial meat grinder to achieve consistent grinding and then run using the commercial blender. Ground *lapan* was mixed with other ingredients, seasonings, binders, and TVP. Each nugget was molded and coated in a batter mixture composed of cold water, eggs, all-purpose flour (APF), cornstarch, ground white pepper, and onion powder. This preparation method was adapted from the rabbit meat nugget formulation described by Malav et al. (2013).

Figure 1

Lapanuggets Preparation



Research Design

This study employed experimental research to analyze the panelists' sensory perceptions and to develop a new rabbit meat–based product. Three modified Lapanuggets were evaluated: Treatment A, which included rabbit meat combined with a higher amount of texturized vegetable protein (TVP); Treatment B, which included more rabbit meat and less TVP; and Treatment C, which consisted of pure lapan. The researchers' objective in having different treatments with different ratios of *lapan* and TVP is to determine the most acceptable product for the consumers. The sensory evaluation was conducted through sample product tasting by the panelists. The physicochemical characteristics of Lapanuggets were determined in terms of the water activity (Aw), pH, moisture content, and cooking yield.

Sensory Evaluation

The sensory evaluation took place at Bulacan Agricultural State College, located in Pinaod, San Ildefonso, Bulacan. A total of 79 untrained panelists, comprising BASC employees and staff, engaged in the evaluation utilizing a 9-point Hedonic Scale sensory evaluation form. Untrained consumer panels are used to identify perceived differences between products and to evaluate their acceptance or preference (Curtis, 2013). The same panelists evaluated the sample treatments in three (3) replications to ensure accuracy. Each Lapanugget sample was cut into four (4) smaller pieces weighing approximately 6.25 grams per portion and was placed in white plastic containers. Each treatment was assigned with a three-digit random code to eliminate any biases and placed in a small container for assessment.

The panelists evaluated the product according to eight sensory attributes: color, crispiness, meaty aroma, flavor, tenderness, juiciness, saltiness, and overall preference. The samples were subsequently presented to the untrained panelists, who were directed to consume water before and after each evaluation of the treatments to cleanse their palates.

Physicochemical Analysis

All physicochemical analyses, such as Aw, pH, moisture content, and cooking yield, were carried out in triplicate, with results expressed as mean ± standard deviation.

Determination of Aw

The samples' water activity was measured using a water activity meter (BIOBASE Smart Water Activity Meter). The samples were chopped and then placed in the sample container, which was kept inside the sample chamber. The readings were recorded, and the procedure was conducted in triplicate.

pH Determination

Five (5) grams of Lapanuggets were blended with 45 ml of distilled water (Kim et al., 2015). The mixture was subsequently filtered, and the pH of the resulting filtrate was determined using a handheld pH meter. Determinations were performed in triplicate, and the results are presented as mean ± standard deviation.

Moisture Determination

The moisture content of the samples was determined using the oven-drying method. Samples were dried at 105 °C until constant weight was obtained. The loss in weight before and after drying was recorded as the moisture content.

Cooking Yield

The Lapanuggets were fried at 180 ± 2 °C for 5 minutes, during which the core temperature of the samples reached 80 ± 1 °C. The fried samples were cooled for 1 hour and then weighed to determine the frying weight. The cooking yield was calculated using the following formula:

$$\text{Cooking yield } (\%) = \frac{\text{Frying weight}}{\text{Initial weight}} \text{ x } 100$$

Microbial Analysis

Determination of Salmonella

To detect the presence of *Salmonella,* 25 g of Lapanuggets was blended with 225 ml of sterile lactose broth. Then, it was incubated for 24 ± 2 h at 35 °C. After incubation, 1 ml of the inoculum was streaked onto pre-poured Bismuth Sulfite Agar (BSA) plates. Plates were incubated in an inverted position for 24 ± 2 h at 35 °C. Afterwards, the plates were checked for the presence of brown, gray, or black colonies, which confirmed the presence of *Salmonella*.

Determination of Staphylococcus aureus

Aseptically, 25 g of Lapanuggets was blended with 225 mL of peptone saline solution. Then, 10^{-2} dilutions were made. Each dilution was inoculated in triplicate on a 3M Petrifilm Staph Express Count Plate. The plates were incubated at 35 °C for 24 ± 2 hours, after which red-violet colonies were counted.

Statistical Analysis

Analysis of variance (ANOVA) was performed using Minitab software to determine statistically significant differences among the Lapanuggets treatment groups. This statistical method evaluated variations within and between groups to determine whether observed differences in sensory attributes and other measured parameters are attributable to treatment effects rather than random chance. A significance level of $p < 0.05$ was employed, suggesting that any observed difference had a probability of less than 5% occurring by random chance.

Tukey's Honestly Significant Difference (HSD) test was conducted to determine which treatments differed significantly. This post-hoc analysis assessed mean differences between treatments and identified significant variations. Tukey's test is effective for multiple comparisons as it minimizes the risk of Type I errors (false positives). The application of ANOVA and Tukey's test facilitated a precise assessment of the sensory and physicochemical properties of Lapanuggets, aiding in identifying the optimal formulation.

Results and Discussion

Sensory Evaluation of Lapanuggets

Table 1 presents the results of the sensory evaluation of Lapanuggets. No significant differences were observed in terms of color, crispiness, and juiciness. These attributes are influenced by the uniform coating applied and by the chemical reactions that occur during frying. All samples used the same quantity and ingredients for coating. Moreover, the treatments were fried at the same cooking temperature and exposed for the same duration. Hence, these attributes were not significantly affected. Moreover, Hidayat et al. (2017), substituting beef sausage with up to 40% texturized vegetable protein (TVP) results in only minor color changes and has minimal impact on physicochemical and sensory attributes, as well as on the protein profile analyzed by SDS-PAGE. Treatments A, B, and C of Lapanuggets exhibit similar color due to all treatments being coated with the same mixture of flour, eggs, and batter.

During cooking, meat undergoes various chemical reactions that generate volatile compounds responsible for its characteristic aroma and flavor (Park & Choi, 2024). These reactions include the Maillard reaction between free amino acids and reducing sugars, Strecker degradation of amino acids, lipid oxidation, and thiamine degradation. Compounds produced during these chemical reactions, combined with the naturally occurring substances present, such as nucleotides, contribute to the meaty aroma and flavors (Yuan et al., 2021). Maillard reactions and Strecker degradation involve amino acids; these reactions produce heterocyclic compounds, such as pyrazines, and other sulfur-containing compounds, such as methanethiol and dimethyl sulfide, which contribute to the meaty aroma and flavor (Park & Choi, 2024). Texturized vegetable protein (TVP) has a different amino acid composition than rabbit meat, leading to a weaker Maillard reaction. It also undergoes Strecker degradation but produces little to no meaty aroma or flavor (Li & Li, 2020). Although rabbit meat is lean, it still contains small amounts of intramuscular fat (Cullere et al., 2022) that may undergo lipid oxidation. While TVP, on the other hand, is fat-free, making it less aromatic.

As shown in Table 1, juiciness refers to the amount of moisture and fat released when chewing. During frying, moisture is lost, making the nuggets drier. No significant differences were observed among

the treatments in terms of juiciness. Since all treatments were subjected to the same temperature and duration of frying, the amount of moisture retained was not significantly different (Sen & Karim, 2011).

Table 1

Mean Sensory Scores of Lapanuggets

Attributes	Treatment A	Treatment B	Treatment C
Color	6.79 ± 1.48	6.69 ± 1.67	6.90 ± 1.55
Crispiness	5.96 ± 1.86	6.12 ± 1.72	6.40 ± 1.94
Meaty Aroma	6.70 ± 1.70^{b}	6.84 ± 1.58^{ab}	7.18 ± 1.54^{a}
Juiciness	6.37 ± 1.79	6.78 ± 1.51	6.61 ± 1.63
Flavor	6.63 ± 1.60^{b}	6.99 ± 1.47^{b}	7.18 ± 1.48^{a}
Tenderness	6.52 ± 1.76^{b}	6.96 ± 1.40^{a}	6.90 ± 1.64^{ab}
Saltiness	6.71 ± 1.34^{b}	6.96 ± 1.46^{ab}	7.12 ± 1.37^{a}
Overall Acceptability	6.69 ± 1.56^{b}	6.97 ± 1.44^{ab}	7.25 ± 1.37^{a}

Note. Values are presented as Mean ± Standard Deviation. Means in a row that do not share a letter are significantly different at a 5% level of significance ($p < .05$). Sensory scale: 1.00–1.89 = dislike extremely, 1.90–2.78 = dislike very much, 2.79–3.67 = dislike moderately, 3.68–4.56 = dislike slightly, 4.57–5.45 = neither like nor dislike, 5.46–6.34 = like slightly, 6.35–7.23 = like moderately, 7.24–8.12 = like very much, 8.13–9.00 = like extremely. Treatments: A = 60% rabbit meat + 40% texturized vegetable protein, B = 80% rabbit meat + 20% texturized vegetable protein, C = 100% rabbit meat.

Increasing rabbit meat produces a stronger meaty aroma and flavor. This agrees with the study by Bakhsh et al. (2021), patties prepared without TVP received higher scores for sourness, bitterness, umami, and richness compared to the other formulations. Treatment C, which contains 100% rabbit meat, has a significantly higher meaty aroma than Treatment A, while Treatment B does not differ significantly from the other two treatments. Moreover, Treatment C exhibits the strongest meaty flavor among all treatments.

In terms of saltiness, treatment C obtained a significantly higher sensory value than treatment A, while treatment B was not significantly different from the two other treatments. Hence, increasing the amount of rabbit meat results in higher sensory acceptance concerning saltiness. Treatments C and B, which contain greater amounts of rabbit meat, show a reduced perception of saltiness, likely due to the increased lysine content. Lysine is an essential amino acid naturally present in meat. A study conducted by Vidal et al. (2020) found that adding lysine to salted meats reduces their salty taste, thereby increasing the product's sensory acceptance.

Tenderness of Lapanuggets refers to how easily it breaks apart when chewed, and this may be influenced by the rabbit meat and TVP structural properties and the processing methods used. Treatment B (with 20% TVP) differed significantly from Treatment A (with 40% TVP), while Treatment C did not significantly differ between treatments. Since rabbit meat is lean and contains a small amount of fat, the Lapanuggets are slightly firmer. This result is attributed to the varying levels of TVP. Treatment A with higher TVP content (40%) likely caused a drier, firmer texture and reduced tenderness. Treatment B, with a minimal TVP content of 20%, had a more balanced moisture and protein content, resulting in greater tenderness. Treatments C and B exhibit similar tenderness characteristics. These findings suggest that excessive TVP can reduce tenderness by drying the product, while moderate TVP levels maintain better texture in rabbit meat nuggets. On the other hand, TVP is usually made from soy and other plant proteins that can also increase the firmness of nuggets. However, excessive use may lead to a drier texture (Hong et al., 2022).

Treatments B and C have higher amounts of lean rabbit meat, resulting in better cooking yields than Treatment A. The rabbit meat's high protein and low fat content helps to retain moisture during cooking. Treatment C, having the highest rabbit meat percentage, obtained the highest scores in sensory

attributes. According to Frunză et al. (2023), rabbit meat's high water-holding capacity leads to lower cooking loss and better yield compared to other lean meats like hare. From a cost perspective, Treatment B which comprises 80% of rabbit meat and 20% of textured vegetable protein (TVP), may effectively replace Treatment C in terms of cost. The TVP in treatment B, serves as a meat extender, which may lower production costs by reducing the reliance on pure rabbit meat. Additionally, since the overall acceptability scores of Treatments B and C do not differ significantly, Treatment B may be considered more suitable for production while efficiently reducing the cost of rabbit meat nuggets.

Physicochemical Characteristics of Lapanuggets

Table 2 displays the result of the physicochemical analysis of Lapanuggets. The incorporation of TVP at levels up to 40% did not significantly affect the water activity (Aw), pH, and moisture content (% MC). This result is consistent with the findings of Yogesh et al. (2012), who found no significant differences in pH, water activity (Aw), or moisture content in the quality of chicken nuggets when all samples were subjected to the same cooking conditions. The same result was observed by Falahudin et al. (2020) where the pH of rabbit nuggets with different amounts of tofu dregs flour was not significantly affected.

The main ingredients of Lapanuggets were rabbit meat and texturized vegetable protein (TVP). These influenced the product's final pH, which ranged from 6.04 ± 0.01 to 6.11 ± 0.04. Rabbit meat typically has a pH ranging from 5.6 to 5.8, depending on the breed and age (Kumar et al., 2023). On the other hand, TVP which is derived from soy flour and is high in fiber and protein (Hackett, 2021) generally has a pH of 6.4 to 6.8 likely due to the inherent pH of soy flour (Victor-Aduloju et al., 2022).Texturized vegetable protein (TVP) is commonly used as an extender for ground meat to lower costs without reducing the nutritional value. The pH value is an important property of meat products as it affects the meat product's capacity to retain moisture (El-Anany, 2020).

Table 2

Results of Physicochemical Tests

Parameters	Treatment A	Treatment B	Treatment C
Water Activity (Aw)	0.928 ± 0.021	0.892 ± 0.010	0.872 ± 0.006
pH	6.10 ± 0.04	6.11 ± 0.04	6.04 ± 0.01
Moisture Content (MC, %)	62.69 ± 0.03	61.73 ± 0.01	58.20 ± 0.01
Cooking Yield (%)	74.00 ± 1.0^{b}	81.82 ± 2.19^{a}	76.27 ± 1.89^{a}

Note. Values are presented as mean ± standard deviation (SD). Means in a row that do not share a superscript letter differ significantly at the 5% level of significance ($p < 0.05$).

All treatments have high Aw and moisture content (%MC), as presented in Table 2. In comparison, a study by Arshad et al. (2017) reported that nuggets made with chicken have a water activity of 0.775 to 0.827, which is lower compared with that of Lapanuggets which ranged from 0.872 to 0.928. Likewise, the commercially available chicken nugget (Sharima-Abdullah et al., 2018) has a moisture content of 57.93%, while that of the lapanuggets ranges from 58.20% to 62.69%. The slight differences may be attributed to the type of meat and ingredients used.

Products with Aw higher than 0.85, high moisture content, and high in nutrients such as protein, are good mediums for microbial growth. Thus, proper handling and storage of the finished product are needed to avoid post-contamination. In terms of cooking yield, Treatments B and C had significantly higher cooking yields than Treatment A. These differences may be due to the higher proportions of rabbit meat in Treatments B and C. Rabbit meat is high in proteins (Dalle Zotte, 2002), this property allows meat to retain more water during cooking which contributes positively to cooking yield of the meat products (Huff-Lonergan & Lonergan, 2005).

Microbial Analysis

Results of Microbial Analysis

S. aureus can cause severe food poisoning, but this bacterium can be easily killed by heat and sanitizing agents. Hence, its presence in processed foods indicates poor sanitation. No visible growth of *S. aureus* was found at the 10^{-1} dilution, indicating that proper handling during the processing of Lapanuggets was observed.

Salmonella is one of the most frequently reported foodborne diseases worldwide. All treatments were negative for *Salmonella* and conformed to the microbial standards of FDA Philippines. Therefore, all treatments are safe to consume after production, provided they are properly stored.

Table 3

Microbial Quality of Lapanuggets

Microorganisms	Treatment A	Treatment B	Treatment C	Microbial Standards
Salmonella /25 g	Negative	Negative	Negative	Negative
S. aureus (cfu/g)	<10	<10	<10	1,000–10,000

Note. Microbial standards were based on FDA Circular No. 2013-010.

Conclusion

The study used different ratios of rabbit meat and texturized vegetable protein (TVP) to assess the acceptability, physicochemical characteristics, and microbiological safety of three Lapanuggets (rabbit meat nuggets) treatments. The highest ratings for meatiness, tenderness, flavor, and saltiness were consistently given to Treatment C, which was made entirely of rabbit meat. It also had the highest cooking yield due to the greater proportion of rabbit meat. These outcomes can be attributed to the exceptional qualities of rabbit meat, including its high protein content, low fat levels, fine muscle fiber structure, and mild flavor profile, which enhance overall palatability and texture.

Even though Treatment C received the highest ratings, statistical analysis revealed no discernible variations in overall acceptability when contrasted with Treatment B, which included TVP as a meat extender and contained less rabbit meat. This implies that Treatment B may be a useful and cost-effective substitute, providing similar sensory attributes with less meat and lower production expenses. Lower sensory scores and cooking yield were observed in Treatment A, which had the highest level of TVP. This was probably because of reduced water retention and changed texture brought on by the higher extender content.

The pH, moisture content (%MC), and water activity (Aw) of all treatments did not differ significantly, according to physicochemical analyses. High moisture and Aw values were found in all samples, suggesting that these parameters are not significantly impacted by TVP inclusion of up to 40%. According to microbial analysis, all treatments were found to be free of *Salmonella* and *S. aureus*, meeting FDA food safety standards and being safe for ingestion when handled and stored appropriately.

The study supports rabbit meat's potential for value-added product development in addition to highlighting its functional benefits in processed meat products. For consumers who are concerned about their health, rabbit meat nuggets present a promising alternative due to their nutritional profile and positive customer feedback.

Overall, while rabbit meat is not yet a popular choice for consumption, several studies show that it is highly nutritious and can contribute to a healthy lifestyle. Producing rabbit meat nuggets helps introduce the product to consumers in an appealing form, increasing awareness and encouraging broader

acceptance. This study aims to show that rabbit meat is safe to eat and can serve as a healthier alternative to more commonly consumed meats.

In terms of cost, Treatment B, using 80% of Rabbit meat and 20% of TVP can be a replacement for treatment C because of the presence of the TVP, which acts as a meat extender and may lower the cost of production since Treatment B does not contain pure rabbit meat.

Recommendations

According to the sensory evaluation, Treatment C had the highest acceptability rating of all the samples, making it a strong candidate for further product development and enhancement. To support this, future studies should examine its water-holding capacity, which is crucial for maintaining the product's texture and juiciness over time. In order to preserve freshness and shelf life without compromising nutritional value, future research can focus on ways to enhance crucial characteristics like tenderness, crispiness, and overall texture. However, since Treatment B exhibits a more cost-effective formulation with comparable sensory quality, it is recommended that further research be done on this treatment as a potential replacement for the pure rabbit meat version.

It is also recommended to conduct Quantitative Descriptive Analysis (QDA) to determine the intensity of the sensory attributes (color, crispiness, meaty aroma, flavor, tenderness, juiciness, and saltiness). Results from the QDA can be statistically correlated with those results obtained from consumers' acceptability test to better understand consumer preferences. This correlation would provide insights into the specific intensity levels of each attribute that corresponds to high acceptability scores, thereby helping to define target sensory profiles for product optimization.

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