SİDAS MEDYA
Akademik Gıda®
ISSN Online: 2148-015X
https://dergipark.org.tr/tr/pub/akademik-gida

Akademik Gıda 20(3) (2022) 199-210, DOI: 10.24323/akademik-gida.1186575

Research Paper / Araştırma Makalesi

Acceptability and Shelf-life Testing of Newly Formulated Crab Balls from Blue Swimming Crab (*Portunus pelagicus*)

Qhaironessia H. Ajik-Cerbas, Rosita T. Jumdain, Albaris B. Tahiluddin ✉

Mindanao State University - Tawi-Tawi College of Technology and Oceanography, College of Fisheries, Sanga-Sanga, Bongao, Tawi-Tawi 7500 Philippines

Received (Geliş Tarihi): 02.07.2022, Accepted (Kabul Tarihi): 22.09.2022
✉ *Corresponding author (Yazışmalardan Sorumlu Yazar): albarist20@gmail.com (A.B. Tahiluddin)*
☏ +639094260941 🖷 +639177043148

ABSTRACT

Meatballs made from fishery products such as fish, shrimp, and squid are among the popular street foods in Asia. To meet the increasing demand for these street foods, there is a need to develop/formulate new balls out of fishery products. Hence, in this study, crab balls from blue swimming crabs (*Portunus pelagicus*) were formulated and standardized using three formulations (meat and binder ratio): Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30). Sensory attributes such as flavor, color, texture (juiciness and chewiness), and general acceptability of the three formulations were evaluated by sensory panelists. Selected formulation was further analyzed in terms of shelf-life testing and comparison with the existing commercial squid ball. Consumer testing was also done to determine the feasibility of the formulated crab ball. Results revealed that Formulations B and C received the highest overall score of sensory attributes ($p<0.05$). Therefore, Formulation C was chosen for further analyses. It was found that the formulated crab ball had a higher acceptability than the commercial squid ball ($p<0.05$). Shelf-life testing revealed that the frozen formulated crab balls could last more than 35 days due to their consistent high to moderate general acceptability scores. This study suggests that blue swimming crab (*P. pelagicus*) can be used as an alternative raw material for fishery meatball preparation.

Keywords: Acceptability, Crab ball, Blue swimming crab, *Portunus pelagicus*, Sensory attributes

Mavi Yüzen Yengeçten (*Portunus pelagicus*) Yeni Formüle Edilmiş Yengeç Köftelerinin Kabul Edilebilirlik ve Raf Ömrü Testi

ÖZ

Balık, karides ve kalamar gibi su ürünlerinden yapılan köfteler, Asya'nın popüler sokak yemekleri arasında yer almaktadır. Bu sokak gıdalarına yönelik artan talebi karşılamak için, balıkçılık ürünlerinden yeni köfteler geliştirmeye/formüle etmeye ihtiyaç vardır. Bu nedenle, bu çalışmada, mavi yüzen yengeçlerden (*Portunus pelagicus*) elde edilen yengeç köfteleri üç formülasyon (et ve bağlayıcı oranı) kullanılarak formüle ve standardize edilmiştir: Formülasyon A (50:50), Formül B (60:40) ve Formül C (70:30). Tat, renk, doku (sululuk ve çiğnenebilirlik) gibi duyusal nitelikler ve üç formülasyonun genel kabul edilebilirliği panelistler tarafından değerlendirilmiştir. Seçilen formülasyon, raf ömrü testi ve mevcut ticari kalamar köftesiyle karşılaştırma açısından ayrıca analiz edilmiştir. Formüle edilmiş yengeç köftelerinin uygulanabilirliğini belirlemek için tüketici testleri de yapılmıştır. Sonuçlar, formülasyon B ve C'nin en yüksek genel duyusal nitelik puanını aldığını ortaya koymuştur ($p<0.05$). Bu nedenle, ileri analizler için Formül C seçilmiştir. Formüle edilen yengeç köftesinin ticari kalamar köftesinden daha yüksek kabul edilebilirliğe sahip olduğu bulunmuştur ($p<0.05$). Raf ömrü testi, donmuş formüle edilmiş yengeç köftelerinin tutarlı yüksek ve orta genel kabul edilebilirlik puanları nedeniyle 35 günden fazla dayanabileceğini ortaya koymuştur. Bu çalışmada, mavi yüzen yengecin (*P. pelagicus*) balık köftesi yapımında alternatif bir hammadde olarak kullanılabileceği belirlenmiştir.

Anahtar Kelimeler: Kabul edilebilirlik, Yengeç köftesi, Mavi yüzen yengeç, *Portunus pelagicus*, Duyusal özellik

INTRODUCTION

Street foods refer to those ready-to-eat foods and beverages which are prepared and sold by hawkers and vendors in public places, mainly on streets [1, 2]. In addition, those foods sold around and within schools that are not coming from restaurants or school canteens are also considered street foods [1]. Hence, street foods are popular and attractive to young consumers [3] because they offer cheap and accessible meal options and as an alternative to home-cooked foods [2, 4-7].

A large number of people globally consume street foods in some form daily as a part of their eating habits [8]. It was estimated that about 2.5 billion people worldwide consumed street foods every day in 2007 [7]. Moreover, in many developing countries, street foods play considerable roles in providing socioeconomic and nutritional opportunities for many low and middle-income populace [1, 4, 9, 10]; and as important tourist attractions in Asia among foreigners [11].

Meatball, such as fish ball, is one of the famous street foods in Southeast Asia, which is served traditionally in various applications, such as cooked/served in noodles and soup, steamed/vegetable, or fried. It comes with various names depending on the country, like 'yu wan' in China, 'yu huan' in Singapore, 'bebola ikan' in Indonesia and Malaysia, 'nga soke' in Myanmar, 'look chin pla' in Thailand, and 'bola bola' in the Philippines [12]. Fish ball is typically white, round shape food that contains fish meat and other ingredients like starch, sugar, and salt, fried in oil, and sold on the street [13]. In the Philippines, meatballs made from fish and fishery products such as fish balls, squid balls, and shrimp balls are popular and widespread forms of street foods [13]. However, the use of crabs as meatballs is still in its infancy, and there is no available commercial crab ball on the markets, particularly in the southern Philippines.

Blue swimming crab (BSC, *Portunus pelagicus*) is an economically marine and estuarine species of crab widely distributed throughout the Indo-West Pacific [14]. Its meat, in the form of fresh or frozen, is popularly sold in the local markets and among crab-flesh canning businesses in Southeast Asia [15]. In the Philippines, BSC is one of the vital and abundant fishery resources that provide a source of livelihood for coastal dwellers [16]. BSC is rich in protein, saturated fatty acids, polyunsaturated and monounsaturated fatty acids, and minerals, such as magnesium, calcium, zinc, and iron [17]; and its nutritional contents of BSC greatly vary according to gender and edible parts [18]. It has been suggested in the previous study that due to its high nutritional contents, crab offers higher potential value-added products for commercial utilization [19]. For instance, Thomas et al. [20] studied and standardized BSC as a ready-to-eat pasteurized crab spread. Waste products of BSC showed potential food flavor [21]. Currently, studies on crab balls worldwide are limited [22]. To the best of our knowledge, there are no available studies on the use of BSC as raw material for balls. In an area where BSC is one of the readily available fishery resources harvested both from capture fisheries and aquaculture, its promising use as value-added products such as crab ball formulation can be a big business and may offer new opportunities, especially for women involved in small or large scale enterprises. Thus, in this study, we formulated and standardized the crab ball made from BSC (*P. pelagicus),* determined its acceptability and shelf-life, compared it with the commercial squid ball, and tested its feasibility for commercialization.

MATERIALS and METHODS

The study was carried out at the Fish Processing Laboratory, College of Fisheries, Mindanao State University-Tawi-Tawi College of Technology and Oceanography, Bongao, Tawi-Tawi, Philippines (Figure 1).

Product Development

Prior to the experiment, a series formulation was done thrice a week for two weeks until the right flavor and texture were attained. The new crab meat was developed with a corresponding ratio of added ingredients.

Raw Material

The raw material, BSC (*P. pelagicus*), was procured from the Qhalipa Venture Processing Plant, Motorpool, Bongao, Tawi-Tawi, Philippines, and brought to the study site. The purchased crab was in the form of meat, which was freshly removed from the shell, cleaned, and free from any foreign materials. Upon arrival, the crab meat was washed, brined at 1:10 (1 cup salt: 10 cups water), drained, then minced using mortar and pestle, and set aside. The flour was sifted, and other ingredients like corn starch, carrots, sugar, salt, MSG, garlic, onion, ginger, white pepper, and water were prepared (Table 1).

Processing of Crab Balls

The lot was divided into three sub-lots, and the pre-weighed ingredients in different concentrations (Table 1) were added to each of the sub-lots. Each of the mixtures was mixed until pasty. Finally, each mixture was formed into balls manually with a uniform weight of approximately 10 grams, and these were dropped into the water at 90°C for 10 minutes (Figure 2).

Sensory Evaluation/Quality Determination

Sensory evaluation was performed at the end of the activities to determine the most acceptable product. The crab balls were fried at 135°C for 5 minutes prior to evaluation. Panelists, composed of seven professionals and students of the College of Fisheries, Mindanao State University-Tawi-Tawi College of Technology and Oceanography, were instructed on the sensory attributes to be used for each study. They were presented with products that possess the characteristics of bland flavor, color, and texture (juiciness and chewiness). They were asked to evaluate the attributes using the 3-point hedonic scale, ranging from poor (score: 1) to good (score: 3) for flavor, dry (score: 1) to extremely juice (score: 3) for juiciness, tough (score: 1) to chewy (score: 3) for chewiness, dirty white (score: 1) to golden yellow (score: 3) for color, and unacceptable (score: 1) to highly acceptable (score: 3) for general acceptability. On the other hand, the crab ball and commercial squid ball were compared based on the sensory attributes using the 3-point hedonic scale. Between each sample evaluation, water was served for cleansing the mouth.

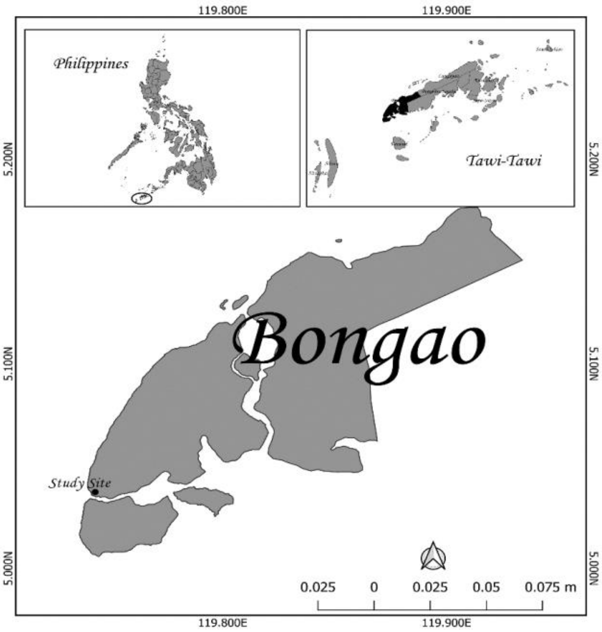

Figure 1. Map of the study site

Table 1. Lists of ingredients using three different formulations*

Ingredients	Weight (g)		
	Formulation A (50:50)	Formulation B (60:40)	Formulation C (70:30)
Crab	250	300	350
Flour	150	120	90
Corn starch	100	80	60
Total	500	500	500
Other Ingredients			
Carrots	35	35	35
Sugar	10	10	10
Salt	8	8	8
MSG	8	8	8
Garlic (ground)	5	5	5
Onion (ground)	5	5	5
Ginger (ground)	1	1	1
White pepper	2	2	2
Water with egg **	50 mL	50 mL	50 mL

*: Formula A (50:50) refers to the meat and binder ratio, which corresponds to meat concentrations of 50% and 50% binder flour and corn starch. Formula B (60:40) has a meat content of 60% and 40% binder flour and corn starch. Formula C (70:30) has a meat content of 70% and 30% binder flour and corn starch. ** 500 mL mixture of one piece egg and water

Shelf-life Testing Using Polyethylene Bag

Shelf-life of the most acceptable product was determined by changes in moisture content, pH value, and microbial test, as well as sensory attributes. Fifteen (15) pieces per pack or a total of seventy-five (75) pieces (5 packs) of the final product were stored at -12°C temperature in the freezer (Markes, Canada). The products were withdrawn every after seven (7) days of storage for the duration of 35 days. Sampling was done in triplicate. Sensory evaluation of the frozen samples was performed on the day of production (Day 0) and after 7, 14, 28, and 35 days of storage. All samples withdrawn were analyzed for moisture content, pH level, and microbial load. Tests were done in triplicate.

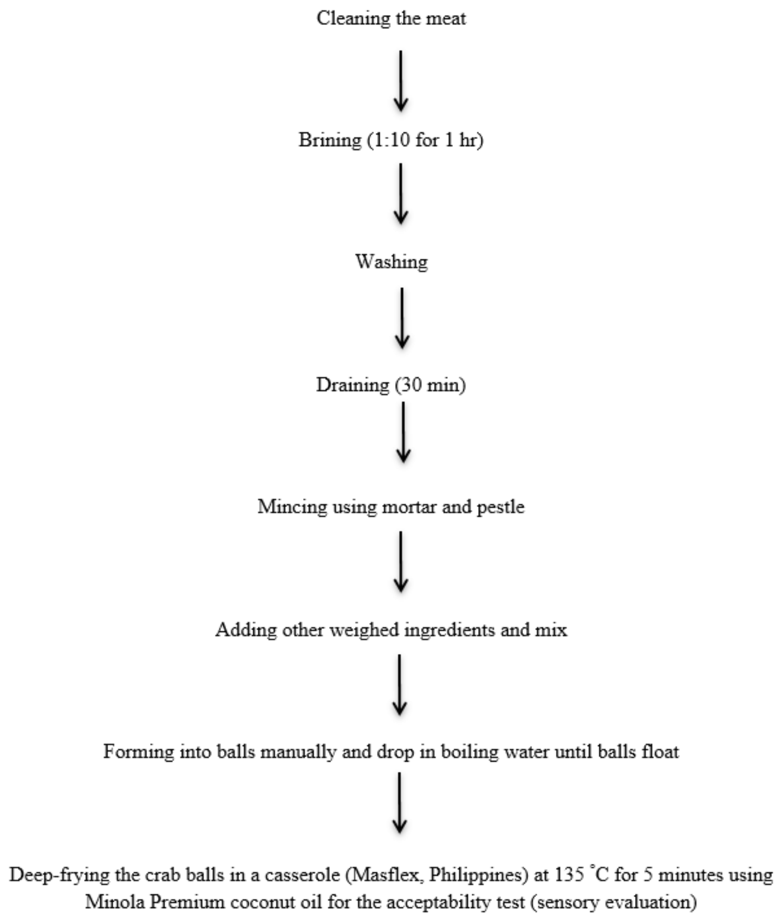

Figure 2. The process used in the processing of crab balls

Sensory Evaluation

Products were deep-fried at 135°C for 5 minutes and then presented to the panelists for evaluation. Each sample was evaluated by the same panelists mentioned above using the 3-point hedonic scale.

Physicochemical Composition and Microbial Analysis

The moisture content of the product was determined using the oven-drying method (Binder, Germany) (AOAC, 1975). The pH level of the product was determined using a pH meter (Sartorius, Germany). A microbial load test of crab balls was conducted every seven days for 35 days to determine if the product was a health hazard. Total Plate Count (TPC) was determined in nutrient agar using the spread plate method. Samples were incubated at 37°C for 18 to 24 hours [23].

Test Marketing of Newly Prepared Product

After the standardization of the product, a consumer acceptability test by 30 people was done to determine the commercial feasibility of the new product. Actual consumer testing was done in terms of general acceptability using a 5-point hedonic scale, ranging from dislike very much (score: 1) to like very much (score: 5).

Statistical Analysis

The data from the sensory evaluation (flavor, juiciness, chewiness, color, and general acceptability) were analyzed using IBM SPSS version 20. One-way Analysis of Variance (ANOVA) was used to check the significant difference, and the Duncan Post-Hoc Test was utilized to compare the sensory attributes of the three formulations, while a t-test was used to compare the selected formulated crab ball and squid ball. The data on the sensory attributes are presented as mean±SE (standard error). The significant level used was 0.05.

RESULTS

Product Formulation/Development

The sensory attributes of the newly formulated crab ball are shown in Figures 3, 4, 5, 6, and 7. The flavor scores of Formulation C (2.76±0.10), Formulation B (2.76±0.10), and Formulation A (2.31±0.23) did not differ significantly ($p>0.05$), although Formulation C and B obtained the highest scores of flavor attribute (Figure 3). However, the juiciness scores in Formulation C (2.14±1.16) and Formulation B (1.91±0.15) were highly significant ($p<0.05$) than Formulation A (1.45±0.15), as shown in Figure 4. The crab balls' chewiness attribute can be seen in Figure 5, and analysis revealed that the chewiness score of Formulation C (2.81±0.07) was significantly greater ($p<0.05$) than Formulation A (2.12±0.25) but not significant ($p>0.05$) with Formulation B (2.59±0.18). The different meat and binder ratios had no significant effects ($p>0.05$) on the color of the newly formulated crab ball (Figure 6). In terms of general acceptability of the crab ball, panelists preferred that Formulation C (2.57±0.96) and Formulation B (2.36±0.11) had the general acceptability scores statistically ($p<0.05$) than Formulation A (1.95±0.19) as shown in Figure 7. Thus, Formulation C with a meat and binder ratio of 70:30 was chosen for the subsequent analyses, i. e. shelf-life testing, comparison with the commercial squid ball, and commercial feasibility test.

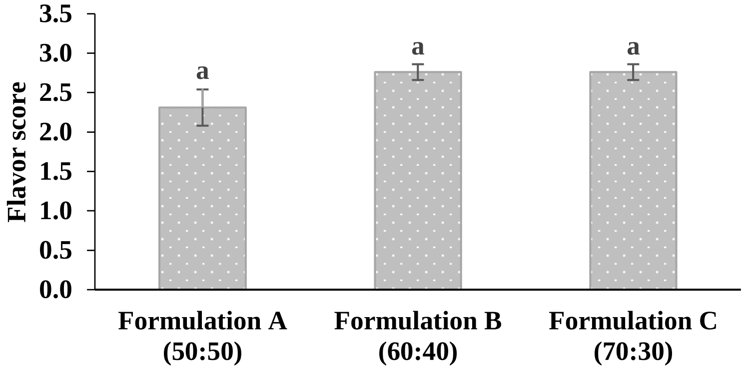

Figure 3. Flavor score of the newly formulated crab ball (blue swimming crab) at different meat and binder ratios: Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30). Scale: 3=Good, 2=Fair, 1=Poor

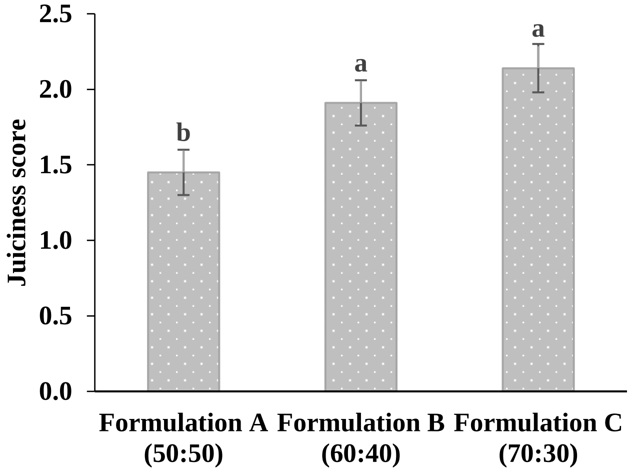

Figure 4. Juiciness score of the newly formulated crab ball (blue swimming crab) at different meat and binder ratios: Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30. Scale: 3=Extremely juicy 2=Just right juiciness, 1=Dry

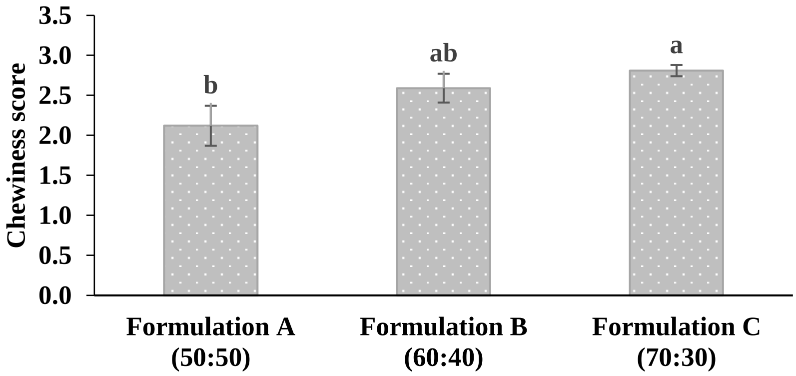

Figure 5. Chewiness score of the newly formulated crab ball (blue swimming crab) at different meat and binder ratios: Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30). Scale: 3=Chewy, 2=Mushy, 1=Tough

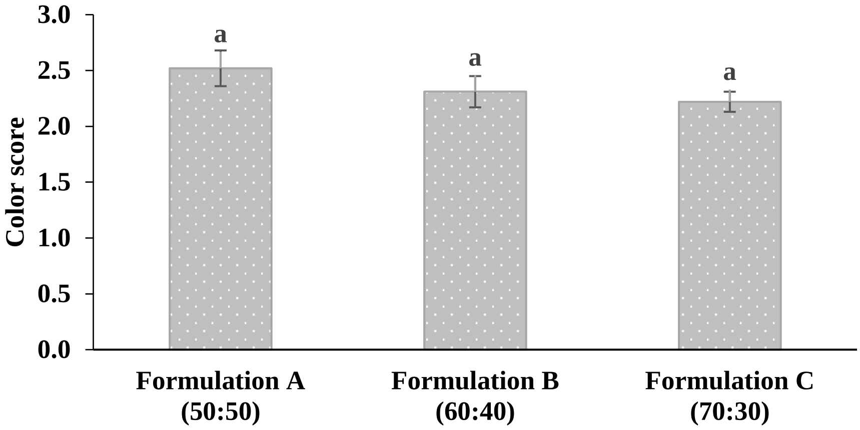

Figure 6. Color score of the newly formulated crab ball (blue swimming crab) at different meat and binder ratios: Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30). Scale: 3=Golden yellow, 2=Light yellow, 1=Dirty white

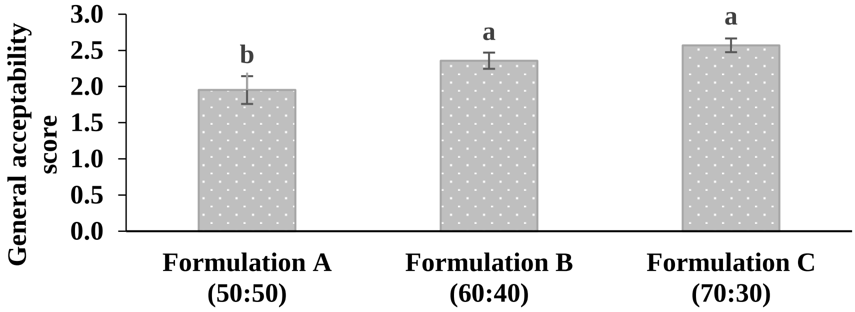

Figure 7. General acceptability score of the newly formulated crab ball (blue swimming crab) at different meat and binder ratios: Formulation A (50:50), Formulation B (60:40), and Formulation C (70:30). Scale: 3=Highly acceptable, 2=Acceptable, 1=Unacceptable.

Comparison between Formulated Crab Ball and Commercial Squid Ball

Seven panelists evaluated the formulated crab ball and commercial squid ball for flavor, juiciness, chewiness, color, and general acceptability. A t-test showed that the formulated crab ball was significantly higher ($p<0.05$) than the commercial squid ball in sensory attributes (Figure 8). Formulated crab ball received a significantly higher ($p<0.05$) flavor (2.95±0.031), juiciness (2.38±0.10), chewiness (2.64±0.14), and color (2.74±0.10) scores compared to commercial squid ball with sensory scores of 2.13±0.18, 1.88±0.20, 2.26±0.17, 2.0±0.13, respectively. In terms of general acceptability, formulated crab balls obtained a significantly greater score of 2.83 ±0.13, described as 'highly acceptable' than the commercial squid ball with a score of 1.64±0.19.

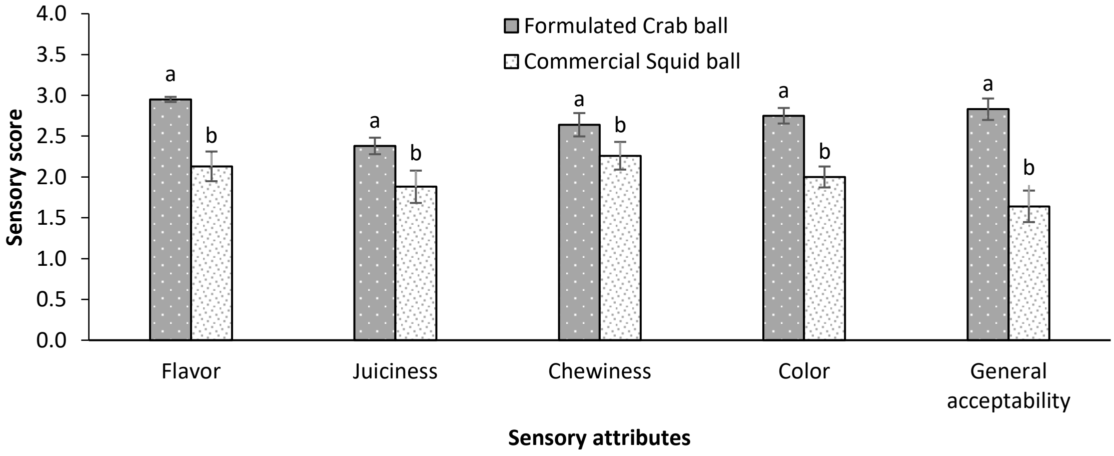

Figure 8. Sensory attributes of formulated crab ball and commercial squid ball using a 3-point hedonic scale

Shelf-Life Testing and Changes in Sensory Attributes during Storage

This study considered the following limiting factors that are critical in the shelf stability of the frozen formulated crab ball products: quality changes in flavor, texture, color, moisture content, pH, and microbial load (TPC). Sensory evaluation of flavor, texture (juiciness and chewiness), color, and general acceptability was carried out for the heat-sealed crab balls stored at -12ºC temperature. Figure 9 shows that the crab ball was described by the panelists on day 0 as a good flavor with a sensory score of 3.0. On day 35, the crab ball gave a flavor score of 2.86, which was still near high acceptable. Figure 10 shows that the sensory score for the juiciness of the crab ball was evaluated as 2.0 on day 0. After 35 days, the crab ball's juiciness changed to a near sensory score of 3.0, which was described as extremely juicy. The chewiness score is shown in Figure 11, which had a little change as the storage period continued from 2.71 on day 0 to 2.57 after 35 days. Figure 12 shows that the color of the crab ball sample had a sensory score of 2.71 on day 0 and reached 3.0 on day 35, which corresponded to the description of 'golden yellow.' The fried crab ball had a golden yellow color throughout the storage period due to the ingredients added, which was attractive to the panelists' eyes. The general acceptability score is shown in Figure 13, which was rated by the panelists as nearly 'highly acceptable' on day 0 with a sensory score (2.71), and it reached 3.0 on day 35.

In terms of change in pH levels, the crab ball initially had a pH value of 9.04 and gradually decreased to almost neutral on day 35 (Figure 14). Initially, the moisture content of the samples in crab ball was 62.5%, and it fluctuated after days of storage, as shown in Figure 15. The changes in the TPC of the crab ball are presented in Figure 16. The initial TPC of the crab ball was 3.0 log CFU g^{-1}. It increased from 3.51 log CFU g^{-1} on day 7 to 5.30 log CFU g^{-1} on day 14. On days 21 to 28, the TPC intensified from 7.09 and 9.11 log CFU g^{-1} until it reached 12.05 log CFU g^{-1} on day 35.

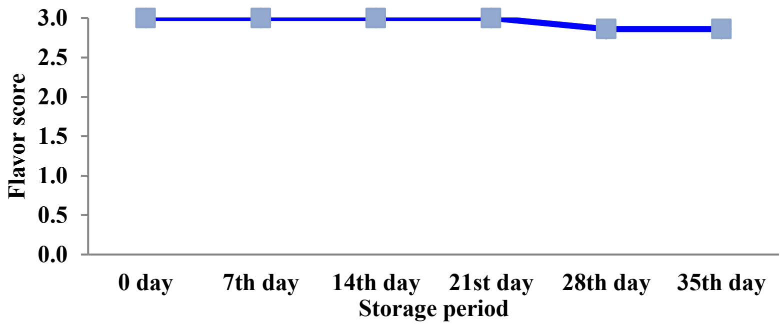

Figure 9. Changes in flavor score of polyethylene-packed crab ball

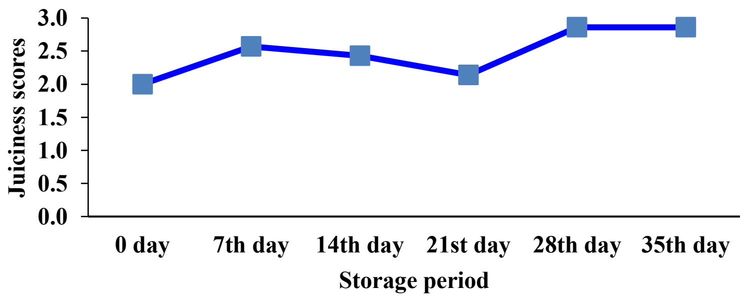

Figure 10. Changes in juiciness score of polyethylene-packed crab ball

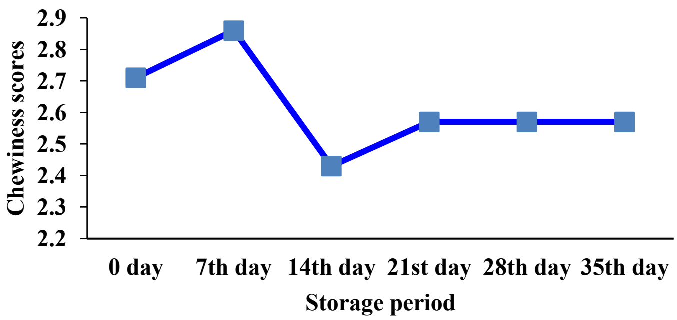

Figure 11. Changes in chewiness scores of polyethylene-packed crab ball

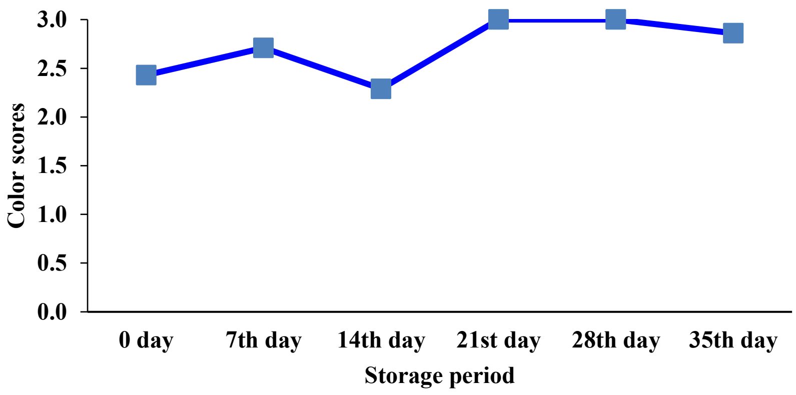

Figure 12. Changes in color score of polyethylene-packed crab ball

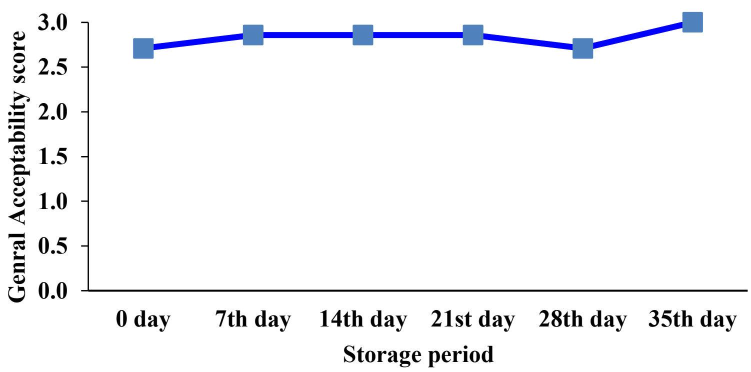

Figure 13. Changes in general acceptability score of polyethylene-packed crab ball

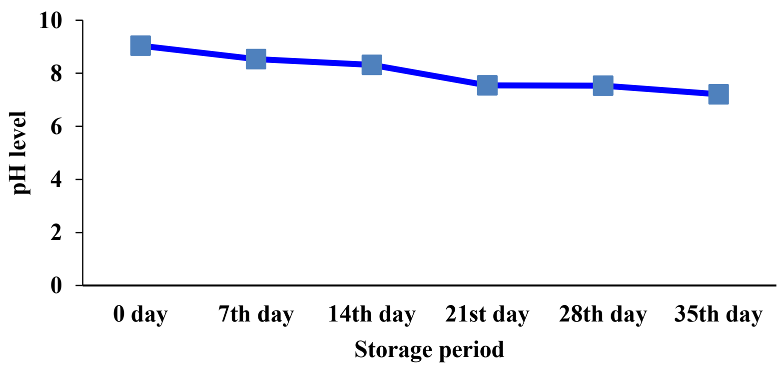

Figure 14. Changes in pH score of polyethylene-packed crab ball

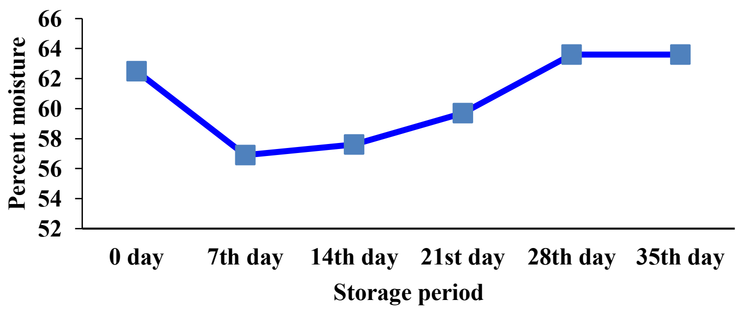

Figure 15. Change in percent moisture content of polyethylene-packed crab ball

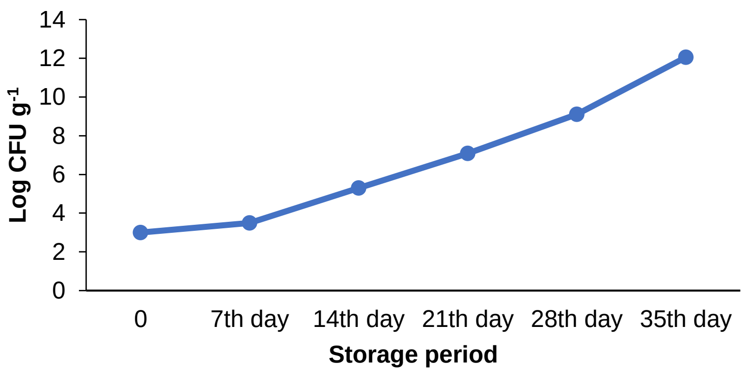

Figure 16. Changes in microbial load (TPC) of polyethylene-packed crab ball expressed as log CFU g^{-1}

Test Marketing of Formulated Crab Ball

The acceptability score of the thirty (30) panelists for crab ball is illustrated in Figure 17 while the product's commercial feasibility is shown in Figure 18. Crab ball had high consumer acceptability, which was noted that they 'liked very much' the product (93.33%), and only 2 persons (6.67%) described as 'slightly like' the product. All consumers (100%) responded that the crab ball had great potential for commercialization.

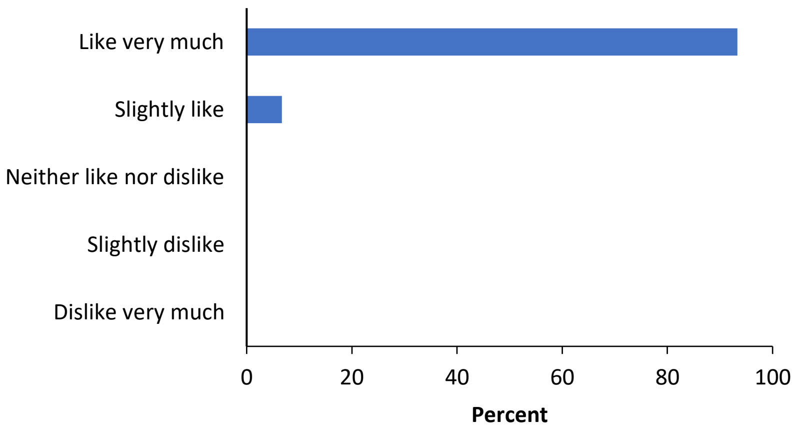

Figure 17. General acceptability of consumers for formulated crab ball using a 5-point hedonic scale

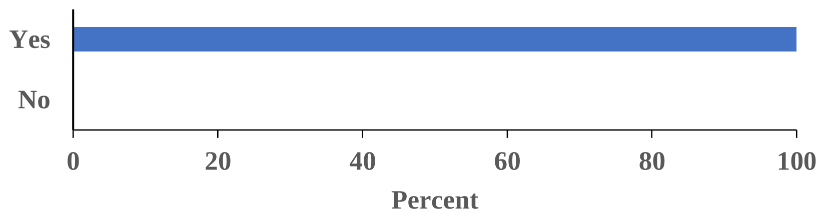

Figure 18. Consumer response for commercial feasibility of formulated crab ball

DISCUSSION

Fish balls are among the famous street foods in the Philippines and in Asian countries [12, 24, 25]. Other forms of street food balls available in the market are squid balls and shrimp balls [13]. To meet changing consumers' habit towards street foods, there is a need to explore other aquatic invertebrates as raw materials for balls. Hence, we utilized and tested the feasibility of BSC as raw material for balls.

Crabs are a very good source of plenty of nutrients (protein, long-chain omega-3 fatty acids, essential amino acids, minerals, and vitamins) that are essential for the health of humans. Crab meat and novel-based processed products have been quite well-known recently [26]. There are scarce studies on the utilization of BSC as value-added products: some of these are the standardization of ready-to-eat crab spread [20] and utilization as food flavour [21] and crabcake [27]. In addition, the meat of green crab (*Carcinus maenas*) used as a formulation for empanada was evaluated as "like slightly" to "like moderately," regardless of the percentage of formulations [28].

The results of our study revealed that formulations C and B with a 70:30 and 60:40 (meat to binder ratio) gained the highest sensory attributes from the panelists.

Also, formulated crab ball (70:30) was "liked very much" by most consumers and even highly comparable to the commercial squid ball. This is maybe due to the higher concentration of crab meat that gives a unique flavor and delicious taste [26]. This indicates that formulated crab ball in this study has a huge potential for commercialization and is likely to compete with the existing balls in the market. Shelf-life testing analysis of the chosen crab ball (formulation C) in this study showed that within 35 days of storage at -12°C, the crab ball was generally still found high to moderate acceptable for consumption based on the sensory attributes. Generally, fish balls are stored at -18°C in order to keep the wholesomeness and the product quality, which can last for six months [12]. Hence, in this study, the newly formulated crab ball still had nearly high acceptability scores after 35 days. Pure pre-cooked crab meat (*Scylla serrata*) had a good flavor after 40 days [29]. Conversely, those fish balls stored in a refrigerator environment (4°C) can only last from 2 to 14 days [12, 30]. To extend the shelf-life of fish balls, some studies used salt solution [31], while vacuum packaging has a great advantage in lengthening the fish balls' shelf-life [12, 31]. Squid balls' shelf-life can also be extended using radiation processing [32]. Fish balls are typically packed in styrofoam trays, wrapped with plastic films, and distributed to supermarkets or being done by packing in bulk in a polyethylene bag for distribution to open markets or restaurants [12].

The TPC may be used to determine sensory acceptability, sanitary quality, and congruence with good manufacturing practices (GMPs). The TPC's results can be useful to judge the shelf-life or forthcoming changes of sensory in a food product [33]. The initial total plate count (TPC) of crab balls in this study was 3.0 log CFU $g^{-1,}$ and the low initial TPC in balls indicated very good quality; this is lower than the initial TPC (4 log CFU g^{-1}) of the fish ball [34] and relatively higher than the initial TPC of the fish ball in curry [35]. The maximum microbiological limit for frozen products is 7 log CFU g^{-1} [37]. However, as the storage was increased, the TPC of the crab ball was also increased. This is parallel to previous studies that the TPC of fish balls generally increases with storage time [31, 36], and this is also true for the total viable count in fish balls [38].

The pH of the food is one of the chemical factors that affect the microbial food, thereby reflecting the food spoilage. Bacteria typically proliferate faster between pH of 6.0 and 8.0 [39]. In the present study, the pH of the crab balls ranged between 9 and 7 throughout the storage period. Generally, the pH of crab balls decreased during storage. Kok and Park [40] also noticed that the pH of set fish balls decreased with time from 7 to 5 after 21 days of being stored at 4°C. Fish balls preserved with coconut shell liquid smoke with a pH of 5.7-5.8 stored a 4°C for 20 days of storage [41]. In curry fish balls, the pH decreased from 6.38 to 6.07 within 12 days of storage at -2°C [35]. Postmortem lowering of muscle pH was attributed to the myofibrillar protein denaturation due to the conversion of muscle glycogen to lactic acid [42]. Psychrotrophs build up as well as denaturation of myofibrillar protein of set fish ball accounted for the pH reduction [40, 43]. Hence, the lowering of pH in the present study may have also been caused by these processes since the APC of crab balls increased with storage.

Water is essential for microorganisms to grow in food products [44]. The majority of microorganisms favor growth at moisture content higher than 15%–17% [45]. In the present study, the initial moisture content of the crab balls was 62.5% and fluctuated between 57% and nearly 64% during storage. These findings are generally lower than other studies on fish balls. The moisture content of Malaysian fish balls ranged from 73.80-88.71% [25]. Fish balls made of *Alburnus mossulensis* mince were 71.3% moisture content stored at -18°C [38]. In Indian mackerel fish balls stored at -18°C, the moisture content slightly decreased from 73.84% at day 0 to 72.69% after six months of storage [34]. The moisture content of fish balls made of cod surimi was found to be 42.14% [46]. Typically, due to high moisture and protein contents, fish balls are greatly perishable [40] since these are among the two important conditions in the growth of spoilage microorganisms [47].

CONCLUSION

The utilization of blue swimming crab (*Portunus pelagicus*) as a great potential raw material for balls has been successfully formulated and standardized. The high acceptability of the crab ball evaluated by the panelists and consumers indicates that the commercialization of formulated crab balls is feasible and can likely rival existing fish balls, squid balls, and shrimp balls on the market. This study may provide opportunities for those venturing into the crab ball business. It also serves as baseline information for further studies investigating the crab ball and similar crab value-added products. Future studies on the quality and shelf-life of crab balls may be further conducted.

ACKNOWLEDGMENTS

The authors are grateful to Joana Joy A. Saclot, Mujaiyon Esmola, Qhurdee N. Hapid, Jainal P. Akrim, Cheryl Gay M. Omamalin for their assistance during the experiment, and to Maria Liza B. Toring-Farquerabao for the map.

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