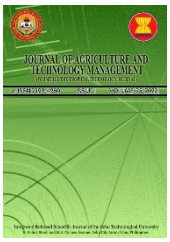
Journal of Agriculture and Technology Management (JATM)
25(1): 221-225 (January-June 2022)



Original article

Formulation of shrimp cookies using white shrimp (*Penaeus vannemei*) crust powder enriched with coconut water

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ABSTRACT

Shrimp crust or shell contains protein, chitin, and minerals. As such, they could be good additives in various food items because of their nutritional value. This study presents the method of preparing shrimp cookies using white shrimp crust powder with varying concentrations of coconut water as pretreatment. Sensory qualities of coconut-water treated cookies using preference and descriptive testing and microbial analyses were done. Based on the ANOVA at a 5% significance level, shrimp crust treated with 25% brine solution and 75% coconut water gave the highest mean score of 8.11, which means "like very much." The sensory panelists described the cookies with 3g coconut-water-treated shrimp crust powder as the most preferred treatment formulation with a golden-brown color, slight shrimp flavor, moderate shrimp odor, and crunchy texture. The most preferred cookie has a bacterial aerobic plate count of < 1.0 x 10^2cfu/g and minimal counts of *Escherichia coli*, *Staphylococcus* aureus, mold, and yeast. The proximate analysis of the cookies has an ash content (1.09%), moisture content (1.53%), total fat content (17.4%), protein content (9.82%), and carbohydrates content (70.2%). Hence, cookies can contain 3g shrimp crust powder using 25% chilled brine solution and 75 % coconut water as a pretreatment method for the crust. The product is viable for community and university enterprises.

KEYWORDS: *coconut water, sensory qualities, shrimp cookie making, shrimp crust*

1 INTRODUCTION

White leg shrimp, also known as Pacific white shrimp or king prawn, is a species of the eastern Pacific Ocean commonly caught for food. Shrimp belongs to a large group of crustaceans and is one of the most crucial commercial seafoods globally (Akonor et al., 2016). Consumers are increasingly concerned about food production's environmental and social impacts in developing countries, and many are willing to take action (Oosterveer, 2006). Proper shrimp waste processing is an approach to recover biomaterials such as chitin, protein, lipids, astaxanthin, flavor compounds, and calcium carbonate. These active components have large-scale applications in biology and food, pharmaceutical, agricultural, cosmetic, pulp, and textile industries (Mao et al., 2017). Turning cast-off shells into nitrogen-rich chemicals would benefit economies and the environment (Yan & Chen, 2015).

Trung (2017) pointed out that shrimp is usually processed to obtain shrimp meat for export. The 35-45% leftovers are shells and heads considered as waste. Every year, some 6 to 8 million tons of waste from crab, shrimp, and lobster shells are produced globally and about 1.5 million tons in Southeast Asia alone (FAO, 2014). As a result, shrimp processing leads to massive amounts of shrimp bio-waste, estimated to be more than 150,000 metric tons (wet weight) per year (Trung, 2017). The continued production of this biomaterial needs to be treated as this can severely damage the market value of shrimp and can hugely contribute to the accumulation of waste hence, this study looked into the possible conversion of this shrimp waste into food additives.

Shrimp's waste (head, shell, and tails) contains several bioactive compounds such as chitin, minerals, amino and fatty acids. The major components of shrimp by-products are protein ranging 9.3-11.6% and total fat content approximately 0.7%. The calcium content (3,000 mg/100g) was higher than those of phosphorus (400 mg/100g) sodium (270 mg/100g), while manganese and iron were present in trace amounts (Heu *et al*., 2003). It also contains a few valuable carotenoids and chitin. Chitosan is a valuable product with many economically attractive applications in food, agriculture, biotechnology, cosmetics, medicine, and waste treatment (Hirano, 1996). Chitosan coating combined with GTE could be used as an effective natural alternative to synthetic antimelanosic agents to inhibit port-mortem melanosis and improve the quality of shrimp during storage in ice (Yuan *et al*., 2016).

These bioactive compounds have a wide range of applications, including medical, cosmetics, paper, pulp, and food (Kandra *el at*., 2011). In the study of Ikasari & Hastarini (2016), they investigated the utilization of

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shrimp powder in the production of lindur fruit-potato simulation chips which was assessed using proximate composition, texture performance and sensory parameters. The results showed that lindur fruit-potato simulation chips enriched with shrimp shell powder had 3.22-4.42% moisture content, 3.33-4.94 ash content, 3.77-5.83% protein content, 14.59-19.04% fat content, 71.06-76.34% carbohydrate content and 341.4-530.9 g/cm2 hardness. Additionally, Castro (2017) (U.M. 2-2015-000093) discloses the method of preparing cookies enriched with small shrimp *Penaeus spp* edible portion for enhancing the color, flavor, and texture of the cookie and found it to be acceptable to consumers.

Coconut (*Cocos nucifera L)* water, also referred to as coconut juice, is a refreshing natural drink consumed in tropical regions of the world (Awua *et al*., 2009). This pure liquid is packed with nutrients that yield an array of health benefits. This contains five essential electrolytes that are present in the human body. This refreshing beverage is consumed as it is nutritious and beneficial for good health. Coconut water helps remove excess oil from the skin, and coconut water has anti-viral, anti-fungal, and antibacterial properties (http://www.coconutwaterlife.com/coconut-water-benefits). It also boasts electrolytes such as potassium, sodium and magnesium, all of which help replenish lost nutrients.

The Cebu Technological University-Technology Research Center (CTU-TRC) conducted a study on coconut water in the 15 nuts varies with its cultivar, the aromatic nuts had 290-368 grams of water which is a lesser amount compared to green nuts having 438-480 grams of water per nut. The coconut industry usually discards coconut water, potentially pretreatment components for the fish process. MacEachern *et al*. (U.M. 2-2014-000712) disclose the method of producing marinated mullet *Mugil cephalus* chunks soaked in 50% coconut water and 10% salt solution at chilled temperature enhances the sensory qualities of chunks mullet. Coconut water from matured coconut is usually a side product in coconut milk, desiccated coconut, and virgin coconut oil. And water from a young coconut is more expensive than matured coconut water. The processing of matured coconut water could still provide additional income to processors in many developing countries, an economic benefit of integrated processing.

This study presents these biomaterials utilizing coconut water in the pretreatment of shrimp waste. Solid shrimp waste undergoes rapid putrefaction because of its alkaline nature (pH 7.5-8.0) (Kandra *et al*., 2011). Due to the high perishability of shrimp waste, appropriate processing needs to be enhanced. The inevitable increase of waste and the application of appropriate technology convert into valuable food products such as cookies that would respond to environmental problems, poverty alleviation, and food security.

This study determined the methods of preparing shrimp crust powder with varying concentrations of coconut water; sensory qualities of coconut-water treated shrimp-crust cookies using preference and descriptive testing; microbial analyses based on bacterial aerobic plate count, *Escherichia coli*, *Staphylococcus aureus*, mold and yeast count of the most preferred treatment; and technology transfer practices of the innovative products to adopters and university enterprise.

2 MATERIALS AND METHODS

This study used experimental research employing different laboratory analyses on the treatment of the experimental samples. The experimental samples were taken from Bohol Agro-Marine Development Corporation (BAMDECOR) and brought to the CTU-Main Campus, Cebu City, Philippines, food production laboratory.

Shrimp Crust Powder Preparation

This study used the white shrimp *Penaeus vannamei* crust from Bohol Agro-Marine Development Corporation (BAMDECOR) Tubigon, Bohol. BAMDECOR is one of the top-five prawn exporters, and the only E.U. accredited processing plant (No. 1641) in the Philippines. It is equipped with a state-of-the-art Gram contact plate freezer and cold storage facilities and is the first to use this model in the Philippines.

The powder was obtained from shrimp crust samples already considered biowaste from BAMDECOR, Tubigon, Bohol, and transported to CTU-Main Campus, Cebu City food production laboratory for processing.

Frozen shrimp crust was weighed and pretreated with different varying concentrations of matured coconut water and chilled brine solution (100% water: 20% salt) to establish the method formulations as shown in Table 1.

Table 1. Treatment formulations of matured coconut water and chilled brine solutions using varying concentrations.

Treatments	%chilled brine solution	%coconut water
T_0	100	0
T_1	75	25
T_2	50	50
T_3	25	75
T_4	0	100

The shrimp crust samples were soaked for 30 minutes in the varying treatment formulations at a chilled temperature (3-5 ^{0}C) as pretreatment. After which, the soaked samples were drained and steamed for 30 minutes to inactivate the enzymes. The steamed crust samples were dried in the dehydrator for 16 hours at 60^{0}Celsius. The dried samples were pulverized using the multi-functional disintegrator to produce a powdery substance

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and sieved to pass through 0.2 mm mesh size to make powder. The shrimp crust powder was packed and stored in an airtight container and placed at room temperature.

Cookie Preparation

Phase 1 of the study was formulating baked cookies using the pretreatment formulations of brine solution (B.S.) and coconut water (C.W.). In this study, the standard shrimp cookie formulation of Castro (U.M. 2-2015-000093) was used and added with different shrimp crust pretreatment formulations, as shown in Table 2.

Table 2. Formulations for shrimp crust baked cookies

Cookie Treatments	Shrimp crust Powder (g)	Wheat Flour (g)	Granulated Sugar (g)	Butter (g)	Eggs (g)	Leavening Agent (g)	Salt (g)
T_0	5 (100% BS:0% CW)	630	255	175	120	5	2
T_1	5 (75% BS: 25% CW)	630	255	175	120	5	2
T_2	5 (50% BS:50% CW)	630	255	175	120	5	2
T_3	5 (25% BS: 75% CW)	630	255	175	120	5	2
T_4	5 (0% BS: 100% CW)	630	255	175	120	5	2

The pre-preparation of ingredients, utensils, and equipment used were gathered and organized. All ingredients in cookie dough preparation were weighed using a digital weighing scale. The butter was creamed until soft and added granulated sugar until fluffy. The creaming was continued until the butter-sugar mixture would produce a soft and fluffy texture. The eggs were added one after the other to the butter-sugar mix. All dry ingredients (wheat flour, leavening agent, shrimp crust powder, and salt) were combined and added into the mixture to produce a cookie dough. The cookie dough was pressed into a lined baking sheet and brushed with an egg wash. They baked the cookie dough into an oven at 320-350^{0}F for about 25-30 minutes. The newly baked cookies were cooled in the rack and packed using appropriate packaging materials and labels. The cookies were stored in an airtight container until ready for the sensory analyses.

Phase 2 of the study utilized the most preferred treatment (T_1), which is 75% BS and 25% C.W. treated shrimp crust powder to cookies based on the result of phase 1.

Table 3. Cookie treatments using varying concentrations of 75% BS and 25% C.W. treated shrimp crust powder.

Treatments	Shrimp crust powder (g)	Wheat flour (g)	Granulated sugar (g)	Butter (g)	Eggs (g)	Leavening agent (g)	Salt (g)
T_1	3	630	255	175	120	5	2
T_2	5	630	255	175	120	5	2
T_3	7	630	255	175	120	5	2

The study of Ibrahim *et al*. (1999) was the basis for the percentage of shrimp crust powder addition and the optimization of the powder concentration incorporated in shrimp cookies. Castro (2015) utilized 30 grams of fresh shrimp for preparing shrimp cookies. However, powdered shrimp is more concentrated than a fresh commodity. Hence, there's a need for optimization of shrimp crust powder.

Sensory evaluation

The formulated cookies with varying coconut water-treated shrimp crust concentrations were subjected to sensory evaluation using descriptive testing utilizing25 trained panelists to preference testing with 50 consumer panelists using a 9-point hedonic rating scale (1= disliked extremely while 9=liked extremely).

Microbiological Analyses

The most preferred cookie treatment was subjected to microbiological analyses. The decimal dilutions of samples for bacterial aerobic plate count, *Escherichia coli, Staphylococcus aureus*, mold, and yeast count were prepared following the Bacteriological Analytical Manual Online January 2000. The experimental samples were submitted to the Department of Science and Technology (DOST) Region 7, Cebu City, for the analyses.

Physico-chemical analysis

The most preferred cookie was subjected to physicochemical analyses. The ash, crude protein, total fat, and sodium contents determination was based on the CSOP-3-003, CSOP -3-009, CSOP-3-007, and CSOP-3-112 respectively. The moisture content and water activity were based on AOAC-934.01 and AOAC-978.18. The carbohydrate and food energy values were determined by the calculation method.

Statistical analysis

The data gathered was analyzed using a one-way Analysis of Variance (ANOVA) at a 5% level of significance.

3 RESULTS AND DISCUSSION

The study investigated the cookies using powder treated with varying concentrations of brine solution and coconut water based on sensory evaluation phase 1. Phase 2 of the study was the sensory evaluation results of cookies with varying concentrations of the most preferred treated shrimp crust powder, using preference and descriptive testing; microbial analyses based on bacterial aerobic plate count, *E. coli*, *S. aureus*, mold and yeast count, and practices of technology transfer to adopters and university enterprise.

Sensory characteristics of cookies using varying

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concentrations of brine solution and coconut water as pretreatment to shrimp crust (Phase 1)

Phase 1 presents the sensory evaluation results based on the preference and descriptive testing of shrimp crust cookies using powder treated with varying concentrations of brine solution and coconut water as pretreatment. The results of sensory evaluation in terms of color, odor, flavor, texture, and overall acceptability are presented in Figure 1.

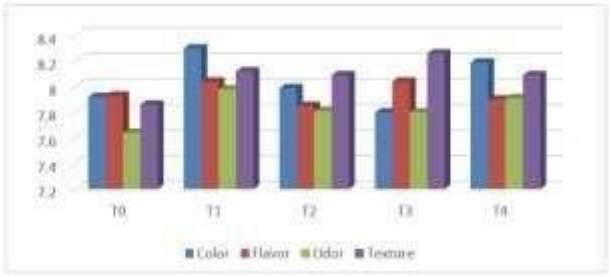

Figure 1. Preference sensory attributes results of cookies with varying levels of brine solution and coconut water

It was shown that T_1 (75%BS: 25%CW) treated shrimp crust powder had the highest mean scores in the color, odor, and flavor sensory attributes compared to other treatments. As to the texture sensory attributes, the panelist observed the highest mean with T_3 (50% BS: 50% CW). Increasing the level of coconut water enhances the crispiness of the cookie samples. Pretreating the shrimp crust with 75%BS:25%CW has the highest sensory attributes mean score of 8.11, implying Like Very Much, which showed the most preferred treatment for cookies. Furthermore, there was no significant difference in the control and pretreated shrimp crust concerning the overall general acceptability.

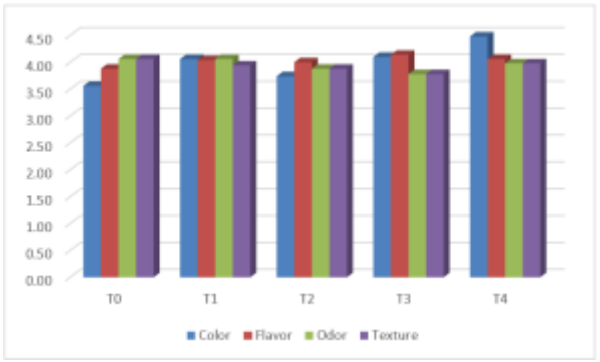

Figure 2. Descriptive test sensory results of cookies with varying levels of brine solution and coconut water

As shown in Figure2, sensory panelists described the organoleptic properties of cookies with varying levels of brine and coconut water solution as a golden-brown color, slightly shrimp flavor, slightly shrimp odor, and crunchy texture. The browning reaction affected the color when the cookie dough underwent high temperature, particularly in an oven. This implies that adding coconut water as pretreatment of shrimp crust before drying and pulverizing, then applied to cookie making enhances all sensory attributes.

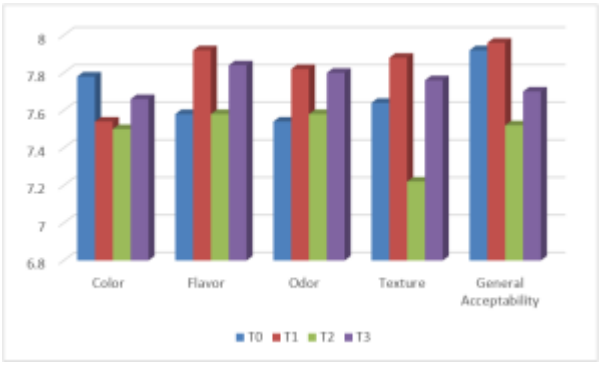

Figure 3. The preference test result of cookies with varying levels of shrimp crust powder

After establishing the appropriate concentration of 25% BS and 75% C.W. to treat shrimp crust powder, this was applied to shrimp cookies preparation based on Castro (2015) as Phase 3 of the study. Varying levels of treated shrimp crust powder (3g, 5g, and 7g) were added to the cookie formulation. The results showed that T_1 (3g shrimp crust powder) had the highest acceptability rating scores of 7.96, which means *Like Very Much* as evaluated by the sensory panelists. After evaluation with replications, the most preferred cookies had 3g shrimp crust powder treated with 25%BS and 75%CW after evaluation with replications. Furthermore, there was no significant mean difference in the sensory attributes in all treatments at a 5% level of significance.

Coconut water-treated shrimp crust cookies are a functional food that utilizes shrimp powder as useful extruded snacks rich in protein. These resources are potential bio-resource to be converted to protein-rich value-added products (Kumar et al., 2017).

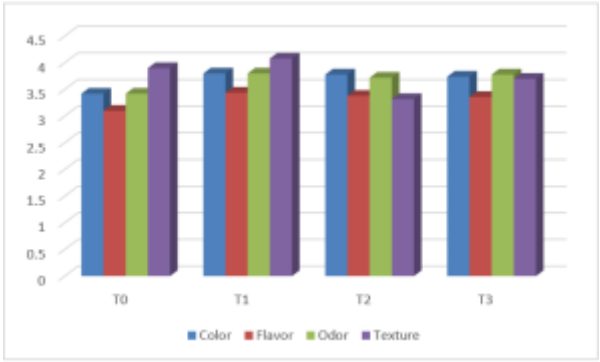

Figure 4. Descriptive test results of cookies with varying levels of crust powder

Sensory panelists described the sensory attributes of cookies added with varying levels of shrimp crust powder. The results revealed that the cookies have a golden-brown color, moderately shrimp flavor, slightly shrimp odor, and crunchy texture, as shown in Figure 4.

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Microbiological Results

Table 4 presents the microbiological results of shrimp crust powder treated with 25% BS and 75% C.W. The results showed that the aerobic plate of the samples was 10^5CFU/g. These results would conform to the idea that drying at 60 ^{0}C for 16 hours is sufficient to inhibit or stop bacterial growth. Shrimp wastes undergo rapid putrefaction because of their alkaline nature (pH 7.5-8.0). Due to the high perishability of the identified commodity, implemented processing is needed (Kandra *et al*., 2012). Artificial drying is one of the processing methods that help inhibit bacterial growth.

Table 4. Microbiological results of shrimp crust powder treated with 25% BS and 75% C.W.

Parameters	Results
Aerobic plate count	8.9 x 10^5 eapc*/g
Escherichia coli Count	< 1.0 x 10 cfu/g
Staphylococcus aureus count	< 1.0 x 10 cfu/g
Mold and Yeast Count	< 1.0 x 10 cfu/g

*estimated aerobic plate count

Table 5 shows the microbiological results of the most preferred shrimp crust cookies. There was a decrease in the aerobic plate count of the experimental samples to < 1.0 x 10^2 eapc*/g. However, the identified pathogens, mold, and yeast counts are minimal. This implies that the application of heat like baking at 320-350^{0}C for 25-30 minutes minimizes bacterial proliferation. The result is acceptable for seafood processing and bakery products.

Table 5. Microbiological results of the most preferred shrimp crust cookies.

Parameters	Results
Aerobic plate Count	< 1.0 x 10^2 eapc*/g
Escherichia coli Count	< 1.0 x 10 cfu/g
Staphylococcus aureus count	< 1.0 x 10 cfu/g
Mold and Yeast Count	< 1.0 x 10 cfu/g

*estimated aerobic plate count

The microbiological results in table 5 reflect the aerobic plate count, the Escherichia coli count, staphylococcus aureus count and the mold and yeast count. An important consideration in making crust cookies especially in using the shrimp shell is the safety component of the ingredients to ensure that it is safe. The formulation of the shrimp cookies using white shrimp crust powder enriched with coconut water yields a good result. This means that the crushed shrimp powder used in making the cookie is safe and can be eaten by both children and adults.

4 CONCLUSIONS

The shrimp cookies using white shrimp crust powder with varying concentrations of brine solution and coconut water when applied to cookie making enhances all sensory attributes. The coconut water enhances the sensory attributes of the shrimp crust cookies, with the most appropriate concentration of 25% chilled brine solution and 75% coconut water as pretreatment for shrimp crust. The 3g coconut water treated shrimp crust powder can be incorporated into the cookies with acceptable sensory attributes. The formulation of shrimp cookies using white shrimp crust powder enriched with coconut water is a sustainable initiative that can help both industries and communities in saving the environment and get income generating projects out of the shrimp waste.

ACKNOWLEDGMENT

The researcher would like to express her gratitude to the funding institutions, namely: Cebu Technological University, DOST, PCC, and LMPC.

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