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Effects of Pre-treatment and Addition of Calamansi Juice Extract on Oyster Mushroom *Kropek* Sensory and Physicochemical Properties

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Abstract:- This study investigated the effects of brine solution pre-treatment and addition of calamansi juice extract on oyster mushroom *kropek* sensory and physicochemical (pH, color, moisture, water activity) properties. Results revealed, that the pre-treatment and addition of calamansi juice extract significantly affected (p<0.05) the appearance (3.44 ±1.43 - 5.21 ±1.71), salty taste (3.35 ±2.29 - 4.92 ±2.17), sour taste (2.51 ±1.98 - 5.42 ±2.51), and spicy taste (2.98 ±2.35 - 4.56 ±2.60) of the *kropek*. The acceptability test also revealed a significant difference (p<0.05) on product appearance (7.09 ±1.22 - 7.47 ±1.46) and overall acceptability (6.40 ±1.18 - 7.18 ±1.07). Although, in terms of consumer preference, no differences were noted among sample ranks (p>0.05). However, treatment 1 was chosen as the most preferred since it had the lowest rank among samples, hence was subjected to laboratory tests along with the control. Physicochemical tests revealed a significant decrease (p<0.05) in the pH of both raw (6.17 ±0.02 - 4.17 ±.01) and cooked (7.01 ±0.02 - 5.44 ±0.02) *kropek* with the increased amount of calamansi juice extract. Also, color parameters such as L* (67.03 ±0.84 - 71.60 ±1.04), a* (5.63 ±0.55 - 9.30 ±0.36), b* (21.90 ±0.62 - 24.07 ± 0.55) and Hue° (1.20 ±0.01 - 1.32 ±0.02) values were affected significantly. Generally, the increase in brine solution and calamansi juice extract resulted in a lighter color (red-yellow), as displayed by treatment 4 (15% brine and 20ml calamansi juice extract), although treatment 3 (15% brine and 20ml calamansi juice extract) exhibited darker color. Nevertheless, the moisture content (1.08 ±0.07 - 1.13 ±0.35) and water activity (0.53 ±0.09 - 0.54 ±0.01) of the most preferred sample and the control were considered low and not significantly different (p>0.05), indicating longer shelf stability. Therefore, results of this study are important as they give baseline information about the effect of pre-treatment and addition of calamansi juice extract on product key parameters that would help solve problems during its processing, preservation, storage, distribution, and even food consumption. However, it is recommended that further studies may be conducted, particularly in terms of the correlation of some physicochemical properties with the results of sensory tests.

Keywords:- *Oyster Mushroom, Calamansi, Kropek, Pre-Treatment, Physicochemical Properties, Sensory Properties.*

I. INTRODUCTION

Mushroom is a fleshy, spore-bearing fruiting body of a macro-fungi, usually cultivated on soil or its growth medium. Generally, mushroom refers to the cultured white button mushroom (*Agaricus bisporus*) from Basidiomycota or Agaricomycetes that have a stem (stipe), a cap (pileus), and gills (lamella) on the underside of the cap. The most primitive mushroom production was documented in China, which remains among the top global mushroom producers, along with the United States, Italy, The Netherlands, and Poland [1]. Mushrooms have been utilized in sub-Saharan Africa during the Paleolithic period (7000–9000 B.P.), where their application has been customarily related to religion [2].

The mostly grown edible mushrooms in the world are *Agaricus bisporus*, *Lentinus edodes*, *Pleurotus* spp., and *Flammulina velutipes*. In the Philippines, the mushroom industry has intensified during 1995, although in 2009, the lowest production volume equivalent to 355 metric tons (MT) was recorded. Majority of the mushrooms produced were imported from neighboring countries namely China, Taiwan, Thailand, Malaysia, Korea, and Japan. Cultivating mushrooms in the country is economically feasible due to inexpensive production cost from the use of low-priced growth media from agro wastes, and its increasing demand, which will be an additional livelihood to the mushroom farmers [3], [4].

Oyster mushrooms (*Pleurotus* spp.) were firstly cultivated in Germany in 1917 on tree stumps and wood logs [5]. They are a part of the genus *Pleurotus* and a good source of non-starchy carbohydrates, containing high amount of dietary fiber and a moderate quantity of proteins, including most amino acids, minerals, and vitamins [6]. According to Croan (2004), protein content varies from 1.6 to 2.5%, and the niacin content is about ten times higher than that of any other vegetable [7]. Moreover, Randive (2012) reported that oyster mushrooms are rich in Vitamin C, B complex, and mineral salts required by the human body

[8]. Due to its high nutrient content, the mushroom is considered a perishable commodity that easily deteriorates by chemical and microbial spoilage. Hence, a preservation method is needed to extend its shelf-life.

Dehydration is one of the oldest and simplest methods frequently employed for food preservation [9], [10]. It is the process that involves the removal of water or moisture in a food product by hot air circulation, which inhibits microbial growth such as bacteria and moulds [10]. Throughout history, dehydration was dependent on the sun, wind, and smoky fire. However, recent advancements involved many types of sophisticated methods to dehydrate foods including osmotic dehydration.

Osmotic dehydration is the process of water removal by immersion of water-containing cellular solid in a concentrated aqueous solution [10], [11]. In this method, foods are immersed or soaked in a saline or sugar solution which diffuses into the surrounding solution of higher osmotic pressure. The diffusion of water and low-molecular-weight substances from the tissue structure during the osmotic dehydration is accompanied by the counter-current diffusion of osmo-active substances [10]. Thus, this method is preferred over other methods due to the retention of color, aroma, nutritional constituents, and flavor compounds [12] prior to product drying.

Drying is a process by which water activity is reduced to a level that stops microbial activity and the deteriorative chemical reactions. When drying is employed as a preservation method, the growth of spoilage and pathogenic microorganisms is prevented, ensuring food quality and safety. The ultimate endpoint for the drying process is the equilibrium in the drying system. In general, meat, fish, and dairy products are dehydrated to a moisture content of < 3% while vegetable and cereal products around 5% and 12%, respectively. A maximum moisture level is usually established for each dried product separately, based on the desired quality after drying and during storage [9].

Combining osmotic dehydration and drying contribute to a food product with longer shelf-life. Hence, the processing of oyster mushrooms utilizing these methods can be useful in food processing and food product development such as in *kropek* production.

Kropek is a traditional dried crispy food product mostly popular in South-East Asian countries, particularly in Indonesia and Malaysia, hence has a high potential economic impact. This low-density snack is prepared from a mixture of fish and starch or flour, seasonings, and other protein-rich ingredients which give its distinct flavor. In *kropek* production, starch is usually mixed with ground fish and other protein-rich ingredients and then kneaded manually to obtain a dough. The dough is formed to a cylindrical shape (with a diameter around 5 to 10 cm) and then cooked by boiling or steaming. The cooked dough is cooled and cut into thin slices (3 mm thickness) and then dried. The dried product obtained is considered an intermediate product – this is typically fried in hot oil to obtain the edible puffed product [13].

In terms of nutritional content, *kropek* provides good sources of carbohydrates and protein, as well as a small amount of vitamin and micronutrients. Also, the starch in this product is converted into resistant starch that remains unabsorbed in the small intestine of healthy individuals. It has the advantages of dietary fibers, which influence the digestive tract, microbial flora, blood cholesterol level, and the glycemic index as well as assist in the control of diabetes [14].

Kantar World Panel reported that consumption of snack foods is increasing which showed a 13 percent growth from March 2015 to the same month in 2017 [15]. Among snack food products, snacks such as tortillas and chips were at the top of the pyramid. Nielsen (2014) also reported that consumers are going towards healthy snack options [16]. In recent years, people are demanding for a healthier snack foods, hence, *kropek* made from mushrooms will be the best alternative.

Furthermore, the value-addition of snack foods can be improved by incorporating high vitamin C food substances such as calamansi. Also called calamondin, calamansi (*Citrus microcarpa*), is considered an economically important citrus hybrid that is native and predominantly cultivated in the Philippines. Its juice extract has the combination of a sweet mandarin-like aroma with a zesty taste of lime, a slightly peel-like note of orange, and a hint of acidic astringency. It has been commonly used as a seasoning in food and is also often used as a flavoring or as a food additive to enhance iron absorption [17]. The ability of calamansi juice to lower cholesterol, boost immunity, control diabetes, and improve respiratory health [18] to name a few were the basis for the addition of calamansi juice extract in mushroom *kropek* development in this study.

II. OBJECTIVES

The main objective of this study was to investigate the effect of pre-treatment and addition of calamansi juice extract on oyster mushroom *kropek* properties. Specifically, this study aimed to;

1. Determine the sensory characteristics, acceptability level, and consumer preference of oyster mushroom *kropek*.
2. Determine the pH and color of the oyster mushroom *kropek*.
3. Determine and compare the water activity and moisture content of the most preferred sample of oyster mushroom *kropek* and the control.

III. MATERIALS AND METHODS

A. Raw Materials and Equipment

Oyster mushrooms (Fig. 1) were procured from Calamba City, Laguna. Other ingredients such as cornstarch, water, ground white pepper, salt, sugar, and MSG were bought from a supermarket in Los Baños, Laguna. Equipment used for the processing and analyses of

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mushroom *kropek* properties were from the laboratory of the Institute of Food Science and Technology, University of the Philippines Los Baños, Laguna, Philippines.

Fig. 1. Fresh Oyster Mushroom after Washing and Draining.

B. *Processing of Oyster Mushroom Kropek*

Mushrooms were washed with tap water and measured according to the formulation in Table 1. Other ingredients such as cornstarch, water, ground white pepper, salt, sugar, and MSG were also quantified according to the formulation. Then, ingredients were combined using a blender until the mixture is homogenized. Next, 5g of the slurry was weighed in a tared plastic molder and steamed for 5 minutes. The molded products were then cut in half and arranged in a drying tray. Drying at 80˚C for 1.5-2 hours was observed. Finally, dried products were conditioned for 30 minutes at room temperature before packaging in a re-sealable aluminum stand-up pouch.

TABLE 1. FORMULATION OF OYSTER MUSHROOM *KROPEK*

Ingredients	**Quantity**	**Unit**
Mushroom	150	ml
Cornstarch	150	ml
Water	220	ml
White Pepper (ground)	3	g
Salt	5	g
Sugar	2	g
MSG	2	g

The formulation above was also used for the *kropek* samples with oyster mushroom pre-treated with brine solution, and mixture with added calamansi juice extract. The mushroom was first soaked in the brine solution for 30 minutes and adding calamansi extract during blending and mixing. The varying concentrations of brine solution and amounts of calamansi juice extract added for different treatments are shown in Table 2.

TABLE 2. TREATMENTS OF OYSTER MUSHROOM *KROPEK*

Treatment	**Brine Solution (%)**	**Calamansi Juice Extract (ml)**
Control	0	0
Treatment 1	5	10
Treatment 2	15	10
Treatment 3	5	20
Treatment 4	15	20

C. *Sensory Evaluation of Oyster Mushroom Kropek*

After processing, *kropek* were cooked in a frying pan with an oil temperature of 180^0C until sufficient puffing was observed. The cooked *kropek* were subjected to sensory evaluation which was performed in triplicates using fifteen (15) semi-trained panelists composed of Food Science students and professors. The panelists evaluated the products using Quantitative Descriptive Analysis (QDA) in terms of appearance, aroma, texture, and taste (salty, sour, spicy, mushroom, and off-flavor); nine (9)- point hedonic scale test for the acceptability evaluation in terms of appearance, aroma, texture, taste and overall acceptability; and ranking for preference test for the determination of consumer preference. Fig. 2 shows the sample presentation of coded samples for sensory evaluation. Results from the sensory evaluation were analyzed statistically to determine the most preferred treatment. Then, the most preferred treatment was subjected to color, pH, water activity, and moisture content analyses.

Fig. 2. Presentation of Coded Samples for Sensory Evaluation.

D. *Color Parameters Analysis*

Sample cooked *kropek* was crushed and flattened in a transparent plastic then the calibrated chromameter was used in determining color, wherein L* indicates the degree of whiteness or darkness (0 = black and 100 = white), a* indicates the degree of redness (+) and greenness (–), and b* indicates the degree of yellowness (+) and blueness (–). Using b* and a* values, hue angle (1) was computed (red=0, yellow = 90).

$$\text{Hue}° = \tan^{-1}\frac{b*}{a*} \tag{1}$$

E. *Determination of pH and Water Activity (a_w).*

For the pH determination, 1 gram of uncooked and 1 gram cooked of *kropek* samples were dissolved in 10 ml water separately and analyzed using a pH pen (Apera Instruments). For the water activity (a_w) determination, crushed uncooked *kropek* was analyzed using a water activity meter (Novasina) until constant a_w values were obtained.

F. *Moisture Content Determination*

Using oven (Memmert) set at 100 ±5˚C, tared crucibles with an initial weight of approximately two (2) grams of uncooked *kropek* samples were dried until constant weights were achieved. Equation 2 was used for the computation of percent (%) moisture content (MC).

$$\% \text{ MC} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{ x } 100 \quad (2)$$

G. Statistical Analyses

Results of sensory evaluation using 9-point hedonic and QDA as well as data on color, pH, water activity, and moisture content were expressed as mean from triplicate values ± standard deviation. Data were subjected to single-factor analysis of variance (ANOVA) and for the post-hoc determination of significant differences at 95% level of significance using Tukey Pairwise Comparisons in Minitab 18.1 version. On the other hand, data on rank preference test were subjected to Kendall Coefficient of Concordance (95% level of significance) using Microsoft excel-MegaStat.

IV. RESULTS AND DISCUSSION

A. Sensory Characteristics, Acceptability, and Consumer Preference of Oyster Mushroom Kropek

Sensory quality is a key factor in food acceptability because consumers seek food with certain sensory characteristics. The acceptance of food will depend on whether it responds to consumers' needs and on the degree of satisfaction that it can provide [19], [20]. For this study, quantitative descriptive analysis (QDA) was used to characterize fried *kropek* samples (Fig. 2 and Table 3), while a 9-point hedonic scale test and rank preference test were used to determine its acceptability level (Table 4) and consumer preference (Table 5).

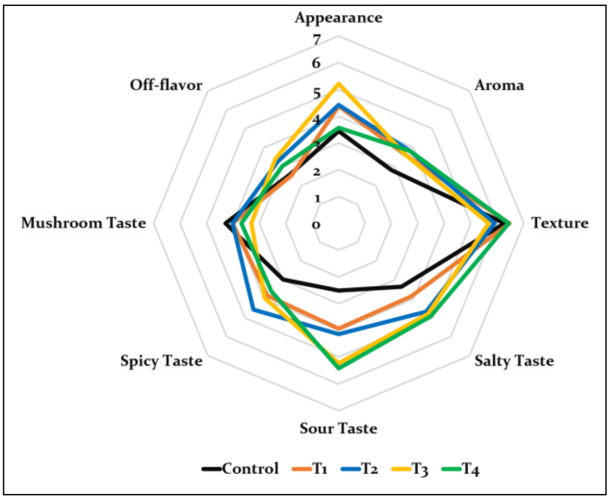

Fig. 3. Sensory Characteristics of Oyster Mushroom *Kropek*.

Fig. 3 shows the sensory characteristics of oyster mushroom *kropek* samples with pre-treatment and added calamansi juice extract as well as the control. It can be seen that there are variations in terms of the sensory characteristics evaluated, specifically in terms of appearance, aroma, texture, and taste (salty, sour, spicy, mushroom, and off-flavor).

Table 3 further shows that the appearance (surface color) of the *kropek* samples ranged from 3.44 ±1.43 to 5.21 ±1.71 which is described as white to light brown. In particular, the control (3.44 ±1.43) was significantly whiter ($p<0.05$) than other samples, except from treatment 4 (3.57 ±1.45). On the other hand, treatment 3 (6.20 ±1.34) was significantly lighter brown ($p<0.05$) than other samples, except from treatment 1 (7.29 ±1.01) and treatment 2 (7.09 ±1.22). However, no significant color differences ($p>0.05$) were noted among treatments 1, 2, and 4. These results may suggest that despite the pre-treatment and the addition of calamansi juice on the *kropek* samples, it significantly changed the color of the product after frying.

According to Miranda and Aguilera (2016), the color of the product is developed during frying as a result of the Maillard reaction and as influenced by factors such as reducing sugar and amino acid content [21]. Also, Nurul et al. (2009) stated that the rate of Maillard reaction depends on its chemical environments such as the chemical composition of food, water activity, pH, and the reaction temperature [22]. Hence, since food samples only varied in terms of pre-treatment and amount of calamansi juice extract added, these might have contributed to the color differences among samples. An additional factor could be the slight differences in time and temperature during frying, despite the rigorous effort of control and monitoring. Nevertheless, color is one of the most important sensory attributes that greatly influence consumer perception and can lead to rejection [23] or acceptance of the product. If the color is not attractive and of acceptable quality, the consumer is less likely to purchase it, regardless of its excellent flavor, taste, or other quality attributes [24].

Using a 9-point hedonic scale test, Table 4 revealed that the differences in the appearance (surface color) of samples significantly affected ($p<0.05$) their acceptability level. In particular, treatment 3 (6.20 ±1.34) had significantly lower acceptability ($p<0.05$) compared to other samples, which described as “liked slightly.” Although, results also revealed that the differences among the control (7.47 ±1.46), treatment 1 (7.29 ±1.01), treatment 2 (7.09 ±1.22), and treatment 4 (7.02 ±1.31) were not significantly different ($p>0.05$). In general, the acceptability level of samples in terms of appearance was described as “liked moderately”.

Differences were also noted among the taste of *kropek* samples, particularly in terms of salty taste, sour taste, and spicy taste (Table 3). The salty taste ranged from 3.35 ±2.29 to 4.92 ±2.17, which is described as weak to moderately strong with the control (3.35 ±2.29) having a significantly weaker salty taste ($p<0.05$) compared to other samples, except from treatments 1 (3.86 ±2.26) and 2 (4.62 ±2.57). This means that the pre-treatments of mushrooms with brine solution before processing significantly increased the saltiness ($p<0.05$) of the *kropek*, although the concentration (5% and 15%) of salt did not significantly affect the salty taste ($p<0.05$) of treatment 1, treatment 2, treatment 3 and treatment 4. Similarly, in terms of sour taste, the control (2.51 ±1.98), treatment 1 (3.94 ±2.55), and treatment 4 (5.42

±2.51) significantly differ (p<0.05) from each other, with treatment 4 having the highest score in sourness, while the control having the least. This means, that the addition of calamansi juice in the mixture was significantly perceptible in the amount of 10 and 20mL. However, results also revealed that despite these variations, the sourness of treatments 2(4.14 ±2.55) and treatment 3(5.24 ±2.52) was not significantly different (p>0.05) from each other and treatments 1 and treatment 4. Lastly, in terms of spicy taste, the control (2.98 ±2.35) and treatment 2 (4.56 ±2.60) was significantly different (p<0.05) from each other, which suggests that the 15% brine pre-treatment and the addition of 10ml calamansi juice extract significantly increased the spicy flavor of the *kropek*. Although, results also revealed that treatments 1 (3.82 ±2.54), treatment 3 (3.96 ±2.51), and treatment 4 (3.60 ±2.55) were not significantly different (p>0.05) from each other, as well as from the control and treatment 2.

Moreover, results also revealed that treatments 1 (3.82 ±2.54), treatment 3 (3.96 ±2.51), and treatment 4 (3.60 ±2.55) were not significantly different (p>0.05) from each other, from the control and treatment 2. Nonetheless, despite these differences in taste of *kropek* samples, Table 4 revealed that these did not significantly affect (p>0.05) the product acceptability in terms of taste (6.33 ±1.58- 7.04 ±1.40). Although, it can be noted that treatment 1 (7.04 ±1.40) had the highest acceptability value which was described as "liked moderately", while treatment 3 (6.33 ±1.58) had the lowest acceptability value and was described as "liked slightly."

On the other hand, results of quantitative descriptive analysis (QDA) in Table 3 showed that the aroma of *kropek* samples ranged from 2.87 ±2.18 to 3.82 ±2.77 (weak to moderately strong), texture (crunchiness) ranged from 5.70 ±2.55 to 6.45 ±2.09 (moderately loud), mushroom taste ranged from 3.30 ±2.29 to 4.29 ±1.61 (weak to moderately strong), and off-flavor ranged from 2.52 ±2.27 to 3.40 ±2.86 (weak). Results also revealed that the use of pre-treatment and the addition of calamansi juice extract did not significantly affect (p>0.05) some of the product characteristics such as aroma, texture, mushroom flavor, and off-flavor.

Among the sensory characteristics, texture/crunchiness had one of the highest scores in the descriptive as well as in terms of acceptability test. Typically, in the development of fried food products, crispness and crunchiness is one of the important and critical properties affecting product acceptability [23]. However, since formulations used in this study were constant, the pre-treatment and addition of calamansi juice showed no significant effect on these characteristics. Nevertheless, possible differences in crispness could arise from air spaces that may develop within the crisp structure [25], due to moisture uptake after frying [21] as well as differences in starch and other chemical components of the food product [26].

The results of quantitative descriptive analysis (QDA) were supplemented by the results of the acceptability test in Table 4 as well as by the use of ranking for preference test in Table 5.

TABLE 3. DIFFERENCES ON THE SENSORY CHARACTERISTICS OF OYSTER MUSHROOM *KROPEK* AND THE CONTROL.

Parameters*	**Sample****				
	Control	***T1***	***T2***	***T3***	***T4***
Appearance	3.44 ±1.43^{c}	4.38 ±1.53^{ab}	4.43 ±1.62^{ab}	5.21 ±1.71^{a}	3.57 ±1.45^{bc}
Aroma	2.87 ±2.18^{a}	3.53 ±2.60^{a}	3.82 ±2.42^{a}	3.59 ±2.44^{a}	3.82 ±2.77^{a}
Texture	6.26 ±2.13^{a}	6.45 ±2.09^{a}	5.84 ±2.30^{a}	5.70 ±2.55^{a}	6.36 ±6.40^{a}
Salty Taste	3.35 ±2.29^{b}	3.86 ±2.26^{ab}	4.62 ±2.57^{ab}	4.79 ±2.38^{a}	4.92 ±2.17^{a}
Sour Taste	2.51 ±1.98^{c}	3.94 ±2.55^{b}	4.14 ±2.55^{ab}	5.24 ±2.52^{ab}	5.42 ±2.51^{a}
Spicy Taste	2.98 ±2.35^{b}	3.82 ±2.54^{ab}	4.56 ±2.60^{a}	3.96 ±2.51^{ab}	3.60 ±2.55^{ab}
Mushroom Taste	4.29 ±1.61^{a}	4.02 ±2.27^{a}	4.01 ±2.45^{a}	3.30 ±2.29^{a}	3.68 ±2.26^{a}
Off-flavor	2.59 ±2.49^{a}	2.52 ±2.27^{a}	3.27 ±2.47^{a}	3.40 ±2.86^{a}	3.02 ±2.60^{a}

**Description: 0-3.49 (white surface color, weak aroma/taste, soft texture/crunchiness), 3.5-6.99 (light brown surface color, moderately strong aroma/taste/crunchiness-loud), 7.0-10.0 (dark brown, strong aroma/taste, loud/texture/crunchiness).*
*** Values in the same row followed by the same letter (a,b,c) are not significantly different (p> 0.05).*

TABLE 4. ACCEPTABILITY OF OYSTER MUSHROOM *KROPEK* SAMPLES AND THE CONTROL.

Parameters*	**Sample****				
	Control	***T1***	***T2***	***T3***	***T4***
Appearance	7.47 ±1.46^{a}	7.29 ±1.01^{a}	7.09 ±1.22^{a}	6.20 ±1.34^{b}	7.02 ±1.31^{a}
Aroma	6.87 ±1.08^{a}	6.89 ±1.15^{a}	6.91 ±1.10^{a}	6.62 ±1.9^{a}	6.84 ±1.22^{a}
Texture	7.47 ±0.94^{a}	7.13 ±1.08^{a}	6.76 ±1.40^{a}	6.71 ±1.59^{a}	6.80 ±1.63^{a}
Taste	6.89 ±1.21^{a}	7.04 ±1.40^{a}	6.71 ±1.06^{a}	6.33 ±1.58^{a}	6.89 ±1.23^{a}
Overall Acceptance	7.00 ±1.13^{ab}	7.18 ±1.07^{a}	6.67 ±1.02^{ab}	6.40 ±1.18^{b}	6.84 ±1.28^{ab}

**Description: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5-neither like or dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely.*
*** Values in the same row followed by the same letter (a,b) are not significantly different (p> 0.05).*

TABLE 5. PREFERENCE TEST OF OYSTER MUSHROOM *KROPEK* SAMPLES AND THE CONTROL.

Sample	**Control**	**T1**	**T2**	**T3**	**T4**
Average Rank*	2.93^{a}	2.80^{a}	2.87^{a}	3.27^{a}	3.13^{a}

**Lowest rank means most preferred. Values in the same row followed by the same letter are not significantly different (p> 0.05) using Kendall Coefficient of Concordance.*

Furthermore, using the ranking for preference test (Table 5), where panelists were forced to rank samples according to their choices, results revealed that no differences were noted among sample ranks, which indicates that all of the samples were equally preferred by the panelists. However, treatment 1 was chosen to be the most preferred and was subjected to laboratory tests along with the control, since it had the lowest rank among samples.

Therefore, it can be established that all samples evaluated in this study have promising market potentials if planned to be commercialized and sold to consumers. Although, it is important to note that if a higher degree of acceptability is sought for fried oyster mushroom *kropek*, key parameters such as appearance and taste should be taken into consideration along with aroma and texture/ crunchiness.

B. pH and Color Parameters of Oyster Mushroom Kropek Samples

Food product has its physicochemical characteristics which will have an important effect on its nutritional and sensory quality [27]. Hence, in this study, physicochemical properties such as pH and color parameters were determined.

The pH value is a direct function of the free hydrogen ions present in food and is a measure of free acidity. In terms of pH of raw *kropek*, Table 6 shows that values ranged from 4.17 ± 0.01 to 6.17 ± 0.02, with treatment 4 having the lowest, while the control (6.17 ± 0.02) having the highest. Results also revealed that the pH value of treatment 1 (4.67 ± 0.01) was not significantly different ($p < 0.05$) from treatment 2 (4.64 ± 0.01). Similarly, no significant difference ($p < 0.05$) was noted on the pH values of treatment 3 (4.20 ± 0.01) and treatment 4 (4.17 ± 0.0). Therefore, it can be established that the pre-treatment and addition of calamansi significantly increased ($p < 0.05$) the acidity of the *kropek*. In particular, increasing the amount of calamansi extract, significantly decreased the pH of the product.

TABLE 6. pH VALUE OF RAW AND COOKED OYSTER MUSHROOM *KROPEK* SAMPLES AND THE CONTROL.

Sample	pH*	
	Raw	***Cooked***
Control	6.17 ± 0.02^{a}	7.01 ± 0.02^{a}
T1	4.67 ± 0.01^{b}	5.52 ± 0.02^{b}
T2	4.64 ± 0.01^{b}	5.44 ± 0.02^{c}
T3	4.20 ± 0.01^{c}	4.56 ± 0.01^{d}
T4	4.17 ± 0.01^{c}	4.64 ± 0.01^{e}

**Reported values are averages of at least 3 trials ±standard deviation. Values in the same column followed by the same letter (a, b, c, d, e) are not significantly different (p> 0.05).*

On the other hand, the pH of cooked oyster mushroom *kropek* ranged from 5.44 ± 0.02 to 7.01 ± 0.02, with treatment 2 having the lowest pH, while the control having the highest pH. Generally, pH values of samples differ significantly from each other ($p < 0.05$), with the sample which received a higher amount of calamansi juice extract having the lowest pH value. Besides, it was observed that the pH of cooked *kropek* increased slightly relative to the pH of the raw *kropek*. Although, it was not determined whether the pH values of raw and cooked *kropek* significantly increased after frying.

Nevertheless, the decrease in pH might have inhibitory effects on microbial contamination [28], hence can contribute to a possible increase in shelf stability. However, it can also have a significant effect on product quality particularly in terms of taste. As noted, on the sensory test, differences in the sour taste were recognized by the panelist with the amount of calamansi juice extract added. As reported by Lee (2000) the pH of calamansi juice extract was 2.4 [29], indicating higher acidity. Hence, once added to food products, it can significantly decrease its pH value and affect its qualities.

On the other hand, the color characteristics of fried oyster mushroom *kropek* samples are shown in Table 7. The result showed that L* values of *kropek* samples were in the range of 67.03 ± 0.84 to 71.60 ± 1.04, indicate lightness. Results also revealed, that differences among the samples were observed with treatment 3 (67.03 ± 0.84) having a significantly lower L* value ($p < 0.05$) compared to other samples, except from the control (69.00 ± 0.79), which indicates that sample exhibits brown or darker color. This result is in agreement with the sensory test results, where treatment 3 was perceived to have a lighter brown color among all treatments. However, instead of the control, treatment 4 (71.60 ± 1.04) was found to have a lighter color. Although, the L* value of treatment 4 was not significantly different ($p > 0.05$) from the control, treatment 1, and treatment 2.

TABLE 7. COLOR CHARACTERISTICS OF OYSTER MUSHROOM *KROPEK* SAMPLES AND THE CONTROL.

Sample	Color Parameters**			
	L*	***a****	***b****	***Hue°***
Control	69.00 ±0.79^{ab}	7.07 ±0.23^{b}	23.40 ±0.56^{ab}	1.28 ±0.00^{b}
T1	70.57 ±1.14^{a}	6.83 ±0.45^{b}	23.93 ±0.49^{a}	1.29 ±0.02^{ab}
T2	70.60 ±1.15^{a}	7.47 ±0.38^{b}	24.03 ±0.65^{a}	1.27 ±0.01^{b}
T3	67.03 ±0.84^{b}	9.30 ±0.36^{a}	24.07 ±0.55^{a}	1.20 ±0.01^{c}
T4	71.60 ±1.04^{a}	5.63 ±0.55^{c}	21.90 ±0.62^{b}	1.32 ±0.02^{a}

***Reported values are averages of at least 3 trials ±standard deviation. Values in the same column followed by the same letter (a,b,c) are not significantly different (p> 0.05).*

In terms of a*, values were in the range of 5.63 ± 0.55 to 9.30 ± 0.36 with treatment 4 (5.63 ± 0.55) having significantly lower a* value among all samples, indicating weaker redness. On the contrary, treatment 3 (9.30 ± 0.36) was found to have a significantly higher a* value among samples which means obvious stronger redness. Nevertheless, differences in a* values of the control (7.07 ± 0.23), treatment 1 (6.83 ± 0.45) and treatment 2 (7.47 ± 0.38) were not significant ($P > 0.05$).

On the other hand, in terms of b*, values ranged between 21.90 ± 0.62 to 24.07 ± 0.55, representing yellowness. However, despite obvious yellow color, treatment 4 (21.90 ± 0.62) had a significantly lower b* value ($p < 0.05$) compared to all other samples, except from the control (23.40 ± 0.56). While, no significant differences ($P < 0.05$) were noted among control (23.40 ± 0.56), treatment 1 (23.93 ± 0.49), treatment 2 (24.03 ± 0.65), and treatment 3 (24.07 ± 0.55).

Lastly, in terms of hue angle (H°), values ranged from 1.20 ± 0.01 to 1.32 ± 0.02 suggesting color towards red. Results also revealed that H° of treatment 3 (1.32 ± 0.02) was significantly lower (P< 0.05) compared to other *kropek* samples. Also, results revealed that the H° of treatment 4 (1.32 ± 0.02) was significantly higher (P< 0.05) from all *kropek* samples, except from treatment 1 (1.29 ± 0.02). Furthermore, differences in the H° of control (85.16 ±2.32), treatment 2 (1.27 ± 0.01) and treatment 1 (1.29 ± 0.02) were not significant (p< 0.05).

Therefore, it can be recognized that the pre-treatment and addition of calamansi juice extract resulted in a lighter color (red-yellow), as exhibited by treatment 4 (15% brine and 20ml calamansi) although treatment 3 (15% brine and 20ml calamansi) had the darker color. However, generally, the frying process would result in the loss of the lighter color of the fried product. For instance, in the case of fish crackers, the frying process at high temperatures contributes to the denaturation and oxidation of fish protein which leads to the darker color of the product [22]. Likewise, the formation of colored compounds can be related to involvements of H_2O released from amino acids and in Maillard-type reactions [30]. Moreover, Ngadi et al. (2007) stated the decrease in the L* value in the fried food sample may be attributed to caramelization at a high frying temperature aside from Maillard browning [31].

C. Moisture Content and Water Activity (a_w) of Oyster Mushroom Kropek

The water activity and moisture content of the uncooked control and most preferred formulation (treatment 1) of *kropek* are summarized in Table 8. Based on the results, the moisture content of the control (1.13 ±0.35) and most preferred sample (1.08 ±0.07) were both low and not significantly different at p>0.05. Moisture content is the quantity or the percentage of water contained in a matrix that influences the taste, texture, appearance, weight, and shelf life of food products [32]. For dehydrated *kropek*, it must have the moisture of ≤10.00%. Controlled reconditioning, appropriate packaging, and storage must be performed to prevent the re-absorption of moisture into the food substrate. Also, efficient drying time, temperature, and humidity are important to acquire balance drying and prevent surface hardening of *kropek*. As specified by Mohamaddan (2016), the drying rate of *kropek* is relatively dependent on humidity value [33].

TABLE 8. WATER ACTIVITY AND MOISTURE CONTENT OF RAW CONTROL AND MOST PREFERRED OYSTER MUSHROOM *KROPEK*.

Parameter	Sample*	
	Control	***Most Preferred***
Water Activity (a_w)	0.54 ±0.01[a]	0.53 ±0.09[a]
Moisture Content (%)	1.13 ±0.35[a]	1.08 ±0.07[a]

**Reported values are averages of at least 3 trials ±standard deviation. Values in the same row followed by the same letter are not significantly different (p> 0.05).*

However, the determination of water content is not sufficiently informative to predict the stability of food products. Thus, water activity (a_w) brings a supplement of information as it accounts for the availability of water in the food matrix that has a unique role in various physical, chemical, and biological reactions, which largely convey possible rheological changes, enzymatic activities, and microbial growth [34], [35]. Water activity is an important intrinsic parameter significant to food safety as well as in food preservation and shelf stability [36]. As defined, water activity is the partial vapor pressure of water in a matrix divided by the standard state partial vapor pressure of water [37]. Commonly, the water activity in food is measured in values from 0.00 to 1.0.

According to the Food and Agriculture Organization (FAO), a shelf-stable dehydrated *kropek* or chips must have a water activity of ≤0.60 [38]. Besides, Fontana (1998) stated that foods with a_w values less than 0.3 are largely protected against lipid oxidation, non-enzymatic browning, enzymatic activity, and microbial spoilage [39]. Hence, based on the results of analysis (Table 8), control (0.54 ±0.01) and the most preferred sample (0.53 ±0.09) have water activity within the required values, indicating conformance with the requirement. Also, results further revealed, that the a_w values of the two samples are not significantly different (p>0.05), emphasizing that the pre-treatment by soaking in 5% brine solution and the addition of 10 ml calamansi juice extract did not significantly affect the a_w content in the sample, considering the similar conditions such as drying time, temperature and conditioning. Therefore, the low amount of moisture and a_w values of oyster mushroom *kropek* indicates high shelf stability.

V. CONCLUSIONS AND RECOMMENDATIONS

This study revealed that varying concentrations of brine solution for pre-treatment and amount of calamansi juice extract significantly affected the oyster mushroom *kropek* sensory properties, particularly in terms of appearance and taste. However, despite the differences in several properties, it did not significantly affect the product acceptability and consumer preference. Besides, increasing the concentration of brine solution and amount of calamansi juice extract significantly increased the acidity of *kropek*, while after frying it was slightly reduced. On the other hand, the color of *kropek* became lighter with the increasing concentration of brine and amount of calamansi juice extract, although other factors such as the composition of food, pH, and temperature during frying might also have contributed. In general, oyster mushroom *kropek* with and without pre-treatment and added calamansi juice extract is considered as low moisture food, which suggests good shelf-stability. Therefore, this study demonstrated that incorporating calamansi juice extracts and the use of pre-treatment have a beneficial (improves properties) or detrimental (alter good qualities) effects on food product properties. Hence, it is recommended that careful manipulation of product and process variables should be taken into account to maintain and improve key properties critical to food products. Also, further studies may be conducted specifically in terms of the correlation of some physicochemical properties with the results of sensory tests. Nevertheless, the results of this study will serve as baseline information that will be useful for food processors and future researchers, especially those engage in *kropek* processing and similar products.

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