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Optimization of the levels of ginger extract, palm oil and glucose syrup on the sensory quality of ginger yema

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ABSTRACT

Ginger *yema* is a product of Guio-ang MPC cooperative of Guindolman, Bohol, Philippines. *Yema* may also be called a custard candy as it is mainly made of egg yolk, sugar and milk. The *yema* product made by Guio-ang MPC cooperative uses these same common ingredients with added ginger extract and glucose. To improve and enhance the sensory quality of the aforesaid product, an optimization study on the ingredients namely ginger extract, palm oil and glucose syrup was conducted.

Response Surface Methodology (RSM) was used to determine the effect of the different levels of ingredients on the product's sensory quality. Statistical analysis revealed that the linear and quadratic term of palm oil and glucose syrup levels significantly affect the color, hardness, chewiness and general acceptability of ginger *yema*. The quadratic term of ginger extract and palm oil significantly decreased the oiliness acceptability. Significant reduction in toothpacking acceptability was observed in the linear term of the glucose syrup level. The interaction of palm oil and ginger extract had a negative significant effect on the color, while the interaction of glucose syrup level and ginger extract significantly affected the hardness and toothpack. The interaction of the glucose syrup level and palm oil significantly affected the product's hardness, chewiness and general acceptability as well.

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The superimposed contour plots of all responses revealed the optimum result for color, hardness, chewiness and general acceptability at 14.75 % w/w ginger extract, 12.00 % w/w palm oil, and 12.20 % w/w of glucose syrup.

Keywords: ginger yema, glucose syrup, optimization, palm oil, sensory quality

INTRODUCTION

Ginger *yema* is a product of Guio-ang MPC (Multi-purpose Cooperative) of Guindolman, Bohol. *Yema* may also be called custard candy, which is traditionally made from egg yolks cooked with sugar and milk (Collins Dictionary 2000). It is now commonly made from condensed milk, and eggs (members.wto.org nd). This is one of the OTOP (One Town, One Product) products identified by the Department of Trade and Industry (DTI) Bohol Province. Observation of the manufacturing process, consultation with the processors and the management revealed that toothpacking, oiliness and melting of the product during storage often led to an undesirable sensory quality of the product resulting to poor acceptability by the consumers. The structure-property-processing relationship of this food was studied in order to achieve a quality product with better consumer-acceptability (Habilla and Cheng 2015). Hence, the identified main problems were solved by establishing the optimum combination of the different components that would provide the best sensory quality possible.

The ingredients and their levels used in the formulation are among the factors that may affect the quality of the product the most. Levels of palm oil, ginger extract, and glucose syrup are considered the top three most important ingredients in ginger *yema* production. Glucose syrup is one of the widely used ingredients in the production of hard candy because of the resulting plasticity and its effect on color, taste, clarity and shine (Suwan et al 2018). Too much glucose could result in an undesirable effect on the product and is believed to cause high toothpacking of the ginger *yema*. Ginger extract was also included as one of the variables in the experiment because some studies showed that it can affect the product quality as well. The aroma of ginger is pleasant, but with antiseptic or pungent compounds, this tends to cause a slightly biting sensation in the sensory receptors (Alam et al 2018). Moreover, significant effects in all the sensory scores for color, appearance, taste, texture, mouthfeel and overall acceptability was observed by Shukla et al (2018) in herbal candy utilizing red ginger. On the other hand, excessive incorporation of palm oil in the formulation as an anti-tacking agent for candy molders was believed to have caused excessive oiliness of the product.

Establishing the right balance or optimum combination among the three mentioned components would make a better *yema* in terms of its sensory quality. This study was therefore conducted to improve the sensory quality of *yema* through optimization of selected ingredients using Response Surface Methodology (RSM).

METHODOLOGY

Preparation of the Ginger Extract

Rhizomes of ginger were washed thoroughly with gentle scrubbing to remove adhering soil. They were sanitized in chlorinated water (10ppm), and then ground and milled using a High-speed multi-function comminutor. The juice was extracted

by pressing the milled ginger and then it was sieved using a clean and sanitized cheesecloth.

Processing of Ginger Yema

The process in producing ginger *yema* followed the procedure employed by Guio-ang MPC. The different levels of variables used in this study were based on the results of the preliminary study conducted prior to optimization. The levels of the variables are 10.0, 11.67 and 13.33% w/w palm oil, 11.66, 13.33 and 15.0% w/w ginger extract and 0, 7.5 and 15.0% w/w glucose syrup. The actual amount of these ingredients used in the processing of *yema* was computed based on the volume of condensed milk used per formulation (780g). Eggyolks (2 medium sized egg) were also added in the mixture. All five (5) ingredients were placed in a shallow pan and heated over a very low fire with constant stirring for 50mins. This was then transferred while hot into sanitized and properly dried silicon molders. It was allowed to cool down and slightly harden at room temperature. The unmolded *yema* were then wrapped primarily with polyethylene bags (0.002mm) cut into pieces at 2x2.5 inches in dimension. Water cellophane was used as secondary packaging. Thirty pieces of the product were placed in polyethylene bags, sealed and stored ready for analysis.

Experimental Design

A Central Composite Design (CCD) of the Response Surface Methodology (RSM) was used in the study employing 17 runs with combinations of different levels of ginger extract, palm oil, and glucose as shown in Table 1. The pre-identified factors namely ginger extract, palm oil and glucose syrup with three levels per factor used in the experiment were based on the preliminary study conducted.

Sensory Evaluation

Sensory evaluation using quality scoring in combination with Hedonic Rating Scale (1-dislike extremely to 9-like extremely) was carried out to assess the sensory attributes of the different treatment runs. An Incomplete Block Design (IBD), as laid out by Cochran and Cox (1957), was followed in presenting samples to the panelists. The sensory panelists (60 pax) were composed of students and staff of the Visayas State University to evaluate the color, aroma, oiliness, hardness, sweetness, flavor, chewiness, toothpacking, and general acceptability of the product.

Table 1. Full experimental design for ginger *yema* following the 3-factor Central Composite Design

Run	Ginger *Yema*		
	Ginger extract (GE) (%w/w) X_1	Palm oil (PO) (%w/w) X_2	Glucose syrup level(GL) (%w/w) X_3
1	11.67	10.00	0
2	11.67	13.33	15.0
3	15.00	10.00	15.0
4	15.00	13.33	0

Table 1. continued

Run	Ginger *Yema*		
	Ginger extract (GE) (%w/w) X_1	Palm oil (PO) (%w/w) X_2	Glucose syrup level(GL) (%w/w) X_3
5	13.33	11.67	7.5
6	11.67	10.00	15.0
7	11.67	13.33	0
8	15.00	10.00	0
9	15.00	13.33	15.0
10	13.33	11.67	7.5
11	11.67	11.67	7.5
12	15.00	11.67	7.5
13	13.33	10.00	7.5
14	13.33	13.33	0
15	13.33	11.67	0
16	13.33	11.67	15.0
17	13.33	11.67	7.5

Statistical Analysis and Modeling

The data obtained from RSM were subjected to Analysis of Variance (ANOVA). The experimental results were fitted via the response surface regression procedure, using the following second-order polynomial equation:

$$Y = \beta_0 + \sum_i \beta_i X_i + \sum_{ii} \beta_{ii} X^2{}_i + \sum_{ij} \beta_{ij} X_i X_j$$

Where Y is the predicted response, $X_i X_j$ are independent variables, β_o is the offset term, β_i is the ith linear coefficient, β_{ii} is the ith quadratic coefficient, and β_{ij} is the $_{ij}$th interaction coefficient. In the study, the independent variables were coded as X_1, X_2, and X_3. Thus, the quadratic response model for Y was written as:

$$Y = \beta_0 + \beta_i X_i + \beta_2 X_2 + \beta_3 X_3 + \beta_{11} X^2{}_1 + \beta_{22} X^2{}_2 + \beta_{33} X^2{}_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3$$

Response Surface Regression (RSReg) analysis using STATISTICA Software Version 10 (StatSoft) was used to determine the effects of independent variables on the response being studied including ANOVA for the regression coefficients and parametric estimates. Contour plots for the sensory acceptability were superimposed to determine the optimum condition.

RESULTS AND DISCUSSION

Effects on Color Acceptability

Color is one of the most important determinants of product quality. It plays a key role in food choice by influencing taste thresholds, sweetness perception, food preference, pleasantness, and acceptability (Clydesdale 1993). Therefore, it is necessary and vital in the manufacture of the product to examine and evaluate the effects of the independent variables on color acceptability.

The majority of the ginger *yema* samples were described by the panelists as 'brownish cream to light brown' (Table 2), with acceptability values ranging from 6.94 to 7.78 (Table 3), corresponding to 'like slightly' to 'like moderately' in the 9-point Hedonic rating scale.

Color acceptability of ginger *yema* is significantly affected by the linear and quadratic terms of glucose syrup level (GL) and palm oil (PO), and the crossproduct terms of PO and ginger extract (GE) (Table 4). Regression Analysis revealed that a square unit increase in the levels of palm oil and glucose syrup results to a decrease by 0.0992 and an increase of 0.0047 on color acceptability, respectively. The crossproduct terms of PO and GE on the other hand, results in a decrease of the response being studied by 0.055. The PO is estimated to positively affect the color acceptability of the product by a 3.0107 increase in acceptability rating for every unit increase of the aforesaid variable. On the other hand, a 0.1887 decrease in color acceptability is estimated for every unit increase of GL added into the product. It shall be noted that ginger is an agricultural crop, and its extract contains flavonoids, phenolics and inherent enzymes that may cause undesirable color of the product. Akib et al (2017) reported that the higher concentration of red ginger led to a decrease in preference towards hard candy. This is in agreement with the results of this study.

Effect on Aroma Acceptability

Molecules must be volatile to reach the top of the nasal cavity where smell receptors are located (Figoni 2008). Comparing all materials in ginger *yema*, the ingredient having the most volatile component is ginger extract.

The aroma of the ginger *yema* was described by the panelists as 'well blended milk and ginger to more perceptible ginger than milk' (Table 2), with an acceptability rating of 6.89 to 7.56 (Table 3) corresponding to 'like slightly' to 'like moderately' of the 9-point Hedonic rating scale.

The results of the study revealed that a square unit increase in GL results in a corresponding 0.0045 increase in the aroma acceptability of the product (Table 4). Maillard reaction plays an important role in the formation of flavors, aromas and colors of some confectionery products containing protein and sugar. Moreover, at high temperatures (>80°C) sugar-sugar interactions or the caramelization reaction occurs. This is a complex series of reactions but many of the intermediate flavor compounds and products are similar to those observed for the Maillard reaction (Davies and Labuza 2000).

The aroma acceptability of ginger *yema* ranges from 6.89 to 7.56 (Table 2) corresponding to 'like slightly' and 'like moderately' in the 9-Point Hedonic scale. According to Lotfabadi et al (2020), the addition of sucrose into rock candy caused perception of a more pronounced d-limonene, and they pointed out that this could be due to the 'salting out' effect of sucrose. The study conducted by Suwan et al (2018) on the effect of sugar/glucose syrup on the sensory of *T. laurifolia* candy revealed that as glucose syrup increases at a constant level of sugar, the liking of the product's odor increases, but statistically these increases are not significant.

Table 2. Summary of the descriptions for color, aroma, oiliness, hardness, sweetness, flavor, chewiness, and toothpacking of ginger *yema*

	Sensory Descriptions							
Run	Color	Aroma	Oiliness	Hardness	Sweetness	Flavor	Chewiness	Toothpacking
1	Light brown to brownish cream	Well blended milk and ginger to more perceptible milk than ginger	Very dry	Not hard	Just right sweetness	Well-blended milk and ginger	Not chewy	None
2	Light brown to brownish cream	More perceptible milk than ginger	Slightly oily	Slightly to moderately hard	Just right to moderately sweet	Well-blended milk and ginger	Moderately chewy	Moderate
3	Brownish cream	Well blended milk and ginger to more perceptible ginger than milk	Slightly oily	Not hard	Just right sweetness	Well-blended milk and ginger	Slight to moderately chewy	Mild to moderate
4	Brownish cream to brown	More perceptible ginger than milk	Slightly to moderately oily	Not hard	Just right to moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Not chewy to slightly chewy	None to mild
5	Brownish cream	More perceptible ginger than milk	Slightly oily	Not hard	Just right to moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Not chewy	None
6	Brown to dark brown	Well blended milk and ginger to more perceptible milk than ginger	Slightly oily	Very hard	Just right to moderately sweet	Well-blended milk and ginger to more perceptible milk than ginger	Very chewy	Extreme

Table 2 continued

	Sensory Descriptions							
Run	Color	Aroma	Oiliness	Hardness	Sweetness	Flavor	Chewiness	Toothpacking
7	Light brown	Well blended milk and ginger to more perceptible ginger than milk	Slightly to moderately oily	Not hard	Moderately sweet	Well-blended milk and ginger to more perceptible milk than ginger	Not chewy	None
8	Brownish cream to brown	Well blended milk and ginger to more perceptible ginger than milk	Slightly oily	Not hard	Just right to very sweet	Well-blended milk and ginger to more perceptible ginger than milk	Not chewy	None
9	Brownish cream to Light brown	Well blended milk and ginger to more perceptible ginger than milk	Slightly dry	Slightly hard	Just right sweetness	Well-blended milk and ginger to more perceptible ginger than milk	Slight to moderately chewy	Moderate
10	Brownish cream	Well blended milk and ginger to more perceptible ginger than milk	Slightly oily	Not hard	Just right to moderately sweet	Well-blended milk and ginger	Not chewy	None
11	Light brown to brown	Well blended milk and ginger	Slightly oily	Slightly to moderately hard	Just right to moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Moderately chewy	Moderate
12	Light brown	More perceptible ginger than milk	moderately oily	Not hard	Moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Not chewy	None

Table 2 continued

	Sensory Descriptions							
Run	Color	Aroma	Oiliness	Hardness	Sweetness	Flavor	Chewiness	Toothpacking
13	Brownish cream to light brown	More perceptible ginger than milk	Slightly to very oily	Not hard	Just right sweetness	More perceptible ginger than milk	Not chewy	None
14	Brown to dark brown	Well blended milk and ginger to more perceptible ginger than milk	Slightly oily	Very hard	Moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Very chewy	Mild to extreme
15	Brownish cream to light brown	more perceptible ginger than milk	Slightly oily	Not hard	Just right to moderately sweet	Well-blended milk and ginger to more perceptible ginger than milk	Not chewy	None
16	Brownish cream to light brown	Well blended milk and ginger to more perceptible ginger than milk	Slightly oily	Slightly to moderately hard	Just right to moderately sweet	Well-blended milk and ginger	Moderately chewy	Moderate
17	Light brown to brown	Well blended milk and ginger	Slightly oily	Slightly to moderately hard	Moderately sweet	Well-blended milk and ginger	Moderately chewy	Moderate

Table 3. Summary of the response means for color, aroma, oiliness, hardness, sweetness, flavor, chewiness, toothpacking, and general acceptability of ginger *yema*

Run	Sensory Acceptability								
	Color	Aroma	Oiliness	Hardness	Sweetness	Flavor	Chewiness	Tooth-packing	Gen. accept.
1	7.58	7.33	6.83	6.94	7.36	7.44	6.50	7.14	6.89
2	7.78	7.22	6.92	6.97	7.39	7.22	7.11	6.53	7.42
3	7.61	7.14	6.97	7.42	7.50	7.42	7.36	7.06	7.50
4	7.47	6.97	6.28	6.56	7.11	6.89	6.06	6.83	6.61
5	7.44	6.97	6.81	6.11	7.11	7.03	6.39	6.86	6.67
6	6.94	7.14	6.72	5.78	7.22	7.33	6.36	6.08	6.67
7	7.56	7.33	6.39	6.14	7.08	7.28	5.75	6.56	6.53
8	7.58	7.17	6.75	6.56	7.25	7.11	6.31	6.78	6.83
9	7.31	7.11	6.94	7.08	7.75	7.44	7.42	7.11	7.28
10	7.64	7.56	6.89	6.83	7.69	7.78	6.83	7.06	7.31
11	7.64	7.56	6.89	6.83	7.69	7.78	6.83	7.06	7.31
12	7.50	7.14	6.19	6.25	7.44	7.44	6.31	7.03	6.50
13	7.14	6.89	5.92	5.53	6.97	6.89	5.61	6.28	6.00
14	6.94	7.22	6.67	5.92	7.67	7.61	6.53	6.56	6.64
15	7.42	7.39	6.58	6.31	6.89	7.36	5.94	6.14	6.72
16	7.75	7.56	7.28	7.53	7.97	7.92	7.83	7.19	7.92
17	7.58	7.50	7.28	7.44	7.69	7.56	7.50	7.36	7.47

Table 4. Summary of parameter estimates for color, aroma, chewiness, toothpacking, hardness, flavor, and general acceptability of ginger *yema*

Parameters	Responses (Acceptability)								
	Color	Aroma	Oiliness	Hardness	Sweet-ness	Flavor	Chewi-ness	Tooth-packing	GA
Intercept	-11.1382	-14.3276	-12.4664	-16.2222	1.9413	-10.7287	-15.854	6.1284	-24.5491**
Ginger extract (GE)	0.2236	1.9655	0.3871	-1.4525	0.2000	1.2854	-0.1588	-1.7137	0.8371
Palm oil (PO)	3.0107**	1.5716	3.047**	5.785**	0.7184	1.7647	4.1466**	2.1495	4.5688**
Glucose level (GL)	-0.1887*	-0.1519	-0.2385	-0.5393**	-0.1669	-0.2019	-0.3839**	-0.3231**	-0.3119**
$(GE)^2$	0.0158	-0.0698	-0.0126*	0.0665	-0.0124	-0.0531	0.0084	0.0588	-0.0164
(PO)(GE)	-0.055**	-0.0138	0.0108	-0.0325	0.0099	0.0037	-0.0088	0.0112	-0.0375
$(PO)^2$	-0.0992**	-0.0598	-0.1276**	-0.2336**	-0.0374	-0.0781	-0.1766**	-0.1012	-0.1764**
(GL)(GE)	0.0028	0.0042	0.0047	0.0172*	0.0072	0.0103	0.0119	0.0164*	0.0067
(GL)(PO)	0.0067	0.0025	0.0108	0.0167*	0.0083	0.0031	0.0181**	0.0103	0.0111*
$(GL)^2$	0.0047**	0.0045*	0.0051*	0.0097**	0.0001	0.0031	0.0058*	-0.0005	0.0091**

-*p* value<0.01; *-*p* value<0.05; GA- General Acceptability

Effect on Oilness Acceptability

The panelists generally described the treatment samples as 'slightly oily' (Table 2). The lowest acceptability rating was observed with ingredient combination Run 13 (5.92), and the highest in Run 16 (7.28) with 13.33% ginger extract, 11.67% palm oil, 15.0% glucose syrup and Run 17 (7.28) with 13.33% ginger extract, 11.67% palm oil, 7.5% glucose syrup (Table 3). The acceptability ratings fall within the 'like slightly' to 'like moderately' category of the 9-point Hedonic Scale.

Table 4 shows that the linear term of PO and the quadratic term of GL significantly increased the oiliness acceptability of the product by 3.047 and 0.0051, respectively. This observation could be due to the trapping of oil within the product when the glucose syrup crystallizes. However, the quadratic terms of GE and PO significantly reduced the oiliness acceptability by 0.0126 and 0.1276, respectively. Apparently, increasing the level of oil will result in an oilier product resulting to decreased acceptability. In addition, ginger rhizomes contain fatty oils (3-6%) and volatile oil (2-3%) (Mbaveng and Kuete 2017 as cited by Mahboub 2019), which may contribute to the oiliness of the product.

Effect on Hardness Acceptability

Hardness acceptability ranges from 5.53 to 7.53, corresponding to 'neither like nor dislike' to 'like moderately' of the 9-point Hedonic scale (Table 2). Runs 6, 13 and 14 had acceptability scores of 5.78, 5.53 and 5.92, respectively (Table 2) corresponding to 'neither like nor dislike'. This is generally because these samples were perceived as very hard by the respondents, except Run 13 (Table 4).

Statistical analysis revealed that the linear term of palm oil (PO), the crossproduct terms of glucose syrup level and ginger extract (GL)(GE); glucose syrup level and palm oil (GL)(PO) and the quadratic term of glucose syrup (GL^2) caused a positive significant effect on the hardness of the ginger yema. However, the linear term of glucose syrup level and the quadratic term of palm oil resulted in decreased hardness acceptability by 0.5393 and 0.2336, respectively. This observation implies that lower levels of oil and ginger extract and decreasing the level of glucose syrup in the formulation will produce a product with a more acceptable hardness.

Reports of Nguyen and Phan (2016) and Suwan et al (2018), are in agreement with the findings of this study, there is a significant interaction that exists between glucose and the rest of the components on the structural property of milk candy.

Effect on Sweetness Acceptability

Most of the sugars in the processed ginger *yema* came from condensed milk and glucose. Varying combinations of glucose syrup, ginger extract and palm oil generally led to describing the product as having 'just right sweetness' to 'moderately sweet' (Table 2). High acceptability scores were reported among treatment samples, from 6.89 to 7.97 (Table 3), corresponding to 'like slightly' and 'like moderately' on the 9-point Hedonic Rating scale. Parameter estimates revealed that all the parameters being studied did not significantly affect the responses (sensory quality acceptability) (Table 4).

Effect on Flavor Acceptability

The ginger extract served as the flavorant of the product. Unexpectedly, all the parameters being studied did not significantly affect the responses (sensory quality acceptability) (Table 4). The mean acceptability scores for flavor of ginger *yema*, ranges from 6.89 to 7.92 (Table 3). These ratings correspond to 'like slightly' and 'like moderately' of the 9-point Hedonic scale.

Effects on Chewiness Acceptability

Chewiness is related to the texture of the product (Akib et al 2017). The harder the candy, the less it is chewable. Ginger *yema* is characteristically a chewy candy, and basically composed of heated glucose, milk and vegetable fat. Therefore, it is relatively close to the definition of a caramel as defined by Minifie (1989) as cited by Sengar and Sharma (2014). According to Sengar and Sharma (2014), the greatest single factor affecting the chew is the amount of moisture left in the caramel. It is expected then that the higher levels of wet ingredients used in the formulation would likely dictate the texture of the product. However, based on the statistical result, two of the independent factors namely palm oil and glucose levels were drivers of acceptability for chewiness of the product. Regression analysis estimated that a unit increase of palm oil will cause a significant increase in acceptability of the response by 4.1466. A significant increase by 0.0058 can be expected in every square unit of glucose added to the product. Correspondingly, samples with highest level (15.0%) of glucose syrup had high acceptability scores from 7.11 to 7.83 (Table 3), and these samples were generally described as 'moderately chewy' (Table 2). On the other hand, the interaction of both palm oil and glucose syrup positively contributes to the acceptability for chewiness, with an estimated 0.0181increase in acceptability (Table 4). Meanwhile, the linear term of glucose syrup level and the quadratic term of palm oil caused a negative significant effect on the chewiness acceptability.

Effects on Toothpack Acceptability

Toothpack is the amount of product packed into crowns of teeth after mastication (Meullenet 1998). This quality parameter is important to consumers of hard and chewy candies. Consumers mostly would dislike a product that left more toothpack after eating. In ginger *yema*, none was perceived on ingredient combinations without glucose syrup, while those having high glucose syrup (Run 3, Run 9 and Run 16) were described as having 'moderate' to 'extreme' toothpacking sensation (Table 4).

Statistical analysis of the acceptability scores of the response under study revealed that a unit increase in glucose syrup level will result to a significant decrease in the toothpack acceptability by 0.3231, while its crossproduct (positive) with ginger extract will result in an increase in the acceptability by 0.0164 (Table 4). The positive interaction of glucose syrup and ginger extract implies that there is an expected increase in toothpacking acceptability when both ingredients are simultaneously increased. Conversely, increasing the amount of glucose syrup while decreasing the amount of ginger extract would result to the decline of its acceptability.

Addition of more ginger extract affects the cohesiveness of the *yema* making the candy sticky. On the other hand, increasing the amount of water in the candy by increasing the amount of ginger extract tends to dilute the candy mixture resulting in canceling out of the cohesive nature of the glucose syrup, hence resulting in less toothpacking.

Effect on General Acceptability

It was revealed that most of the responses were generally dictated by the levels of palm oil and glucose syrup. Similar trend was observed in the overall acceptability of the product. Notably, the linear term of glucose syrup (0.3119) negatively affects the general acceptability of ginger *yema* while palm oil caused an increase in general acceptability by 4.5688. However, a positive significant effect was observed in the quadratic term of glucose syrup level, while negative significant effect was noted in the quadratic term of palm oil. Meanwhile, the interaction of glucose syrup level and palm oil resulted in an increase in the response acceptability.

Results of the study of Da Silva (2016) are contrary to the findings of this study. In açai chewy candies, the addition of sucrose did not significantly differ in terms of overall acceptability as compared to the candy having none (Da Silva 2016). Aggarwal and Michael (2014) reported on the other hand that the type of sugar matters. They revealed that overall acceptability was highest in Kinnow candy with fructose, than in sucrose.

Attaining the Optimum Conditions for Ginger Yema

The shaded regions of the superimposed contour plots in Figure 1 represent the combinations of ginger extract, palm oil and glucose syrup at which the optimum acceptability of the product is set at acceptability ratings of ≥7.40 for color; ≥7.20 for aroma, sweetness, flavor, and general acceptability; and ≥6.80 for oiliness, hardness, chewiness, and toothpacking.

The candidate optimum range of values are 11.1 to 12.2, 14.5 to 14.75 and 12.2 to 16.0 % w/w for palm oil, ginger extract, and glucose syrup levels, respectively. The main objective of this study is to maximize the use of ginger due to its potential nutraceutical benefit. Using 14.75% level of ginger extract suggests that the values for palm oil should be high (12.0%) since the linear coefficients in all attributes are positive. On the hand, glucose syrup should be low (12.2%) since its linear coefficients in all attributes are negative. Therefore, the identified optimum combination of the variables in the development of ginger *yema* is at 14.75 % w/w ginger extract, 12 % w/w palm oil and 12.2 % w/w of glucose syrup.

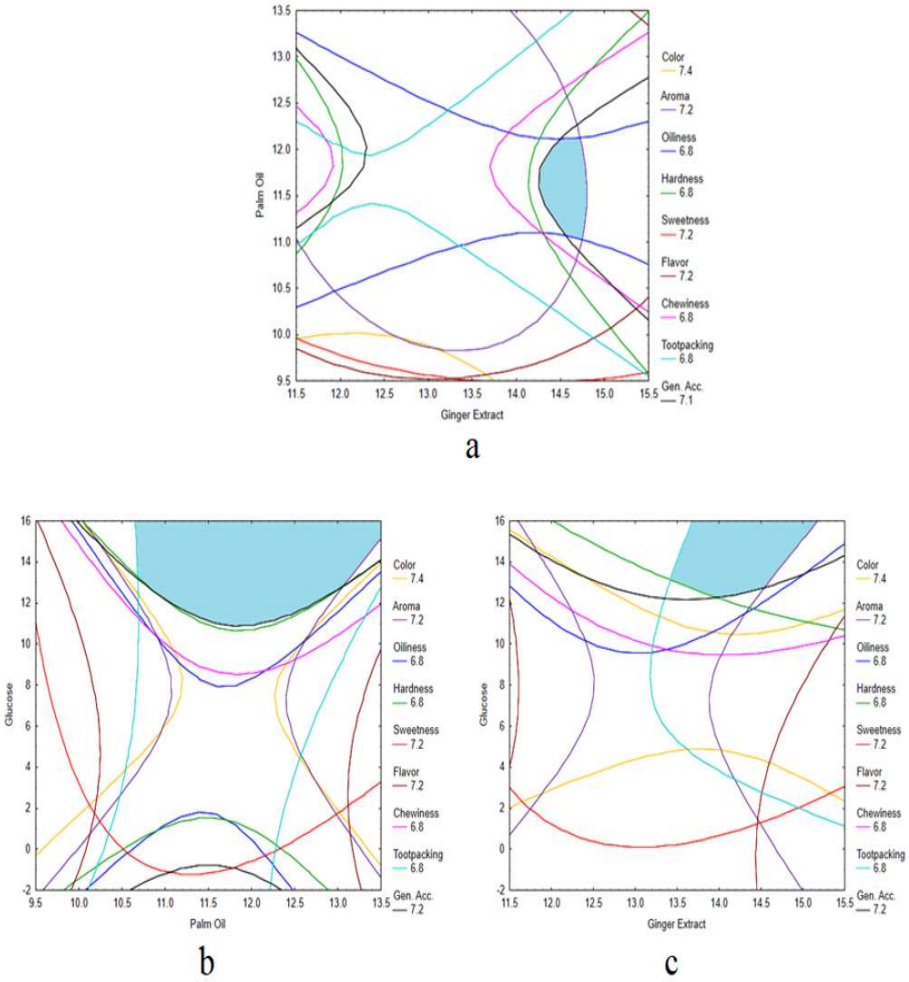

Figure 1. Optimum regions for ginger *yema* is set at an acceptability rating range of 6.8 to 7.2 based on the 9-Point Hedonic Scale; a) at constant glucose (12.2%), b) at constant ginger extract(14.75%), c) at constant palm oil (12%)

CONCLUSIONS

Majority of the response acceptability being studied were affected by the linear, quadratic and crossproduct terms of glucose syrup level and palm oil. Only glucose syrup level affected the aroma of the ginger *yema* while sweetness was not affected by any of the variables. The optimum combination for ginger *yema* is generated at 14.75% w/w ginger extract, 12.00% w/w palm oil, and 12.2% w/w of glucose syrup. The optimum formulation provided lower levels of the variables compared to the original formulation.

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AUTHOR CONTRIBUTIONS

LCC conceptualization, methodology, writing-original draft, review and revision.
ICE conceptualization, methodology, review and revision.
RDL conceptualization, methodology.
JBC methodology, statistical analysis, revision.
WBY data gathering
KRN data gathering.
LMV data gathering.

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Department of Trade and Industry-Bohol & Visayas State University

AVAILABILITY OF DATA AND MATERIALS

Data are available from the corresponding author upon request.

ETHICAL CONSIDERATION

The Ethics Review Committee (ERC) in VSU during the time of experiment and the submission of this paper was still in the process of organizing, and guidelines were yet to be drafted and finalized. The authors however ensure that ethical considerations were implemented during conduct of the research.

COMPETING INTEREST

The authors declare that they have no competing interests.

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