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Utilizing Optimization Technique in the Formulation and Development of Snacks for Public Secondary School Students of the Philippines

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Abstract: Due to limited allowance, students buy food primarily because it is cheap and delicious. The nutrient contents of the food are the least that they consider. This study proposes snack item that will meet the buying capacity of the students at the same time meeting the nutritional and palatability value of the food. In order to do this, a linear programming diet model is used to develop a model recipe for snacks that would meet the energy requirement for the growing up years of adolescents. This study involved 1364 adolescent participants from various public high schools of East II District of Cagayan de Oro City, Philippines in order to examine the sources of income of their parents, daily allowance allotted for their snacks in school, their prevalent food choices and the reasons for such food choice. Based on the survey, the average allowance of the students for snacks is PhP 6.00-10.00 (USD 0.13-0.22) per day. Results of the LP model provide modified recipes for fried banana spring roll with ingredients rich in calories, fats, carbohydrates and protein. Upon sensory acceptability test, respondents confirmed a very desirable rating for the new recipes developed. The recipes are recommended to be produced among school canteens to meet the nutritional needs of students at cost affordable to them.

Key words: Energy and nutrient consumption, linear programming, optimizing diet, adolescence, food cost, RENI

INTRODUCTION

The World Health Organization (WHO, 2014) identifies adolescence as the period in human growth and development that occurs after childhood and before adulthood, from ages 10 to 19. It represents one of the critical transitions in the life span and is characterized by a tremendous pace in growth and change. This dramatic increase in physical growth and development creates a high demand for nutrients and energy (Story and Resnic, 1996). In order to develop to their utmost potential, it is necessary that adolescents are provided with nutritionally sound diet. In the dietary habits of young people, snacks generally form an integral part of meal patterns.

In the Philippine context, these adolescents are mostly in their secondary (high school) and post-secondary/non-tertiary education (Philippine Standard Classification of Education, 2012). They spend most of their waking up hours in school. Hence, schools play of utmost importance in providing the students with healthy food being sold in school canteens. The customary meal patterns among Filipinos constitute of three meals a day and two snacks in between (Philippines: Eating Habits and Hospitality, 2015).

Majority of the secondary school students in the Philippines are enrolled in public high school (Department of Education, 2010) and most of them belong to low-income families. In fact, survey shows that 60-90% of the Filipinos belong to lower-middle (Philippines, 2015) and low-income families (Socioeconomic Classes Explained). The Philippine government supported this survey results by Republic Act No. 6655 (1988), known as Free Public Secondary Education declaring that students shall be free from payment of tuition and other school fees, except fees related to membership in the school community. This law is further strengthened by memorandum released (DO 28, s. 2010) from the office of the President of the Republic that graduation rites in public schools shall be held in school premises in the most austere manner.

In light to this situation, it is interesting to note that dietary quality assessed by a global index declines when less money is spent on food. Clearly, according to Darmon *et al.* (2002), the price of food, although not systematically perceived as a barrier to healthy eating, is an important determinant of food choice, especially among low income groups and the unemployed. Darmon and Drewnowski (2008) further established that epidemiologic data show that diet quality follows a socioeconomic gradient. These studies, therefore, suggest that families and individuals of low income can hardly afford to buy highly nutritious foods.

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Because of these findings, it is therefore imperative that there is a need to come up with enhanced snack recipe for public high school students that will meet nutrient requirements at low cost. In order to do this, Linear Programming is the tool to be utilized.

MATERIALS AND METHODS

In this study, a linear programming model was formulated to come up with recipe for snacks which met the nutrient requirements and acceptable palatability at low cost. In order to identify the constraints for the LP model, reasonable ingredients which are locally available and of minimum cost were identified. To do this, a review was made on the best but cheap food sources that meet the nutrient requirement for calories, fats, carbohydrates and proteins. Moreover, the prices of each of the identified ingredients were gathered and canvassed from local public markets and grocery stores. Table 1 shows the nutritional value of the ingredients and their corresponding cost.

The nutritional content analysis was based on every 100 g of the ingredients. The ingredients were further divided according to serving size deemed reasonable and practical to be used as fillings. The nutritional content per 100 g was also divided according to serving sizes. The cost was based on edible parts per 100 g. The cost was similarly divided according to serving sizes identified in the nutrient content bases. The data on nutrient contents and costs collected during these steps were utilized in the developing of the model recipe for snacks. Linear Programming was used to select combination of these ingredients to come up with a recipe.

To identify further which food to enhance and as to how much would be the cost, a survey was conducted in various public secondary schools students in Cagayan de Oro City, a capital city in the southern part of the Philippines. The respondents were 1364 students (652 male and 712 females) whose age bracket ranges from 12-19 years old. They were randomly chosen using the stratified random sampling with 95% level of confidence. The survey was conducted using a guided questionnaire to find out the socioeconomic status of the students and their food preference.

Survey results showed that the parents of public high school students belong to low-income earners. Most of their livelihood is on daily wage basis. From this data, it can be deduced that the families of the students in public high school have low income. The survey further revealed that most of the students have an allowance of PhP 6-10 (USD 0.13-0.23) daily to spend for snacks and that the top three food preferences were Banana spring roll (locally known as turon), biscuits and crackers and banana que.

For the purpose of this study, turon was chosen being the top food preference. However, upon initial evaluation, the nutrients content of existing turon recipes as shown in Table 2 were not compliant to the nutrient requirement as reflected in Table 3. Thus it is imperative to enhance it in such a way that it becomes acquiescent to the nutrient requirement at the least cost.

The cost for ingredients was set to PhP7.50 (USD 0.17) which was also based on the survey result regarding the students' daily allowance allotted for snacks.

In the formulation of the ingredients for the model recipe, the nutrient content of each ingredient were carefully considered. The recommended energy intake for Filipino adolescents at various age brackets as presented by Barba and Cabrera (2008) was followed. The minimum and maximum required energy and nutrient intake referred to the 25-33% allocation of daily intake intended for snacks (Brown, 2008). Failure to follow this nutrient requirement may affect the nutrient requirement of the students.

Linear programming model for recipe formulation:

$$\text{Min } Z = \sum_{i=1}^{n} Cixi$$

Subject to:

$$x_1 \geq 1 \quad (1)$$

$$x_1 \leq 2 \quad (2)$$

$$x_2 = 1 \quad (3)$$

$$x_3 = 1 \quad (4)$$

$$x_4 \geq 3 \quad (5)$$

$$x_4 \leq 5 \quad (6)$$

$$\sum_{i=1}^{n} Dixi \geq 563 \quad (7)$$

$$\sum_{i=1}^{n} Dixi \leq 743 \quad (8)$$

$$\sum_{i=1}^{n} Eixi \geq 13 \quad (9)$$

$$\sum_{i=1}^{n} Eixi \leq 17 \quad (10)$$

$$\sum_{i=1}^{n} Fixi \geq 77 \quad (11)$$

$$\sum_{i=1}^{n} Fixi \leq 102 \quad (12)$$

$$\sum_{i=1}^{n} Gixi \geq 16 \quad (13)$$

$$\sum_{i=1}^{n} Gixi \leq 21 \quad (14)$$

$$\sum_{i=1}^{n} Cixi \leq 7.50 \quad (15)$$

$$xi \geq 0 \text{ for } i = 1,2,.....,40 \quad (16)$$

Table 1: Nutritional value and cost of each ingredient per serving size. source: (Nutritionvalue.org)

---------- Ingredients ---------						
Weight	Item	Calories	Fats (g)	Carbohydrates (g)	Protein (g)	Cost/serving
100 g	Banana, raw	89.0	0.3	23.0	1.1	1.00
10 g	Brown sugar	38.00	0.00	9.80	0.01	0.35
15 g	Canola oil	132.93	15.04	0.00	0.00	1.13
10 g	Spring roll wrap	29.10	0.15	5.80	0.98	0.43
4 g	All-purpose flour, roasted	14.56	0.04	3.04	0.40	0.18
5 g	Red apple, batonet	2.95	0.01	0.70	0.02	0.88
5 g	Ripe avocado, cubed	8.00	0.75	0.43	0.10	0.18
5 g	Unsalted butter, batonet	35.85	4.05	0.01	0.05	0.93
5 g	Cheddar cheese, batonet	8.80	0.45	0.55	0.65	2.30
4 g	Desiccated coconut, roasted	23.68	1.88	1.76	0.21	0.35
5 g	Whole egg, scrambled	7.45	0.55	0.08	0.50	0.50
4 g	Garlic bread, crushed	14.00	0.68	1.68	0.34	0.16
4 g	Graham biscuit, crushed	17.12	0.60	2.52	0.32	0.68
5 g	Mongo beans, boiled	5.25	0.03	0.90	0.38	0.35
4 g	Oats, baked	15.56	0.28	2.64	0.68	0.45
4 g	Peanut butter	23.52	2.00	0.96	0.88	0.42
5 g	Peanuts, roasted and ground	29.25	2.50	1.10	1.20	0.51
5 g	Plain cheese, batonet	17.10	1.70	0.21	0.30	1.03
5 g	Plain soymilk	2.05	0.09	0.17	0.15	0.32
5 g	Potato, boiled and mashed	2.90	0.01	0.60	0.13	0.35
4 g	Powdered chocolate	20.04	1.28	1.20	0.52	2.03
4 g	Powdered milk	9.52	0.48	0.64	0.68	1.83
2 g	Refined sugar	7.74	0.00	2.00	0.00	0.09
5 g	Sweet corn, boiled and mashed	18.25	0.24	3.70	0.47	0.54
5 g	Sweet potato, mashed	5.05	0.01	1.15	0.10	0.10
5 g	Tofu, dried and frozen	24.00	1.50	0.75	2.40	0.50
5 g	Boiled tuna, flaked	5.80	0.04	0.00	1.30	1.25
5 g	Coconut Meat, fresh, grated	17.70	1.65	0.75	0.15	0.50
4 g	Taho (soy bean curd)	15.44	0.23	2.28	1.43	0.20
4 g	Ripe mango, sliced thinly	2.80	0.01	0.68	0.02	0.60
4 g	Candied young coconut meat	15.48	0.00	1.81	0.00	0.40
4 g	Boiled chicken meat, strips	7.08	0.27	0.00	1.08	0.70
2 g	Sesame seeds, roasted	11.30	0.96	0.52	0.34	0.44
4 g	Jackfruit, ripe, strips	3.80	0.01	0.92	0.07	0.30
4 g	Pineapple	2.00	0.00	0.52	0.02	0.30
4 g	All-purpose cream	11.00	1.20	0.20	0.00	0.67
4 g	Carnation condensed milk	17.32	0.40	2.93	0.53	0.59
4 g	Squash, boiled	1.60	0.00	0.40	0.04	0.20
4 g	Mayonnaise	9.52	0.88	0.37	0.02	1.33
4 g	Biko (glutinous rice cake)	6.20	0.31	0.82	0.07	0.53

Table 2: Nutrient composition and cost of existing turon recipes

Recipes	Calories	Fats (g)	Carbohydrates (g)	Protein (g)	Cost
1 Serving	244.5	10.5	38.6	2.1	2.9
2 Servings	489	21	77.2	4.2	5.8

Table 3: Minimum and maximum required energy intake for snacks female, 13-15 years old. Source: (Barba and Cabrera, 2008)

Nutrients	Calories	Fats (g)	Carbohydrates (g)	Proteins (g)
Minimum requirement	563	13	77	16
Maximum requirement	743	17	102	21

Table 4: Scoring for sensory evaluation and acceptability test of the formulated recipes

Scale	Range	Qualitative description
5	4.21-5.00	Very desirable
4	3.41-4.20	Moderately desirable
3	2.61-3.40	Neither undesirable nor desirable
2	1.81-2.60	Undesirable
1	1.00-1.80	Very undesirable

Table 5: Ingredient composition and cost of various formulated turon recipes

Ing.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
Rec.	g	g	g	pcs	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	Cost
1	183	10	15	3	-	-	-	-	-	-	-	-	27.3	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-	25.4	-	-	-	-	-	-	-	-	-	-	6.72
2	199	10	15	4	12.0	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	10.0	-	-	5.6	-	-	20.0	-	-	-	-	-	-	-	-	-	-	6.85
3	200	10	15	4		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-	32.2	-	-	-	-	-	-	-	-	-	-	6.87
4	200	10	15	3		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	44.3	-	-	-	-	-	-	-	-	-	-	6.98
29	200	10	15	3		-		-	-	-		-		-	-				-	-	-	-	-					-	-	42.5	-		-	-	-	-	-	-	-	-	6.99
28	200	10	15	4		-		-	-	-		-		-	-				-	-	-	-	-					-	-	40.0	-		-	-	-	-	-	-	-	-	7.01
7	200	10	15	4		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	30.0	-	-	-	-	-	-	-	-	-	-	7.08
5	200	10	15	4		-	-	-	-	-	6.7	-		-	-	-	-	-	-	-	-	-	-		-	-	1.2	-	-	25.0	-	-	-	-	-	-	-	-	-	-	7.15
15	200	10	15	4		-	-	-	-	-		-		-	-	-	4.5	-	-	-	-	-	-		-			-	-	30.0	-	-	-	-	-	-	-	-	-	-	7.16
16	200	10	15	4		-	1.4	-	-	-		-		-	-	-	4.0		-	-	-	-	-		-			-	-	30.0	-	-	-	-	-	-	-	-	-	-	7.18
14	200	10	15	4		-	-	-	-	-		-		-	-	-	7.8	-	-	-	-	-	-		-			-	-	25.0	-	-	-	-	-	-	-	-	-	-	7.26
17	200	10	15	4		-	-	-	-	-		-		-	-	-	7.8	-	-	-	-	-	-		-			-	-	25.0	-	-	-	-	-	-	-	-	-	-	7.26
20	200	10	15	4		-	16.5	-	-	-		-		-	-				-	-	-	-	-		-			-	-	30.0	-	-	-	-	-	-	-	-	-	-	7.27
30	200	10	15	4		-		-	-	-		-		-	-				-	-	-	-	-	5.0		0.2	11.5	-	-	10.0	-		-	-	-	-	-	-	-	-	7.27
24	200	10	15	4		-		-	-	-		-		1.7	-				-	-	-	-	-					-	-	35.0	-		-	-	-	-	-	-	-	-	7.28
6	200	10	15	4		-	-	-	-	-	6.8	-		-	-	-	-	-	-	-	-	-	-		-	-	4.9	-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.30
8	200	10	15	4		-	-	-	-	-	6.8	-		-	-	-	-	-	-	-	-	-	-		-	1.3	4.9	-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.30
10	200	10	15	4		-	-	-	-	-	4.0	-		-	-	-	-	-	-	-	-	-	-		4.7	-	-	-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.32
18	200	10	15	4		-	13.9	-	-	-		-		-	-	-	4.0		-	-	-	-	-		-			-	-	25.0	-	-	-	-	-	-	-	-	-	-	7.35
11	200	10	15	4		-	-	-	-	-		-		-	-	-	-	8.7	-	-	-	-	-		-	9.4	0.9	-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.35
21	200	10	15	4		-		-	-	-		-		-	-				-	-	-	-	-		-			-	-	30.0	-	6.6	0.3	-	-	-	-	-	-	-	7.37
25	200	10	15	4		-		-	-	-		-		-	-				-	2.1	-	-	-					-	-	35.0	-		-	-	-	-	-	-	-	-	7.37
22	200	10	15	4		-		-	-	-		-		-	-				-	-	-	-	-		1.9			-	-	30.0	-	5.0	-	-	-	-	-	-	-	-	7.40
23	200	10	15	4		-		-	-	-		-		-	-				0.3	-	-	-	-					-	-	30.0	-	6.6	-	-	-	-	-	-	-	-	7.40
12	200	10	15	4		-	-	-	-	-		-		-	-	-	-	-	-	-	-	-	-		-		1.5	-	-	20.0	-	2.2	-	-	-	-	-	-	-	-	7.41
26	200	10	15	4		-		-	-	-		-		-	6.8				-	-	-	-	-					-	-	35.0	-		-	-	-	-	-	-	-	-	7.41
27	200	10	15	4		-		-	-	-		4.8		-	-				-	-	-	-	-					-	-	35.0	-		-	-	-	-	-	-	-	-	7.42
13	199	10	15	4		-	-	-	-	-		-		-	-	3.7	-	8.8	-	-	-	-	-		-			-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.48
19	199	10	15	4		-	-	-	-	-		-		-	-	3.7		8.8	-	-	-	-	-		-			-	-	20.0	-	-	-	-	-	-	-	-	-	-	7.48
9	200	10	15	4		-	-	-	-	-	5.2	-		-	-	-	-	-	-	-	-	-	-		-	13.8	8.3	-	-	15.0	-	-	-	-	-	-	-	-	-	-	7.50

Ingredients:
1: Banana, raw
2: Brow sugar
3: Canola oil
4: Spring roll wrap
5: All-purpose flour, pan roasted
6: Red apple, batonet
7: Ripe avocado, mashed
8: Unsalted butter, batonet
9: Carrots, boiled and mashed
10: Cheddar cheese, batonet
11: Desiccated coconut, pan-roasted
12: Whole egg, scrambled
13: Garlic bread, crushed
14: Graham biscuit, crushed
15: Mongo beans, boiled
16: Oatts baked
17: Peanut butter
18: Peanuts, roasted and ground
19: Plain cheese, batonet
20: Plain soymilk
21: Potato, boiled and mashed
22: Powdered chocolate
23: Powdered milk
24: Refined sugar
25: Sweet corn, boiled and mashed
26: Sweet potato, boiled and mashed
27: Tofu, fried
28: Boiled tuna, flaked
29: Coconut meat, fresh and grated
30: Taho
31: Ripe mango, sliced thinly
32: Candied young coconut meat
33: Boiled chicken meat, strips
34: Sesame seeds, pan-roasted
35: Squash, boiled and mashed
36: Ripe Jackfruit, strips
37: Mayonnaise
38: Fresh coconut meat, grated
39: Condensed milk
40: Glutinous rice cake
Ing.: Ingredients
Rec.: Recipes

Table 6: Nutrient composition and cost of various formulated turon recipes

Recipes	Calories	Fats (g)	Carbohydrates (g)	Protein (g)	Cost
Recipe 1	563.0	17.0	93.4	16.0	6.72
Recipe 2	563.0	13.0	100.6	16.0	6.85
Recipe 3	563.0	13.0	102.0	17.6	6.87
Recipe 4	563.0	13.6	98.5	21.0	6.98
Recipe 29	563.0	13.5	98.9	20.0	6.99
Recipe 28	563.0	13.4	99.4	20.0	7.01
Recipe 7	563.0	15.0	98.1	17.1	7.08
Recipe 5	563.0	16.0	96.4	16.0	7.15
Recipe 15	563.0	15.2	97.2	17.8	7.16
Recipe 16	563.0	15.2	97.2	16.8	7.18
Recipe 14	563.0	16.5	95.1	16.8	7.26
Recipe 17	563.0	16.1	95.1	17.8	7.26
Recipe 20	563.0	15.4	97.5	17.2	7.27
Recipe 30	563.0	15.3	97.5	16.0	7.27
Recipe 24	563.0	13.4	100.0	18.8	7.28
Recipe 6	563.0	17.0	94.4	16.0	7.30
Recipe 8	563.0	17.0	94.4	16.0	7.30
Recipe 10	563.0	17.0	94.5	16.0	7.32
Recipe 18	563.0	16.7	95.4	16.8	7.35
Recipe 11	563.0	17.0	94.6	16.0	7.35
Recipe 21	563.0	13.0	99.1	16.8	7.37
Recipe 25	563.0	13.9	99.0	18.7	7.37
Recipe 22	563.0	13.0	99.8	17.0	7.40
Recipe 23	563.0	13.0	99.1	16.9	7.40
Recipe 12	563.0	17.0	93.5	16.0	7.41
Recipe 26	563.0	13.2	100.0	19.1	7.41
Recipe 27	563.0	13.7	99.0	19.1	7.42
Recipe 13	563.0	17.0	94.5	16.0	7.48
Recipe 19	563.0	17.0	94.7	16.0	7.48
Recipe 9	563.0	17.0	94.2	16.0	7.50

Table 7: Mean hedonic ratings for sensory attributes and overall acceptability tests

	Recipe A	Recipe B	Recipe C	---------- Overall rating ----------	
Criteria	(Recipe 1)	(Recipe 2)	(Existing turon)	Rate	Description
Appearance of the food	4.64	4.51	4.24	4.46	VD
Flavor of the food	4.76	4.24	3.74	4.25	VD
Aroma of the food	4.64	4.38	4.00	4.34	VD
Texture of the food	4.64	4.60	4.53	4.59	VD
Taste of the food	4.58	4.18	3.65	4.14	MD
Price of the food	4.38	4.12	4.60	4.37	VD
Average rating/recipe	4.61	4.34	4.13		
Qualitative Description	Very Desirable	Very Desirable	Moderately Desirable		

This study aimed to come up with enhanced snack recipes for public high school students that met nutrient requirements at a minimum cost. For the purpose of this study, the nutrient requirement for females of 13-15 years old was considered because the average age of high school students under survey was 14.47. Moreover, the RENI for this particular age bracket and gender met the maximum RENI of 10-12 years olds and the minimum RENI of 16-18 years olds, both male and female.

In the linear programming formulation presented, the objective function Z is the sum of the product of the cost of the different ingredients and their corresponding quantities included in the formulation. The ingredients and their corresponding nutritional value and cost per serving are shown in Table 1. In this LP formulation, x_i (I = 1, 2…., n) denotes the quantity of each food ingredients considered in the recipe formulation. The cost for each ingredient is denoted by C_i. Moreover, D_i, E_i, F_i and G_i correspond to the amount of calories, fats, carbohydrates and proteins nutrient in each of the food ingredients as shown. The values on the right hand side of the LP model above corresponds to the minimum and maximum nutrient recommendations based on Table 2. Constraint (1) provides that the banana ingredient must not be less than 1 serving, while constraint (2) specifies that it should not exceed 2. Constraints (3) and (4), requires the sugar and cooking oil respectively, must be equal to one serving, while constraint (5) and (6) indicate that spring roll wrap must be at least 3 but should not

exceed 5. Constraint (7) indicates that the total formulation for calories must be at least 563; while constraint (8) requires that the total formulation must not be more than 743. Moreover, constraint (9) necessitates that fat content must be at least 13 g and not more than 17 g (10); carbohydrate not less than 77 g (11) and not more than 102 g (12) and protein must be at least 16 g (13) and not more than 21 g (14). Constraint (15) imposes that the total cost of the formulation must not exceed PhP7.50 (USD 0.17), while constraint (16) ensures that each ingredient must not be less than zero.

Development of the recipe and sensory evaluation: The cooking process employed in the production of model recipe was deep-fat frying because the process is a cheap and fast process of simultaneous heat and mass transfer that changes the sensory and nutritional characteristics of food (Ziaiifar *et al*., 2008) there by attaining the crispy texture (Fellows, 2000).

The top two least-cost formulated recipes and the existing recipe of turon were utilized as subject for acceptability test. They were labeled A, B and C respectively. Participants were thirty students of Technology and Livelihood Education majoring in Foods and fifteen public school teachers who were randomly chosen. Three servings of turon were presented to the participants. Evaluation forms were distributed and explained prior to the actual food tasting. Participants were asked to rate the samples for taste, feel, texture and visual impression using a modified 5-point Hedonic scale with 1 representing 'Very Undesirable', to 5 representing 'Very Desirable' (Tortoe *et al*., 2014). Participants were also given the option to write their comments about the products. Furthermore, they were also asked if they are willing to buy the same products if sold in the canteen.

The evaluation was conducted in the student lounge area of the school. Unsalted cracker and water were supplied to panelists for refreshing their palates before tasting subsequent samples (Tortoe *et al*., 2014). The scoring guide for sensory evaluation and acceptability test of the model recipes is found on the Table 4.

RESULTS AND DISCUSSION

LP formulation of model recipes: This study considered the various combinations of 40 food ingredients taken 40 (39, 38, 37 and so on at a time) in order to come up with a recipe that met the nutrient requirements of 13-15 year-old females at low cost. Linear Programming (LP) models were formulated by considering each possible combinations of the different ingredients and then solving the resulting LP models using the excel solver. Thirty possible recipes had been obtained. These recipes, their ingredient composition and corresponding costs are shown in Table 5.

It can be seen in Table 5 that recipe 1 is the cheapest recipe which costs PhP 6.72 (USD 0.15), while recipe 9 is the most expensive with a cost of PhP 7.50 (USD 0.17). The cheapest recipe consisted of banana, sugar, oil, spring roll wrap, soy bean curd pudding (locally known as taho), crushed garlic bread and refined sugar, while the most expensive recipe consisted of banana, granulated sugar for syrup, oil, wrapper, desiccated coconut, mashed sweet potato, tuna flakes and taho.

Fig. 1: Sample product of turon

All of the 30 recipes contained taho. This could be attributed to the rich nutrient content and cheap cost of the said ingredient. It is interesting to note, however, that sweet potato was the cheapest of all ingredients, however, in the 30 recipes it was considered only four times in the formulation of recipes. This could be due to its low fat and protein contents.

The nutrients content of the 30 least cost recipes are shown in Table 6. It can be observed that all 30 recipes satisfied the recommended nutrients as shown in Table 3. However, notice in Table 2 that a serving size of existing turon recipe, though it costs less than half of the formulated recipe as shown in Table 5, contained much lower nutritional value that they do not even meet the minimum nutrient requirements as reflected in Table 3. Two servings of turon met the minimum carbohydrates requirement. However, it had too much excess of fats and less of calories and protein. This explains that, although two servings of existing turon recipes costs almost as much as the formulated one, its nutritional value is not as healthy. Furthermore, the standard recipe may not be as laborious as the formulated recipe, but it also lacks the variation of flavor that the formulated recipe has.

Of the 30 model recipes formulated by LP, Recipes 1 and 11 were the top two least recipes and had minimum ingredients to be prepared; hence they were less laborious when it comes to food preparation and production. Their possible flavors were interesting as well due to the combined texture of the varied ingredients. They were the chosen recipes to be developed for acceptability test.

Sensory evaluation and acceptability test: Table 7 presents that the mean score for recipes A and B were very desirable, while recipe C was moderately desirable. Further results presented that recipes A and B had better mean scores in flavor, aroma and taste. This could be due to the varied ingredients used as fillings for the turon. The lower mean score in flavor, aroma and taste for the existing turon recipe could be due to its banana-sugar only taste as it had no other ingredient added to it to enhance its flavor and taste.

It is interesting to note that the price of recipe C was much favored than the price of recipes A and B. Nonetheless, the participants confirmed that they were willing to buy the recipes A and B. They further confirmed, upon verbal interview, that the small difference in cost was considerable knowing that the new recipes met their nutrient requirements.

The texture of the three variants of turon ranked first in the overall rating obtaining a mean score of 4.59. This could be attributed to the crispiness of the spring roll wrapper of the turon and the firmness of the banana flesh inside. The deep-fat frying method of cooking in medium fire helped much in the attainment of the crisp texture of the food. The development of a crispy, crunchy and crackly texture is one of the distinct properties of fried food products and considerably affects acceptability (Tortoe *et al*., 2014).

The appearance of the three recipes ranked second with a mean score of 4.46. The picture (Fig. 1) of the sample food product explains the high score it got from the respondents. According to Tortoe (2014), the color of the food is one of the most important physical attribute that greatly influences consumer perception and can summarily lead to rejection (or acceptance) of the product.

Conclusions and recommendations: Based on the survey results, students have limited allowance intended for their snacks, hence their option was to buy delicious foods that were low-cost. However, their food preference do not meet the nutrient requirement. Thus, a linear programming model was utilized to develop snack item. In the formulation of linear programming model, 30 recipes were produced where the nutrient and energy requirement for 13-15 year-old females were met. The cost for these recipes was minimal. From the 30 formulated turon recipes, the top two least-cost recipes were implemented and were subjected to acceptability test along with the sample of existing turon recipe. The sensory test revealed that the formulated recipes were very desirable due to their crispness of texture, added flavour and taste which were attributed to their varied added ingredients and aroma.

Because of these, students in public high schools are given the chance to enjoy delicious and nutritious snack items that can be bought at cost within their budget. It should be noted that although the cost of the new turon recipes were higher than the cost of the existing turon the students buy from their school canteens, the energy and nutrient content of each of these recipes, however, met the minimum requirement. Furthermore, the two variants of new turon recipes presented for acceptability test were both very desirable since it had an acceptability score of 4.61 to 4.34 on a 5-point Hedonic scale.

It is recommended that these recipes may be produced in public schools to provide students with highly nutritious, less expensive and delicious snack items. Furthermore, it is also recommended that other possible nutrients be explored for a more varied flavor for this food item.

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