Nutritional Quality and Acceptability of Brown Rice Ice Cream Sandwich

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Summary Processing adds value to agricultural products, making them more nutritious and economically competitive. Brown rice, by its unremoved bran, contains substantial amounts of protein, dietary fiber, minerals and vitamins; while buffalo’s milk has higher protein and calcium and lower cholesterol than other dairy milks. These were suitable ingredients to develop healthy and nutritious value-added product. An ice cream sandwich was developed using brown rice flour (BRF) substituted at 0, 40, 50 and 60% (wt/wt), and fresh buffalo’s milk. Acceptability of the product was determined through a consumer survey ($n = 100$; 15 to 30 y old). Consumer sensory evaluation showed that cracker substituted with 50% BRF complemented with buffalo’s milk-based ice cream produced an acceptable ice cream sandwich. This resulted in a brown rice cracker ice cream sandwich (BRICS) that has 164 kcal, 8 g fat, 5.7 g protein, 20 g carbohydrates and key minerals. Product testing revealed that taste, mouthfeel, and aroma were the top attributes considered by respondents in buying ice cream products, and BRICS achieved high acceptability rating in these attributes. BRICS obtained an overall acceptability rating of 8.9 in a 9-point hedonic scale. Eighty eight percent (88%) of the respondents were willing to buy BRICS at PhP15–20. Therefore, BRICS is a convenient, nutritious, and marketable value-added product made from BRF and buffalo’s milk.

Key Words brown rice, buffalo’s milk, cracker, ice cream sandwich, sensory evaluation

Cereal-based bakery snacks have gained consumer importance among all age groups due to its good nutritional value, sensory attributes and convenience (1, 2). However, wheat is the basic ingredient in most of these products and in recent years, there is a growing concern over potential health problems caused by the gluten in wheat. Brown rice is highly nutritious, fibre-rich, a good source of protein and minerals, and gluten-free. Brown rice flour (BRF) has been found to be a suitable replacement for wheat flour in bakery products (1) and could improve the properties of the products due to its characteristic nutty flavour and chewy texture (3).

The frozen bakery industry has been on a higher global growth trajectory for the last few years. This market segment banks on consumer preference for a convenient alternative to freshly baked products (4). In the Philippines, the market for ice cream products grows at 5.6% annually (5). Buffalo’s milk is considered a premium ingredient for various local desserts in the country, especially for ice cream (6). It possesses higher protein and calcium, and lower cholesterol than other dairy milks (7). Buffalo’s milk is considered as a better source of fat for ice cream because it has higher emulsifying capacity and it produces better body and texture in ice cream (7). Considering that 97% Filipino consumers opt for healthier food products, especially those that are high in fibre, protein, and have whole grain (8), a product using brown rice flour and buffalo’s milk was developed and its consumer acceptability and nutritional composition were evaluated.

Materials and Methods

Formulation of the product

Ice cream. Ice cream formulation was optimized by testing different levels of sugar: 19% (control), 17% and 15% as derived from the total working ice cream formulation. The ingredients were weighed accurately in accordance with the proportions indicated in Table 1. The egg yolks were mixed with sugar and the mixture was whisked and tempered with simmered buffalo’s milk. The liquid mixture was constantly stirred under low heat until a custard base was formed. Afterwards, the cooled custard base was chilled for 3 h. After chilling, the ice cream base was churned for 20 min and then frozen for 3 h.

Selection of best ice cream. The best formulation of buffalo’s milk ice cream was determined by 15 experienced and semi-trained Philippine Rice Research Institute (PhilRice) staff using a 9-point hedonic scale (9-like extremely, 1-dislike extremely). The attributes evaluated by the panelists were aroma, color, texture, mouthfeel, sweetness, taste, flavor, and overall acceptability. Friedman’s ranking test was also used to determine the most and least preferred among the samples.

Rice cracker preparation. BRF was sifted and sieved (100 $\mu$m) and substituted to all-purpose flour at 0, 40,
A dough was formed from mixing the ingredients presented in Table 2. The dough was kneaded to form a smooth dough ball, rolled and cut into 2 × 3.5 in pieces, baked for 13 min at 163˚C.

Assembly of brown rice cracker ice cream sandwich (BRICS)

BRICS was assembled using the best formulation of ice cream and the crackers with different levels of BRF, as shown in Fig. 1. The product was packed in an aluminum foil and was placed in a freezer until the ice cream hardened (~2 h). Then, the ice cream sandwiches were packed in a PE pouch and stored in a freezer for ~8 h.

Sensory evaluation of BRICS

The cracker sandwiches with different levels of BRF were evaluated for their sensory attributes, namely color, aroma, texture, mouthfeel, sweetness, taste, flavor and overall acceptability.

Nutritional analysis

The product with the best sensory quality attributes was subjected to nutritional analysis (total calories, total fat, total carbohydrates, protein, magnesium, calcium, potassium, iron and zinc) using standard methods (9). The total sugar content was determined based on Pearson’s Chemical Analysis of Foods (10).

Consumer Testing of Brown Rice Cracker Ice Cream Sandwich

Consumer testing. A survey was conducted to measure consumer acceptability toward BRICS and how likely they would purchase the product. Adolescents to adults (n=100, 15–30 y), the target consumers of the product, were randomly selected in a shopping mall in Nueva Ecija, Central Luzon, Philippines. A non-probabilistic “purposive” sampling method was employed. The criteria for choosing the respondents were: (a) age, (b) would eat a frozen/cold dessert or snack (e.g. ice cream, ice drop, mousse, and other frozen food snack), and (c) enough representation from each gender (50% males and 50% females). The survey was administered by trained enumerators using a structured questionnaire. The product was presented to respondents and they tasted it. The attributes of the product were rated through a 9-point hedonic scale and the consumers’ likelihood of purchase toward the product were specified by answering whether they were willing to buy the product or not if it was available at certain price ranges.

Statistical Analysis

The sensory data were evaluated using ANOVA. Tukey’s Honest Significant Difference Test was used to determine which samples were different at significance level of p<0.05. The rank scores were assessed using non-parametric Friedman Test. All statistical analyses were performed using SPSS for Windows version 20 statistical software package (IBM SPSS Statistics, Armonk, NY). Market survey data were analyzed using descriptive statistics (e.g. means, percentage distribution).
Table 4. Sensory attributes of ice cream sandwich substituted with BRF.¹

| Sensory Attributes | Levels of Substitution (%BRF)² |
|--------------------|-------------------------------|
|                    | 0 | 40 | 50 | 60 |
| Color              | 7.2±0.4 | 7.0±1.2 | 7.6±0.5 | 6.9±1.1 |
| Aroma              | 6.6±1.0 | 6.9±1.1 | 6.8±1.0 | 6.9±1.2 |
| Hardness           | 5.1±1.5 | 5.7±1.1 | 6.5±1.4 | 6.0±0.0 |
| Texture            | 6.3±1.3 | 6.3±0.9 | 6.4±1.1 | 6.3±1.0 |
| Mouthfeel          | 6.9±1.3 | 6.7±1.3 | 6.7±1.4 | 6.3±2.0 |
| Flavor             | 6.9±0.7 | 7.5±0.7 | 7.3±0.6 | 7.3±0.6 |
| Taste              | 6.7±0.7 | 7.0±0.7 | 7.4±0.7 | 7.2±0.6 |
| Overall            | 6.3±1.0 | 6.6±0.7 | 7.1±0.7 | 6.9±0.8 |

Friedman ranking test (sum of ranks): 38ᵃ 27ᵇ 16ᵃ 19ᵇ

¹ Scale: 9-point hedonic scale rating (1-extremely important to 9-very important).
² Mean±SD (n=15).

Table 5. Nutritional Composition of BRICS.

| Nutritional Composition | Amount per 50-g serving size |
|-------------------------|-----------------------------|
| Total Calories (kcal)   | 164                         |
| Calories from fat       | 73                          |
| Total Fat (g)           | 8                           |
| Protein (g)             | 5.7                         |
| Carbohydrates (g)       | 20                          |
| Total Sugars (g)        | 15.2                        |
| Magnesium (mg)          | 17                          |
| Calcium (mg)            | 31                          |
| Potassium (mg)          | 67                          |
| Iron (mg)               | 0.5                         |
| Zinc (mg)               | 0.9                         |

Results

The best formulation of buffalo milk ice cream. High sweetness acceptance and texture scores were evident in the ice cream with 17% sugar of the total working formulation as shown in Table 3. Thus, the treatment with 17% sugar was selected as the optimum formulation.

The best formulation of brown rice cracker ice cream sandwich. Regardless of substitution level, the cracker of the ice cream sandwich with BRF had comparable quality with the unsubstituted control (Table 4). The panelists also deemed the samples as acceptable as the control. The rank sum scores, however, revealed that crackers with higher percentage (≥50%) of BRF were more preferred by the panelists. With its lowest sum of ranks indicating the highest preference by consumers, substitution at 50% was selected for the final product.

Nutritional Composition of BRICS

A 50-g serving of brown rice cracker sandwich contains 164 kcal, 8 g fat, 5.7 g protein, 20 g carbohydrates and minerals as stated in Table 5.

Consumer Testing of Brown Rice Cracker Sandwich

Characteristics of the target market of BRICS. The target market (15 to 30 y old) of BRICS was a group of consumers who usually eat this kind of product. They came from the different cities or municipalities of Nueva Ecija. Most of them were living in the rural areas (71.0%). There were 52% males and 48% females with an average age of 22.2 y. Most of them were single (77.0%). The average length of education was 11 y and the average monthly household income was PhP 12,973.

Consumers’ acceptability of BRICS. Table 6 shows the consumers’ perceived importance of the different attributes of frozen food product that affects their decision in buying and the acceptability or degree of liking for each attribute of BRICS. Taste (8.1±1.9) was the most important attribute considered by the respondents when they buy a frozen/cold dessert or snack product. This was closely followed by mouthfeel (8.0±1.1), while aroma (7.3±1.9) ranked as third most important attribute. Other attributes, such as appearance, serving size, hardness/softness, and color were also deemed important but to a lesser degree.

According to the respondents, the overall acceptability of the brown rice cracker sandwich was 8.4±0.8 or “like very much”. The texture in terms of hardness/softness (8.5±8.4), taste (8.4±0.9), and aroma (7.6±1.5) acceptability rates were higher than their respective importance ratings, which indicated a positive gap, that

Table 7. Willingness-to-buy the BRICS based on price.

| Price Range (PhP) | % Willing to buy |
|-------------------|-----------------|
| 15 to 20          | 88              |
| 21 to 25          | 59              |
| 26 to 30          | 26              |
| 31 to 35          | 13              |

n=100.
these attributes exceeded what respondents expected from them.

Most of the consumers (88%) specified that they were willing to buy BRICS at PhP 15–20 per 50 g serving. However, fewer respondents were willing to buy the product if it costs higher than PhP 20 (Table 7).

**Discussion**

The main function of sweeteners is to increase the acceptance of ice cream by making it sweet and by enhancing the pleasing creamy flavor. Lack of sweetness produces a flat taste: too much tends to mask desirable flavors (11). Furthermore, it also plays an important role in producing the right texture. When an ice cream is consumed, the texture of the ice cream can either complement or detract the apparent flavor. Hence, the ice cream sample with the better texture is considered to have a better flavor (12). This is in correlation with the findings where increased acceptability in texture relatively increased the flavor acceptability of ice cream with 17% sugar. Significant differences were observed in the texture and sweetness of the samples because sugar affects the freezing point of the mix and sweetness intensity (Table 3).

In addition, one of the functional properties of sugar is that it lowers the freezing point of liquid and is primarily influenced by sweeteners (including the lactose in milk) and milk salts. Lowering the freezing point of an ice cream mix results in less crystal formation at a given temperature (10), which affects the texture and mouthfeel of the food. The texture of the ice cream improved with 17% sugar because of the absence of large crystals of ice. Small ice crystals have a positive effect on the sensation in the mouth.

BRF is a suitable replacement for wheat flour in the production of baked products like biscuits and crackers because it is a good source of functional components which provide health benefit beyond basic nutrition (13). Hence, it was utilized as a composite flour for cracker development. Acceptability results showed that the cracker of the ice cream sandwich can be substituted with up to 60% BRF. However, at this level some of the panelists noted a detectable grainy texture that shifted its acceptability to “like slightly” (Table 4). Hence, 50% was selected as the most acceptable BRF substitution level. Akubor and Ukwuru noted similar changes with soy and cassava flour in cookies (14). Thus, it can be suggested that replacement and/or substitution of all-purpose flour with BRF for cracker production and buffalo’s milk ice cream as complementary ingredients for ice cream sandwich is very feasible.

Based on the the Philippine recommended energy and nutrient intakes (RENI), a serving of BRICS can meet 26% carbohydrates, 3% calcium, 8% magnesium, 6% zinc and 5% iron of the daily requirement of a 13–15 y-old. A 50 g serving of BRICS can supply adults on 2000 calorie-diet with 8% calories. 27% carbohydrates, 4% calcium, 7% magnesium, 3% potassium, 8% zinc, and 8% iron. When compared to a famous ice cream sandwich brand in the Philippines, BRICS offers higher total energy (17%), calcium (94%), iron (67%) and thrice amount of fat. This can be attributed to the BRF and buffalo’s milk in BRICS, which has the nutrient-rich bran and has higher amount of calcium, respectively (Table 5). Buffalo milk has twice as more fat as cow’s milk which is responsible for its high energy value as reported by Varrichio et al. (15).

The acceptable macronutrient distribution range for fat is 15–30% among teenagers and adults. Based on a 2,000 kcal diet, it is recommended to consume 33–67 g of fat daily, which implied that BRICS contained low fat and can provide 12–24% of the suggested fat requirement. The World Health Organization (WHO) recommended a limiting sugar intake of 5% of the total calories which is equivalent to 25 g of sugar daily. Given that, BRICS was within the suggested sugar threshold, but for individuals who have diabetes and sugar restrictions, it should be consumed in moderation.

Protein and energy malnutrition, as well as iron deficiency anemia, remain as public health problems among young adults of the country. One and three out of 10 Filipino adolescents were wasted and stunted, respectively; and one out of 10 Filipino adults was chronic energy-deficient. Moreover, one out of 10 Filipinos were anemic or iron deficient (16, 17). BRICS is a complementary source of these nutrients and energy that supports the shortfalls of the diet.

As for marketability, consumer testing revealed high market potential for BRICS. For products to become marketable and competitive, consumer expectation must be met. In the case of BRICS, results showed that consumers put high expectation on the product as indicated by the high importance ratings. The top three attributes that consumers considered in buying this kind of product were taste, mouthfeel/texture, and aroma. These three sensory attributes are regarded as the basic indicators of food quality that affect consumer acceptance and the overall eating experience of a person—before, during, after an eating event (18).

In response to this expectation, BRICS managed to get high acceptability or degree of liking ratings. The sensory qualities of BRICS were rated positively by the respondents. The overall acceptability was also remarkably high. These imply that BRICS met consumers’ expectation.

In terms of BRICS’ likelihood of purchase by consumers, most of the respondents were willing to buy the product at PhP 15 to 20. In comparison, a commercial ice cream sandwich brand in the Philippines is sold at PhP 20.

In conclusion, BRICS is a highly acceptable and marketable frozen snack that can supply most key nutrients for improved diet among teenagers/adolescents and adults.

**Disclosure of State of COI**

No conflicts of interest to be declared.

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