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Development of Nutrient-Rich Squash (*Cucurbita maxima*) Jam to Address Micronutrient Deficiencies

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Abstract: This study aimed to develop and evaluate a nutrient-rich jam from squash (*Cucurbita maxima*) as a value-added food product to help address micronutrient deficiencies. Specifically, the research determined the proximate composition and nutritional content of the developed jam, including fat, ash, protein, carbohydrates, and selected minerals, using standard laboratory methods. Results revealed that the squash jam contains measurable amounts of essential nutrients contributing to its overall energy value. The product provides approximately 210 kcal per serving and contains fat, sodium, protein, carbohydrates, potassium, calcium, iron, and zinc within acceptable levels based on Recommended Energy and Nutrient Intake (RENI) and Daily Values (DV) for Filipinos. Findings indicate that squash jam can serve as a nutritious and acceptable food product suitable for children, adolescents, and adults. Its nutrient composition supports its potential as a functional food that may contribute to improved dietary intake, particularly in addressing micronutrient gaps. Furthermore, the product shows promise for further development and commercialization as a locally sourced, affordable, and nutritious food spread. However, additional studies on micronutrient bioavailability, shelf life, and consumer acceptability are recommended to fully establish its health benefits and market potential.

Keywords: *Squash Jam, Cucurbita Maxima, Proximate Analysis, Consumer Acceptability, Value-Added Food Product.*

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I. INTRODUCTION

Squash (*Cucurbita Maxima*) usually eaten fresh, cooked as vegetables or used as ingredients in pies, soups, sweets, marmalades, beverages and are also considered excellent sources of carotenoids (vitamin A), flavonoids, polyphenols, antioxidants and minerals, such as Ca, K, P, Zn and Fe (Rachel and Kabelka, 2009; Yadav et al., 2010) [1,2]. Ahmed et al. (2022)[3] investigated a comparative study of jam processing from pumpkin with sugarcane and pumpkin with date juice. The author stated that the chemical composition of the pumpkin and its antioxidant content makes it an important food product for human consumption. The carotenoids content in pumpkin vegetables give them their distinctive yellow - orange hue. In general, fruits and vegetables are very important healthy foods, as they provide the body with essential needs, such as vitamins, polyphenols, antioxidants, sterols, minerals and other substances that boost the immune system and prevent faster aging, cell damage and diseases (Dror and Allen, 2011; Chambial et al., 2013; Jones et al., 2018) [4,5,6].

In fact, polyphenols also play significant roles in keeping blood vessels flexible to provide excellent health, promoting blood and nutrient circulation throughout the body (Cory et al., 2018) [14]. Cory et al. (2018) [7] also stated that polyphenols have anticancer, anti-obesity and antioxidant functions. In addition, they reduce chronic swelling and regulate blood pressure and sugar in the human body.

According to the 2022 Global Nutrition Report the prevalence of stunting among children under five is 28.8% in the Philippines, which is higher than the Asian regional average of 21.8% [8]. Meanwhile, approximately one third of adults are overweight or obese [8]. Micronutrient deficiencies also persist, with an estimated 70 to 80% of adults not meeting the recommended nutrient intakes for many vital micronutrients, including iron, calcium, and vitamin A [9]. This coexistence of both over- and undernutrition is known as the double burden of malnutrition (DBM) and can occur at the population, household, and/or individual level [10]. Understanding the patterns and dynamics of malnutrition is crucial for developing effective intervention strategies [11].

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Studies of the DBM most frequently report on the coexistence of undernutrition and over nutrition at the population level [12]. DBM research in the Philippines is similarly population-level focused, with some recent work assessing individual-level DBM [13.14]. However, household-level manifestations of the DBM have not been widely studied in the Philippines. Hence this was conducted investigate the nutritional value and show that the squash is not used as a vegetable but can be made into other products like Jam that can be of great help for youth and children suffering from mineral, vitamin and energy deficiencies.

II. MATERIALS AND METHODS

➢ *Research Procedure*

The previous study involved the development of squash (*Cucurbita maxima*) jam using different formulations. The developed products were subjected to sensory evaluation to determine the most acceptable formulation in terms of appearance, flavor, texture, odor, and general acceptability. Based on the results, the best-performing formulation was identified and selected for further analysis. This selected formulation then underwent physicochemical and nutritional characterization in the present study to evaluate its quality and potential as a value-added food product.

➢ *Preparation of Squash Jams*

A total of 1.5 kilograms of mature squash was used in the study. The squash was peeled, deseeded, cut into strips, thoroughly washed, drained, and blended to obtain a uniform pulp. The blended squash was mixed with the following ingredients: 75% sugar, 15% vanilla, 5% lemon juice, and 4% salt. The mixture was cooked over moderate heat for approximately 30 minutes with continuous stirring until a homogeneous consistency was achieved. The finished product was then packed into sterilized glass jars, sealed, and properly labeled. All treatments were subjected to sensory evaluation, and the most acceptable formulation was selected for subsequent chemical and nutritional analyses conducted at the Department of Science and Technology (DOST) Regional Office V.

➢ *Proximate and Nutritional Analysis*

The selected squash jam sample was submitted to the Department of Science and Technology (DOST) Regional Office V, Legazpi City for laboratory analysis. The chemical properties of the product, including proximate composition (e.g., moisture, ash, fat, and protein), mineral content, and nutritional values, were determined using the TM-CHE-001 method with reference to AOAC 900.02A (21st Edition).

➢ *Statistical Analysis*

The data obtained from the sensory evaluation were analyzed using Analysis of Variance (ANOVA) to determine significant differences among treatments. All statistical tests were conducted at a 5% level of significance ($p < 0.05$).

III. RESULTS AND FINDINGS

➢ *Proximate Chemical Analysis of Squash (Cucurbita maxima) Jam*

Based on the results of the sensory evaluation, Treatments 2 to 5 were rated as acceptable, while Treatment 1 (T1) was identified as highly acceptable. Consequently, T1 was selected for further chemical and nutritional analyses. The analyses were conducted at the Department of Science and Technology Regional Office V (DOST V). The proximate composition of the squash jam is presented in Figure 1.

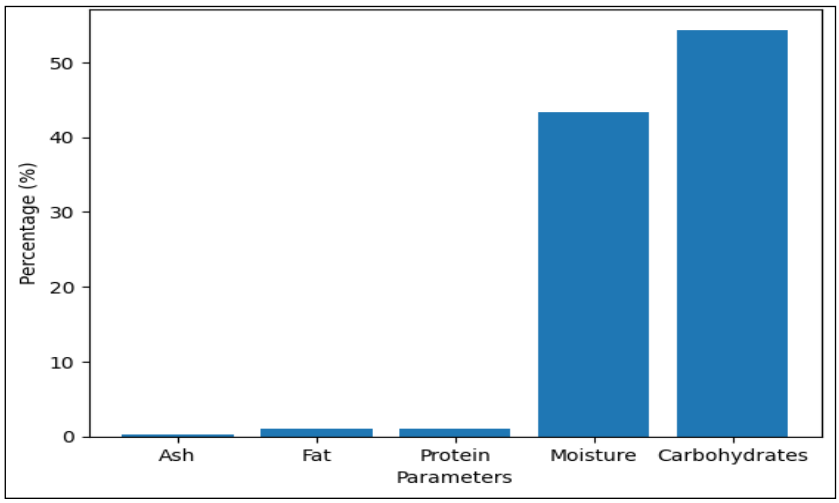

Fig 1. Proximate Chemical Analysis of Squash (*Cucurbita maxima*) Jam

Based on the results of the sensory evaluation, Treatments 2 to 5 were rated as acceptable, while Treatment 1 (T1) was identified as highly acceptable. Consequently, T1 was selected for further chemical and nutritional analyses. The analyses were conducted at the Department of Science and Technology Regional Office V (DOST V). The proximate composition of the squash jam is presented in Table 4.

The proximate composition of squash (*Cucurbita maxima*) jam revealed that carbohydrates (54.37%) constitute

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the highest proportion of the product. This finding is consistent with typical jam formulations, where high sugar content significantly contributes to total carbohydrate levels. Similar carbohydrate ranges (14–48 g/100 g) have been reported in fruit jams such as pineapple and jackfruit (Eke-Ejiofor & Owuno, 2013) [15]. The high carbohydrate content also explains the relatively elevated energy value of the product (231 kcal), indicating that squash jam can serve as a readily available energy source.

The moisture content (43.36%) observed in this study is comparable to previously reported values for fruit-based jams, such as roselle jam (33–34%) (Ashaye & Adeleke, 2009) [16]. Moisture content plays a crucial role in determining the shelf life and microbial stability of food products. According to Fellows (2000), lower moisture levels reduce water activity, thereby inhibiting microbial growth and extending shelf life. Similarly, Singh et al. (2007) emphasized that moisture content is a key factor influencing the storage stability of processed foods, including jams [17].

The protein content (0.97%) of squash jam is relatively low, which aligns with the findings of Eke-Ejiofor and Owuno (2013) [18], who reported low protein levels in pineapple (0.46 g/100 g) and jackfruit jam (0.19 g/100 g). This is expected because the primary ingredients used in jam production—fruit, sugar, pectin, and acidulants—are not significant sources of protein.

The fat content (1.05%) is slightly higher than values reported for other fruit jams such as apricot, strawberry, blueberry, and grape, which typically range from 0.1 to 0.2 g/100 g (Mohd Naeem et al., 2017) [19]. However, the fat content remains low overall, indicating that squash jam can still be classified as a low-fat food product.

The ash content (0.25%), which reflects the total mineral content, falls within the range reported for other fruit jams such as pineapple, jackfruit, and mango (0.15–0.49 g/100 g) (Eke-Ejiofor & Owuno, 2013)[20]. Comparable values have also been documented for apricot jam (0.2 g/100 g) (FSANZ, 2010; Sartaj et al., 2011) [20]. The relatively low ash content suggests that although squash jam contains minerals, it is not a major source of dietary minerals

- *Mineral Composition of Squash (Cucurbita maxima) Jam*

Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Table 1 Comparison of the Mineral Composition of Squash (*Cucurbita maxima*) Jam

Parameters	**Squash (Cucurbita maxima) Jam**	**Method Used**
Sodium (Na), mg/100g	38	TM-CHE-049 with reference to Agilent 4200 MP-AES Method
Potassium (K), mg/100g	88	TM-CHE-049 with reference to Agilent 4200 MP-AES Method
Calcium (Ca) , mg/100g	25	TM-CHE-049 with reference to Agilent 4200 MP-AES Method
Iron, (Fe) mg/100g	1.76	TM-CHE-049 with reference to Agilent 4200 MP-AES Method
Zinc (Zn), mg/100g	.56	TM-CHE-049 with reference to Agilent 4200 MP-AES Method
*Crude fiber	1.2	TM-CHE-001 with reference to AOAC 978.10, 21ST Ed.
*PH	4.75	TM-CHE-001 with reference to AOAC 981.12, 21ST Ed.

*Test not within the scope of accreditation

Table 1 presents the mineral composition of squash (*Cucurbita maxima*) jam analyzed using TM-CHE-049 based on the Agilent 4200 MP-AES method, while crude fiber and pH were determined using standard AOAC methods [24].

The results reveal that squash jam contains potassium (88 mg/100 g) as the most abundant mineral, followed by sodium (38 mg/100 g) and calcium (25 mg/100 g**)**. Potassium is an essential nutrient that contributes to fluid balance and proper muscle function (Whitney & Rolfes, 2019) [25]. The relatively high potassium content suggests that squash jam can serve as a modest source of this important mineral.

The iron (Fe) content (1.76 mg/100 g) observed in this study is higher compared to some fruit jams. According to Mohd Naeem et al. (2017)[26], fruit jams such as grape and apricot generally contain lower iron concentrations. This indicates that squash jam may provide a better contribution to dietary iron intake than commonly consumed fruit jams. In terms of sodium (Na) and potassium (K) content, the values obtained are higher than those reported for grape jam. Panceri et al. (2013) [27] found that grape jam contains only about 1–2 mg/100 g sodium. The higher sodium content in squash jam may be attributed to the addition of **sodium citrate** during processing, which acts as an acidity regulator and stabilizer (Desrosier & Desrosier, 2018) [28].

The zinc (Zn) content (0.56 mg/100 g) is relatively low, consistent with findings of Muchuweti et al. (2011)[29], who reported that fruit jams typically contain low zinc levels ranging from 0.10 to 0.30 mg/100 g. The low zinc content may be due to losses during thermal processing, as heat treatment can reduce mineral availability (Mohd Naeem et al., 2017)[26]. Furthermore, the squash jam exhibited crude fiber content of 1.2% and a pH level of 4.75.

The presence of crude fiber indicates retention of dietary fiber, which is beneficial for digestion and gastrointestinal health (Slavin, 2013) [30]. The pH value falls within the acceptable range for jams, contributing to microbial stability and extended shelf life (Fellows, 2017)[31]. Overall, the findings suggest that squash (*Cucurbita maxima*) jam is not only acceptable in sensory qualities but also contains beneficial minerals, particularly potassium and iron, making it a nutritious alternative to traditional fruit jams.

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➢ *Nutrition Facts of Squash (Cucurbita maxima) Jam*

Table 2 Nutrition Facts and % Daily Value of Squash (*Cucurbita maxima*) Jam

Nutrient	Amount per Serving	% Daily Value*
Calories	210 kcal	—
Total Fat	2.5 g	1%
Sodium	60 mg	2%
Total Carbohydrates	20 g	18%
Protein	0 g	0%
Calcium	23 mg	2%
Potassium	80 mg	2%
Iron	2 mg	10%
Zinc	1 mg	10%

*****Percent Daily Values (DV) are based on a 2,000 kcal diet. Nutrition Facts: Servings per container: 4, Serving size: ½ cup (91 g)

Table 2 presents the computed Nutrition Facts and corresponding % Daily Value (%DV) of squash (*Cucurbita maxima*) jam. The product contains four servings per container, with each serving equivalent to ½ cup (91 g) and providing 210 calories per serving. This indicates that consuming the entire container would result in a total caloric intake of 840 calories**.** Caloric intake recommendations vary depending on age, sex, and activity level. On average, adult women require approximately 2,000 calories per day**,** while men require about 2,500 calories per day to maintain body weight. Lower caloric intake is recommended for weight loss (Osilla et al., 2022) [35]. Based on these recommendations, a single serving of squash jam contributes a moderate amount of energy to the daily requirement. However, since jam is typically consumed in small portions as a spread or dessert, it is unlikely that the entire container will be consumed in one sitting. Thus, squash jam may serve as a supplementary energy source rather than a primary food item.

In terms of macronutrients, the product contains 2.5 g of fat (1% DV)**,** 60 mg sodium (2% DV)**,** 20 g carbohydrates (18% DV)**,** and 0 g protein (0% DV)**.** The relatively low fat and sodium content suggests that the product can be incorporated into a balanced diet when consumed in moderation. The carbohydrate content, primarily from sugars, contributes significantly to the caloric value of the jam, which is typical for fruit-based preserves (Fellows, 2017) [32]. For micronutrients, the jam provides iron (2 mg, 10% DV) and zinc (1 mg, 10% DV)**,** while calcium (23 mg) and potassium (80 mg**)** contribute negligible percentages to the daily value. The presence of iron and zinc, even at moderate levels, indicates that squash jam may contribute to meeting essential mineral requirements, particularly in populations at risk of micronutrient deficiencies (Whitney & Rolfes, 2019) [26]. Overall, the %DV values of fat, sodium, carbohydrates, iron, and zinc fall within acceptable limits, suggesting that squash jam can be recommended as a supplementary food for both male and female diets when consumed appropriately.

➢ *Nutritional Analysis (%RENI) of Squash (*Cucurbita maxima*) Jam*

The Recommended Energy and Nutrient Intakes (RENI) is a set of guidelines developed by the Food and Nutrition Research Institute under the Department of Science and Technology. It serves as a reference for the daily intake of energy and essential nutrients necessary to maintain health and well-being among Filipinos. The RENI system replaced the earlier Recommended Dietary Allowances (RDA) and provides updated recommendations for energy and 21 essential nutrients, including protein, calcium, iron, and zinc. According to FNRI-DOST (2002) [36], RENI represents the levels of nutrient intake considered sufficient to meet the nutritional needs of nearly all healthy individuals in the population.

In this study, the nutritional contribution of squash jam can be evaluated in relation to RENI values. While the product provides modest amounts of energy and certain micronutrients such as iron and zinc, it does not significantly contribute to protein and some mineral requirements. Therefore, squash jam should not be considered a primary source of nutrients but rather a complementary or supplemental food that can enhance overall dietary intake when combined with other nutrient-dense foods.

Table 3 Nutrition Facts Computation (%RENI) of Squash (*Cucurbita maxima*) Jam

Nutrient	Amount per Serving	RENI	%RENI
Energy	210 kcal	2400 kcal	9%
Fat	1 g	67 g	1%
Sodium	34 mg	1500 mg	2%
Potassium	80 mg	2000 mg	4%
Carbohydrates	49 g	130 g	38%
Protein	0 g	71 g	0%
Calcium	23 mg	750 mg	3%
Iron	2 mg	12 mg	17%
Zinc	1 mg	11 mg	9%

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Table 3 presents the computed percent Recommended Energy and Nutrient Intake (%RENI) of squash (*Cucurbita maxima*) jam per serving (½ cup or 30 g), based on the Philippine Dietary Reference Intakes (PDRI) 2002 for male adults aged 19–29 years [37].

The results show that each serving of squash jam provides approximately 210 kcal, contributing about 8% of the RENI for daily energy requirements. Energy intake is essential for maintaining body functions and supporting daily physical activities, and foods such as jams contribute primarily through carbohydrates (FNRI-DOST, 2002) [36].

In terms of macronutrients, the jam contains 1 g of fat**,** 49 g of carbohydrates**,** and negligible protein. The %RENI contribution of these nutrients remains relatively low, indicating that squash jam is not a significant source of macronutrients except for carbohydrates, which are the primary contributors to its caloric value (Whitney & Rolfes, 2019)[26].

For micronutrients, the product provides calcium (23 mg)**,** iron (2 mg)**,** and zinc (1 mg**)**, contributing approximately 3%, 17%, and 16% RENI**,** respectively. These values suggest that while squash jam is not a major source of most minerals, it can contribute modestly to iron and zinc intake. Iron is particularly important for oxygen transport in the blood, while zinc supports immune function and cellular metabolism (Whitney & Rolfes, 2019)[26].

Despite all nutrient contributions being below the recommended daily intake, it is important to interpret these findings with caution. While the relatively low %RENI values indicate that the product does not exceed recommended nutrient limits, this does not necessarily mean that consuming one full container per day is advisable**.** Jams are typically high in sugars and are intended to be consumed in moderation as part of a balanced diet (Fellows, 2017) [32].

Therefore, squash (*Cucurbita maxima*) jam can be considered a supplementary food product that contributes to daily energy and micronutrient intake, particularly iron and zinc. However, it should be consumed alongside other nutrient-dense foods to ensure a well-balanced diet rather than as a primary food source.

- *Comparative Analysis of %RENI for Male and Female (19–29 years old) of Squash (*Cucurbita maxima*) Jam*

Table 4 Computed %RENI of Squash (*Cucurbita maxima*) Jam (Per Serving: 30 g)

Nutrient	**Amount**	**Male (19–29 yrs.) RENI**	**%RENI (Male)**	**Female (19–29 yrs) RENI**	**%RENI (Female)**
Energy (kcal)	210	2500 kcal	**8%**	2000 kcal	**11%**
Total Fat (g)	1	67 g	**1%**	55 g	**2%**
Sodium (mg)	34	1500 mg	**2%**	1500 mg	**2%**
Potassium (mg)	80	3400 mg	**2%**	2600 mg	**3%**
Carbohydrates (g)	49	300 g	**16%**	260 g	**19%**
Calcium (mg)	23	750 mg	**3%**	750 mg	**3%**
Iron (mg)	2	12 mg	**17%**	28 mg	**7%**
Zinc (mg)	1	5 mg	**20%**	4 mg	**25%**

The percent Recommended Energy and Nutrient Intake (%RENI) of squash (*Cucurbita maxima*) jam was computed based on the Philippine Dietary Reference Intakes (PDRI, 2002) [37] developed by the Food and Nutrition Research Institute under the Department of Science and Technology. The analysis provides insight into how the product contributes to the nutritional requirements of both male and female adults.

In terms of energy contribution, squash jam provides approximately 9% RENI for males and **11%** RENI for females per serving. The slightly higher percentage in females is due to their lower daily energy requirement (2,000 kcal) compared to males (2,400 kcal). This indicates that the pr4oduct can serve as a moderate source of dietary energy, primarily derived from carbohydrates.

For macronutrients, both male and female groups show **low** %RENI for fat (1–2%) and protein (0%), while carbohydrates contribute the highest %RENI at approximately 38%. This confirms that squash jam is an energy-dense, carbohydrate-rich food, which is typical of jam products due to their high sugar content (Fellows, 2017) [32]. However, the negligible protein content suggests that it cannot support body-building or tissue repair functions, emphasizing the need to pair it with protein-rich foods. With regard to micronutrients, the product contributes modestly to mineral intake. The iron content provides about 17% RENI for males but only 7% for females. This difference is attributed to the significantly higher iron requirement in females due to physiological factors such as menstruation (Whitney & Rolfes, 2019)[26]. Similarly, zinc contributes around 9% RENI for males and 13% for females, indicating a slightly better contribution to female dietary needs. Meanwhile, calcium contribution remains low (about 3% for both groups), suggesting that squash jam is not a significant source of bone-supporting nutrients.

For sodium and potassium, both groups receive minimal contributions (approximately 2–4% RENI), indicating that the product does not pose a risk of excessive sodium intake when consumed in moderation. This is beneficial in maintaining cardiovascular health, as excessive sodium consumption is linked to hypertension (World Health Organization, 2012) [38].

Overall, the comparative analysis shows that squash (*Cucurbita maxima*) jam contributes moderate energy and carbohydrate intake, with notable but limited contributions to iron and zinc, particularly for males. However, its low protein and calcium content indicate that it should not be considered a

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primary nutrient source. Instead, it is best classified as a supplementary food product that can enhance energy intake and provide some micronutrients when incorporated into a balanced diet.

- *Integrated Nutritional Analysis (%DV and %RENI) of Squash (Cucurbita maxima) Jam*

Nutritional evaluation using both Percentage Daily Value (%DV) and Recommended Energy and Nutrient Intake (%RENI) provides a comprehensive assessment of the contribution of squash (*Cucurbita maxima*) jam to dietary requirements at both international and national levels. While %DV is widely used in food labeling to guide general consumer choices, %RENI—developed by the Food and Nutrition Research Institute—offers a more localized benchmark tailored to the nutritional needs of the Filipino population.

The results indicate that squash jam is primarily an energy-dense, carbohydrate-rich product, providing approximately 210 kcal per serving, which corresponds to about 8% of RENI and a moderate proportion of daily caloric intake. This highlights its potential role as a supplementary energy source, particularly for individuals with increased caloric requirements. The carbohydrate content further supports this function, contributing significantly to both %DV and %RENI, consistent with the formulation of jam products that rely heavily on added sugars.

From a micronutrient perspective, both %DV and %RENI analyses consistently demonstrate that squash jam provides notable contributions to iron and zinc intake, with values reaching approximately 10% DV and 16% RENI per serving. These findings are nutritionally significant, as iron and zinc are essential for physiological processes such as oxygen transport, immune response, and cellular metabolism. The relatively higher contribution of these minerals suggests that squash jam may offer added nutritional value compared to conventional fruit jams, particularly in addressing micronutrient deficiencies.

In contrast, nutrients such as calcium, potassium, sodium, fat, and protein contribute only minimal percentages to both %DV and %RENI. While this indicates that squash jam is not a major source of these nutrients, the low fat and sodium content is advantageous from a public health perspective, as it aligns with dietary recommendations to limit excessive intake of these components.

Importantly, the differences between %DV and %RENI values reflect variations in reference standards and population-specific requirements. While %DV is based on a generalized 2,000 kcal diet, %RENI accounts for age- and sex-specific nutrient needs, providing a more precise evaluation within the Philippine context. Despite these differences, both approaches consistently indicate that squash jam contributes moderately to energy and selected micronutrients, but does not independently meet daily nutritional requirements.

IV. CONCLUSION

The proximate analysis revealed that squash jam is primarily composed of carbohydrates (54.37%) and moisture (43.36%), with minimal amounts of protein (0.97%), fat (1.05%), and ash (0.25%). These results confirm that the product is energy-dense and consistent with the typical composition of fruit-based jams. The moderate moisture content suggests acceptable shelf stability, while the low fat content supports its suitability for general consumption.

Mineral analysis showed that squash jam contains potassium, sodium, calcium, iron, and zinc, with relatively higher levels of potassium and iron compared to some conventional fruit jams. The presence of these minerals, particularly iron and zinc, enhances the nutritional value of the product. The nutritional evaluation using both %Daily Value (DV) and %Recommended Energy and Nutrient Intake (RENI) demonstrated that squash jam provides a moderate contribution to energy intake and notable contributions to iron and zinc requirements. However, its contribution to other nutrients such as calcium, protein, and potassium remains limited. These findings indicate that squash jam functions as a supplementary food product rather than a primary source of essential nutrients.

Overall, squash (*Cucurbita maxima*) jam can be considered a nutritionally acceptable and functional food product, with potential to contribute to energy intake and selected micronutrient requirements, particularly in populations at risk of nutrient deficiencies.

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