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Effect of Sugar Substitution with Date Palm on the Quality of Mango Fruit Jam

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Abstract
Jam is a food product prepared by boiling fruit pulp with sugar, pectin, acid and other ingredients. This study aims to determine the effects of sugar substitution with date palms on the quality of mango fruit jam. Ten (10) kilograms of matured mango fruits were washed properly; peeled, sliced and pulped using an electric blender to get mango puree. The samples were analyzed for proximate composition, mineral, pH and sensory properties. Sample MJ0 had the highest moisture content (37.57%) while the Ash content of jam samples was 1.03 % to 2.40 % with sample MJ4 as the highest (2.40 %) while the fat content recorded 0.92% for sampleMJ4 as the highest value. Sample MJ4 had the highest value (3.91%) for protein content while sample MJ0had the SampleMJ4had the highest value (3.11%) for fibre while Sample MJ4 had the highest carbohydrate content (57.86 %). Calcium content was higher in sample MJ0 (4.675) while Iron content in the samples was significantly higher in sample MJ1 (3.296) and sample MJ3 (7.21) was highest in magnesium. Ascorbic acid content increased in the range of 0.214 – 0.269 from sample MJ0 to MJ4. The mean acidity value increased from 0.112mg/100g to 0.167mg/100g as the sugar replacement increased from MJ0 to MJ4. However, the PH ranges from 2.92 to 3.31 as sample MJ4 recorded the highest pH while MJ0 recorded the lowest. MJ0 was reported excellent in consistency, appearance (8.1±O.1.4), overall acceptability (8.1±O.1.3) and mouthfeel (7.4±1.3), compared to the rest of the samples
Keywords: fruits, jam, vitamins, minerals, proximate, sugar substitute, and total soluble solid

Introduction

Jam is a semi-solid food product, prepared by boiling fruits or vegetable pulp with sugar, citric acid and pectin (Melaku, 2021). The principle of jam-making is the boiling of suitable prepared fruit, sugar and water at an acidic pH of 3-3.5. The proportion of the fruit to sugar is usually within the range of 45% to 55% respectively (Ullah *et al.,* 2018). The effect of high sugar concentration tends to make the moisture unavailable for the multiplication of micro-organisms (especially bacteria) thereby inhibiting their growth, hence extending the shelf life of jam (Rawat, 2015). Jams are of varying varieties which differ from each other owning to the raw material used; method of processing and additives used, the jam can be classified into: Jam, Preserves, Jellies and Dietetic jellies, and it can be classified into solid, semi-solid and liquid jam according to their textures (Rawat, 2015).

Mango is an edible fruit derived from the tropical tree *Mangifera indica*. It is called the king of fruits, It is indigenous to southern Asia and consists of various tropical fruiting trees in the flowering plant family *Anacardiaceae* (Kathy, 2021). Mangoes are nutritious fruits which contain proteins, fats, fibre, minerals, and vitamins, in particular, vitamin A (beta carotene), vitamin B1, vitamin B2, and vitamin C (ascorbic acid), and most especially phenolic compounds (Kathy, 2021). Mango fruits are very much loved for their exotic flavour and delicious taste. Mango serves as a cash crop and as a subsistence crop for family farms. Mango can be processed into various products e.g. puree, dried products, squash, canned slices and jams(Singh *et al*., 2005 Koubala *et al*., 2008).

Date palm (*Phoenix dactylifera*) is one of the oldest cultivated trees in the world (Phoenix dactylifera, 2017). However, it's a plant species in the family, *Arecaceae,* cultivated for its edible sweet fruits "dates". It is mostly planted across northern Africa, the Middle East and South Asia ("Plants of the world online, 2023"). Date fruit contains 44.88% sugar, fat (0.2-0.5%) minerals such as potassium (2.5 times more than bananas) magnesium, calcium and iron, protein 2.35.6%), dietary fibre (6.4-11.5%) as well as vitamin and amino acid (Al-Shahib and Marshall, 2003). In various ways, dates may be considered as an almost perfect food and provide a wide range of essential nutrients and potential health

benefits (Makanjuola and Alokun, 2019). Data consumption is very high during the Islamic Holy month of fasting. Dates are used in the production of sweets, confectionery, chocolates, baking products, preservatives, salads, sauces, and breakfast cereals (Besbes*et al.*, 2009). Dates also have numerous benefits to food industries (PHDEB, 2008). Therefore; this work is aimed at evaluating the effect of sugar replaced with date palm on the quality of mango fruit jam

Material and Method

Collection of raw materials

Ten (10) kilograms of mango fruits and three (3) kilograms of date fruits were obtained from the Dutsin-ma Wednesday market, while the sugar, pectin, and citric acid used for jam processing was obtained from Dutsin-ma supermarket located at Dutsin-ma local government of Katsina State. Analytical grade reagents were used for analysis.

Sample Preparation

The mango fruit jam samples MJ, MJ1, MJ2, MJ3 and MJ4 were prepared from the mango fruit as shown in the formulation table below:

First, 10 kg of the mango fruit was obtained from the Dutsin-ma market. The mangos were taken to the laboratory. The fruits were hygienically washed using running tap water; peeled, sliced and pulped using a food processor. The puree was prepared using the appropriate proportion of mango puree, sugar and date palm and was mixed in a stainless-steel pan. The mixtures were heated and stirred under a low-flame gas cooker. One (1%) citric acid was added when the mixture reached a TSS of 60°Brix. The heating was stopped when the TSS of the concentrate got to 67-68°Brix. Finally, the hot prepared jam was filled in sterilized glass jars.

Proximate Composition

The proximate composition was determined on the jam samples for moisture, fibre, fat, ash, and protein according to the method as postulated by the Association of Official Analytical Chemists (AOAC, 2012).

Determination of Minerals and Vitamins

Vitamin C content was determined by high-performance liquid chromatography. Calcium (Ca) and Magnesium (Mg) contents were investigated using an Atomic Absorption Spectrophotometer (210 VGP model). Sodium (Na) and Potassium (K) levels were also assayed using the Flame Photometric Method while the Phosphorus (P) level was determined colourimetrically using the Vanadomolybdate method (Kitson& Mellon, 1944).

Determination of pH value

The jam pH was evaluated using a glass electrode pH meter at room temperature.

Determination of Total Soluble Solids (TSS)

T.S.S. of mango jam was measured with the aid of a hand refractometer at (20ºC); the result was expressed as (%) or degree Brix.

Determination of Total Titrable Acidity

Total titrable acidity was determined according to the AOAC (2016) method.

Sensory Evaluation

A sensory evaluation of prepared mango jams was conducted. The prepared jam was kept refrigerated at 12°C and ambient temperature for 24 hours before the sensory evaluation. The colour, taste, aroma and overall acceptability were assessed by 20 semi-trained panelists which included staff and students of Federal University Dutsin-ma. Each panellist receives the coded samples of the mango jam and also a slice of bread to assay. Bread was used as a carrier since jam is normally consumed with bread. A 9-point Hedonic scale as described by Iwe, (2002) was used to analyze the sensory evaluation.

Statistical Analysis

All the data obtained were subjected to one-way analysis of variance (ANOVA) at a 5 % level of significance using SPSS version 20.0 and the results were presented as mean ± standard deviation.

Result and Discussion

Proximate Analysis

The moisture content of the samples runs from 37.57% to 32.04 % with sample MJ0 as the highest (37.57%) while sample MJ4 (32.04%) was the lowest. The moisture content of the samples decreased significantly ($p < 0.05$) with an increase in the substitution of sugar with dates. The reduction in moisture content could be a result of the heating process employed and also the number of date palms used for substitution. The moisture content reported in this research is lower than that reported in Adewole *et al*. (2022), who reported that the moisture content of jam produced from apple and banana blends ranged from 40. 32 to 45.20 % and that variation in moisture content could be as a result of boiling temperature and ingredients used. The moisture content of samples helps in suggesting the shelf life of the product as foods with low moist content tend to have longer shelf-life than those with higher moisture content (Agomuo *et al.,* 2022). The Ash content of the samples ranges from 1.03 to 2.40% with sample MJ4 having the highest ash content (2.40%) and MJ0 (1.03 %.) lowest. The ash content of the jam samples improved significantly ($p < 0.05$) with an addition in the level of substitution. The Ash content in this study is greater than that of Monika *et al*. (2018) who recorded that the ash content of jam ranges from 0.32 to 0.34%. Ash content gives a fraction of the mineral present in the food sample. The fat content of jam samples ranged from 0.16 to 0.92%, where samples MJ4 and MJ0 recorded the highest (0.92%) and the lowest (0.16%) values correspondingly. The result obtained in this study is lower than that obtained from the jam by Olugbenga *et al.* (2018), who reported that the fat content varies from 0.25 to 3.85%. The protein content of the jam sample ranges from 3.46 to 3.91%, with sample MJ4 as the highest (3.91%) while MJ0 was the lowest (3.46%). The values for protein improved significantly ($p < 0.05$) as the substitution with date increased; the same increase in

protein content was reported by Nwanekezi *et al.,* (2015) who reported an increase in protein content of bread sample with substitution of sucrose with dates. The protein content in this study is also elevated than that reported in Adewole *et al.,* (2022) which was in the range of 0.26 to 0.69 with an increase in blends of banana and apple. The fibre content values ranged from 1.51% to 3.11% with sample MJ4 as the highest (3.11%), and MJ1 (1.51%) as the lowest. This work is similar to that recorded by Olugbenga *et al.* (2018) where the fibre content of jam prepared from a combination of pineapple, banana and watermelon was in the range of 1.25- 3.03% but is not in line with Naeem *et al.* (2017) which recorded 0.09 – 0.54 % for the crude fibre content of different fruit jams. The carbohydrate content value ranged from 54.35 to 57.86 % with sample MJ0 as the highest (57.86 %) while MJ4 had the lowest 54.35%. the values for carbohydrates decreased with an increase in the level of substitution. Similar reports were given by Adegbanke*et al.,* (2022) that carbohydrate content ranged from 41.08 to 70.44 % with an increase in blending and enrichment with date powder.

Physicochemical characteristics

The total titratable acidity (TTA pH and the Soluble Solids (TSS) of the jam samples (MJ0,
MJ1, MJ2, MJ3 and MJ4) are presented in Table 3.

Titratable acidity

The mean acidity runs from 0.112mg/100g to 0.167mg/100g with an increase in the level of substitution with date. This increase in acidity could be attributed to the formation of organic acids due to the denaturation of polysaccharides and the breaking of pectic bodies. This result agrees with the findings of Wasif *et al.* (2015) who observed the same trend in acidity of apple and olive blended jam. However, the pH ranges from 2.92 to 3.31 as sample MJ4 recorded the highest pH while MJ0 recorded the lowest PH value with the results depicting significant ($P \leq 0.05$) differences among the pH of the samples. The values for pH show that the jam samples can stay for a long since most spoilage organisms cannot thrive under low pH. The outcomes of these findings did not correlate with the reports of Inam *et al*. (2012) for mixed fruit marmalade, Sindumathi and Amutha (2014) for coconut-based jam and also that reported by Wasif *et al.* (2015), who recorded a decline in pH of apple and olive fruit blended jam. The maximum T.S.S. was accounted for by jam sample MJ4 (72.15ºBrix) and Jam sample MJ0 recorded the lowest (67.67ºBrix). This outcome showed a significant ($P \leq 0.05$) increase among the samples as the level of substitution increased. This increase in total solid could be attributed to the percentage of date powder added to substitute for sugar. An incessant increase in TSS of the jam was testified by some researchers including Sindumathi and Amutha's (2014) coconut-based jam, and Patel *et al*. (2015) banana - pineapple blended jam.

Micronutrient composition

The micronutrient composition of the jam samples presented in Table 4 illustrated that the Calcium (Ca) content was higher in sample MJ0(4.675), followed by sample MJ1 with a Calcium content of 4.51, sample MJ2 with a value of 4.537 and sample MJ3 with the value of 3.148. Calcium content was lowest in sample MJ4 (3.105). These results presented a significant ($P \leq 0.05$) decline in the content of calcium in the mango jam samples as the level of substitution increased. Calcium is associated with physiological improvement of teeth, muscles and bones; it is also connected with vitamin D metabolism (NIH, 2022). Iron (Fe) content in the samples was significantly highest in sample MJ1 (3.296) and lowest in sample MJ0 (1.851). The samples MJ4, MJ3 and MJ2 were 2.786, 2.779 and 2.430 respectively. At a significant level of $p<0.05$MJ, MJ3 and MJ4 each were different from all of the samples while MJ2 and MJ0 were significantly different from MJ2. Iron is said to be highly recent in date (Assirey, 2015). Magnesium (Mg) composition in the samples was highest in sample MJ3 (7.211) followed by MJ2 (6.72), MJ1 (5.858), MJ0 (5.056) and MJ4 (4.125) recorded the lowest. The inclusion of date sugar also facilitated the increase in the magnesium content of the jam samples. This is because the date has a high level of magnesium content (Ayad *et al*., 2020). The ascorbic acid (vitamin C) content of the jam showed that samples MJ3 and MJ2 were the highest with the values 0.269 and 0.268 respectively others MJ1, MJ4and MJ0 had values of 0.223, 0.217 and 0.214 respectively. Ascorbic acid is an unstable and heat-labile vitamin; it lessens in the product during storage and heating. Ascorbic acid is influenced by oxidation during processing and storage (Ullah *et al*., 2018).

Sensory Evaluation

Table 5 presents the values for the sensory evaluation of mango jam. Sample MJ0 recorded the highest values for appearance (8.1±O.1.4), overall acceptability (8.1±O.1.3) and mouthfeel (7.4±1.3), for taste and aroma, sample MJ2 had the highest score (8.0±0.9) and (7.5±1.0) respectively. However, sample MJ4 had the lowest values for taste (6.6±1.7), aroma (6.0±1.5), mouthfeel (6.1±1.6), appearance (5.9±1.4) and overall acceptability (5.4±1.9). There were significant ($P< 0.05$) reductions in taste, aroma mouth feel appearance and overall acceptability within all the samples of jams products, the sample MJ0 (Control) had excellent consistency, appearance (8.1±O.1.4), overall acceptability (8.1±O.1.3) and mouthfeel (7.4±1.3), compared to the rest of samples while sample MJ2 was recorded the best with the highest score (8.0±O.9) and (7.5±1.0), (7.6±0.516) respectively in taste, taste aroma and appearance. Generally, the minimum scores were recorded by sample MJ4 while samples MJ0 and MJ2 were highly accepted. The level of substitution accepted by consumers was 35 % sugar and 20 % dates.

Conclusion

The use of sucrose date palm in the manufacture of mango jam was shown to be satisfactory, which gives a product with jam characteristics and with taste and flavour comparable to conventional jam with low-calorie value. The partial substitution of sugar in mango

jam using date palm improved the taste, nutrient content and acceptability in the sample replaced with 20% date. A sample with a date concentration of 20% had a good result. An increase in date concentration caused a gradual increase in acidity increased, acid TSS and pH of the samples. The moisture content of the samples declined with the increase in date palm concentration but the Ash, lipid and protein content increased as the date concentration increased.

Recommendations

The mango characteristics should be monitored and measured during processing. So that if there is any problem is discovered, it can be quickly detected, and the process will be adjusted to compensate for it.

More research be carried out to improve the texture and appearance attributes of low-calorie jam.

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Table 1: Sugar replacement concentration

Sample	Sugar Replacement concentration	
	Sugar	**Date Palm**
MJ	55%	Control
MJ1	45%	10%
MJ2	35%	20%
MJ3	25%	30%
MJ4	15%	40%

MJ0= (control) 55% sugar, 0 % date; MJ1= 45% sugar, 10% date; MJ2= 35% sugar, 20% date; MJ3= 25 % sugar, 30% dates; MJ4= 15% sugar, 40 % date

Table 2: Proximate composition of jam samples (mg/100g)

	Moisture (%)	Ash (%)	Fat (%)	Proteins (%)	Fiber (%)	CHO (%)
MJ0	37.57±0.31^{c,d,e}	1.03±0.06*	0.16±0.00^{b,c}	3.46±0.006*	2.31±0.01*	57.86±0.01*
MJ1	36.47±0.21^{d,e}	1.42±0.02*	0.61±0.01*	3.65±0.011*	1.51±0.10*	57.45±0.07^{a,c,d,e}
MJ2	36.08±0.12^{a,e}	1.61±0.01*	0.72±0.01*	3.66±0.000*	1.82±0.02*	57.39±0.01^{a,c,d,e}
MJ3	35.57±0.16^{a,b,e}	1.94±0.01*	0.82±0.00^{b,c}	3.70±0.006*	2.09±0.01*	56.91±0.02*
MJ4	32.04±0.12*	2.40±0.01*	0.92±0.00^{b,c}	3.91±0.010*	3.11±0.01*	54.35±0.35*

Values having different alphabetical letters in a row/column are significantly different (p<0.05). The values are expressed a s the mean ±SD of 3 replicates. MJ0= (control) 55% sugar, 0 % date; MJ1= 45% sugar, 10% date; MJ2= 35% sugar, 20% date; MJ3= 25 % sugar, 30% dates; MJ4= 15% sugar, 40 % date

Table 3: Physicochemical characteristics of the jam Samples

Sample	TTA(mg/100g)	pH	T.S.S (%)
MJ0	0.112±0.008^{d,e}	2.92±0.015*	67.67±0.577
MJ1	0.153±0.021	3.19±0.010^{a}	69.37±0.321^{d,e}
MJ2	0.133±0.010^{e}	3.17±0.115^{a}	70.13±0.231^{d,e}
MJ3	0.153±0.006^{a}	3.27±0.015^{a,b,c}	71.40±0.346^{a,b,c}
MJ4	0.167±0.003^{a,c}	3.31±0.012^{a,b,c}	72.15±0.208^{a,b,c}

Values having different alphabetical letters in a row/column are significantly different (p<0.05). The values are expressed as the mean ±SD of 3 replicates.MJ0= (control) 55% sugar, 0 % date; MJ1= 45% sugar, 10% date; MJ2= 35% sugar, 20% date; MJ3= 25 % sugar, 30% dates; MJ4= 15% sugar, 40 % date

Table 4: Micronutrient composition of the jam samples

	MJ0	MJ1	MJ2	MJ3	MJ4
Ca	4.675±0.005*	4.510±0.001*	4.537±0.001*	3.418±0.001^{b,c}	3.105±0.006*
Fe	1.851±0.001^{c}	3.296±0.002*	2.430±0.001^{c}	2.779±0.001*	2.786±0.001*
Mg	5.056±0.001*	5.858±0.001	6.720±0.001*	7.211±0.001	4.125±0.001*
Ascorbic Acid	0.214±0.004^{c,d}	0.223±0.006^{c,d}	0.268±0.001^{a,b,d}	0.269±0.001^{a,b,d}	0.217±0.001^{c,d}

Values having different alphabetical letters in a row/column are significantly different (p<0.05). The values are expressed a s the mean ±SD of 3 replicates.MJ0= (control) 55% sugar, 0 % date; MJ1= 45% sugar, 10% date; MJ2= 35% sugar, 20% date; MJ3= 25 % sugar, 30% dates; MJ4= 15% sugar, 40 % date

Table 5: Sensory Evaluation of the Jam samples

Samples	Taste	Aroma	Mouth Feel	Appearance	Overall Acceptability
MJ0	7.9±1.7	7.3±1.3^{e}	7.4±1.3^{e}	8.1±1.4^{b,d,e}	8.1±1.3^{e}
MJ1	7.8±1.1^{e}	7.3±1.6^{e}	7.1±1.5	7.1±1.1^{a,e}	7.4±1.5^{e}
MJ2	8.0±0.9^{e}	7.5±1.0^{e}	7.3±1.6	7.5±1.4^{e}	7.5±1.3^{e}
MJ3	7.2±1.5	6.8±1.4	7.0±1.4	6.7±1.2^{a}	7.2±1.5^{e}
MJ4	6.6±1.7b,^{c}	6.0±1.5^{a,b,c}	6.1±1.6^{a}	5.9±1.4^{a,b,c}	5.4±1.9*

Values with different alphabetical letters in a row/column are significantly different (p<0.05). The values are expressed as the mean ±SD. MJ0= (control) 55% sugar, 0 % date; MJ1= 45% sugar, 10% date; MJ2= 35% sugar, 20% date; MJ3= 25 % sugar, 30% dates; MJ4= 15% sugar, 40 % date