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Effect of sucrose substitution with date syrup on the physicochemical properties of the dough and bread

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Abstract
The effect of sucrose substitution with date syrup on the physicochemical properties of the dough and bread were investigated. Sucrose (50 g) was substituted with 0, 5, 10, 15, 20 and 25 g of date syrup (DS). Established procedures and analytical methods were used for chemical, physical and alveograph as well as organoleptic properties analyses. The results of proximate composition (%) showed that fibre and ash increased significantly (p<0.05) from 0.31 – 4.57 and 1.43 – 1.56, respectively, while moisture and protein decreased from 34.76 – 21.46 and 16.27 and 14.95, respectively. The calcium, phosphorus, sodium, potassium and magnesium respectively increased from 2.24 – 2.97, 0.06 – 1.66, 0.09 – 6.29, 0.04 – 9.04 and 0.95 – 1.40. The loaf volume (cm^3) and specific loaf volume (cm^3/g) decreased from 1850 – 1525 and 4.65 – 3.96, respectively. The alveograph properties in terms of tenacity (P) increased from 97.25 – 128.60 mm, extensibility (L) from 98.05 – 101.20 mm and distortion (P/L) from 0.95 – 1.27. The sensory properties of DS bread compared favourably with the control. The substitution of sucrose with DS improved the fibre, ash, mineral content as well as alveograph properties of the dough. Substitution of sucrose with up to 25 g DS in the production of bread is recommended.

Keywords: proximate, mineral, alveograph, physical and organoleptic

Introduction
Bread is considered a popular staple food consumed as part of the daily diet worldwide (Wandersleben *et al*., 2018 [1]. It is made from cereal grains (mostly commonly wheat) ground into flour, moistened and kneaded into a dough and then baked. Often leavened by the action of bakers yeasts or by addition of sodium bicarbonate. Some researchers (Nwanekezi *et al*., 2015) [2] have reported that bread is a food product that is universally accepted and very convenient form of food that has desirability of all population, rich and poor, rural and urban. The researchers also stated that in Nigeria, bread has become the second most widely consumed and non-indigenous food product after rice and has become an important source of food to Nigerians.

Reports have it that increased consumption of foods and beverages containing added sugars may be majorly responsible for the rising rates of obesity amongst the prospective consumers (Sengev and Oguche, 2017) [3]. The authors further explained that added sugars refer to sugars and syrups added to foods and beverages when they are processed or prepared, as opposed to sugars that naturally occur in fruit, vegetables or milk.

High consumption of sucrose possess a health challenge to prospective consumers of products containing high amount of sucrose. Hashim and Shamsi (2016) [4] also reported that increased intake of added sugar might increase the risk of obesity, cardiovascular diseases, dental caries, glucose intolerance, diabetes mellitus as well as hypertension.

Date products have been applied in many food formulations. Shinde *et al*. (2019) [5] and Fatma *et al*. (2020) [6] have successfully used date paste and date seeds respectively in bread products. Bellaouchi *et al*. (2017) [7] investigated the physicochemical and microbial properties of undervalued dates and processed dates by-products. The authors further reported that date fruits are rich in sugars (52.6 - 88.6%), fiber (3.6 - 10.9%), protein (1.1 - 2.6%), ash (1 - 1.9%) and antioxidants.

Since bread constitutes the second most consumed products in Nigeria, substituting sucrose with date syrup could provide the prospective consumers with more nutritious product, since date is more nutritious than sucrose. This may also reduce the incidences of diseases associated with high sucrose consumption and improve the health of the consumers. Therefore, the aim of this research was to produce more nutritious bread with improved physicochemical properties for nutritional benefits and consumer acceptability.

Materials and Methods

Sources of Materials

About 2.0 kg of fresh dates was purchased from a local Market in Lafia, Nasarawa State. Other ingredients such as wheat flour, sugar (sucrose), yeast, salt and margarine were purchased from a super Market in Makurdi, Nigeria. Equipment used included water bath, crucibles, blender, mortar, meter rule and weighing balance. It was ensured that the chemicals and equipment used for the sample preparation and analyses were of analytical grade and obtained from the Department of Food Science and Technology, Federal University of Agriculture, Makurdi.

Preparation of Date Syrup

The date syrup was prepared using the method described by Sengev and Oguche (2017) [3]. The date syrup produced has 73 ^{o}Brix, refractive index of 1.49 and pH value 5.00.

Product Formulation

Sucrose (50 g) was substituted with date syrup at five replacement levels of 0, 5, 10, 15, 20 and 25 g (i. e. samples A, B, C, D, E and F respectively) for bread production. One treatment with 50 g sucrose and 0 g date syrup was used as a control (sample A). The formula of ingredient mix for bread production is shown on Table I.

Bread Baking Process

Doughs from the flour blends were baked using the straight-dough method described by Sengev *et al*. (2013) [8] with modification. The baking formula was 500 g of flour blend, 5 g of compressed baker's yeast, 5 g of salt (NaCl), 50 g of sugar, 7 g of margarine and approximately 280 mL of water. All the ingredients were mixed in a Kenwood mixer (Model A 907 D) for 3.5 min. The doughs were fermented for 90 min at 28°C ± 1°C then punched, scaled to 250 g dough pieces, proofed for 90 min at 30 °C, 85% relative humility and baked at 250 ° C for 30 min.

Table 1: Ingredient Mix for Bread Production

Ingredient	Product					
	A	B	C	D	E	F
Wheat Flour (g)	500	500	500	500	500	500
Sucrose (g)	50	0	0	0	0	0
Date Syrup (g)	0	5	10	15	20	25
Water	280	280	280	280	280	280
Salt	5	5	5	5	5	5
Margarine	7	7	7	7	7	7
Yeast	5	5	5	5	5	5

Source: Sengev and Oguche (2017) [3] and Sengev *et al*. (2013) [8]

Chemical Analysis of the Bread

The moisture, crude protein, crude fat, crude fibre and ash and mineral content was determined using atomic absorption spectrophotometer, all analyses were carried out using standard methods as outlined by AOAC (2005) [9], while carbohydrate was determined by difference as described by Sengev *et al*. (2013) [8].

Physical Characteristics Determination

Loaf volume was determined by the sorghum displacement method (Greene and Bovell-Benjamin, 2004) [10]; loaf weight by the method of AACC (2000) [11], specific loaf volume as described by Penfield and Campbell (1990) [12], while loaf height was measured using a meter rule.

Dough Analysis

Alveograph properties of dough were determined according to ISO Standard (2015) [13] using a Chopin alveograph. A dough was made from 250 g of flour mixed with a 2.5% salt solution. Five circular balls of dough were formed with diameter of 4.5 cm made by mixing and extrusion, followed by conversion into small disks, which are left in standby for 20 min in the alveograph, in a compartment with temperature set to 25 ^{o}C. Each disk made of dough was tested individually. The alveograph blew air into the disk of dough, which extended into a bubble that eventually broke. The pressure inside the bubble was recorded as a curve on graph paper. The parameters obtained are: tenacity of the dough (P) – the maximum over pressure, extensibility of the dough (L) – the average abscissa at rupture and strength of the dough (W) – the deformation energy of 1 g of dough.

Sensory Evaluation

A 15-member panel of judges selected from both staff and students of the Department of Food Science and Technology, Federal University of Agriculture, Makurdi were used for the evaluation. Sensory evaluation was performed 24 h after baking to evaluate appearance, crust appearance, crumb texture, flavour and overall acceptability of the bread samples using a 9-point Hedonic scale as described by Meilgaard *et al*. (2007) [14]

Statistical Analyses

Data were generated in duplicate and subjected to analysis of variance. Means were tested for significant difference using Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1960) [15]. Significance was accepted at $p<0.05$.

Results

Proximate Composition of Bread Samples

The effect of sucrose substitution with date syrup on the proximate composition of bread is presented in Table II. The results showed that crude fibre and ash increased significantly ($p<0.05$) from 0.31 to 4.57% and 1.41 to 1.56%, respectively. The moisture and crude protein also decreased significantly ($p<0.05$) from 34.76 to 21.49% and 16.27 to 14.95%, respectively, while crude fat and carbohydrate remained unaffected.

Mineral Content of Bread Samples

The result of the mineral (Ca, P, Na, K and Mg) content (mg/100 g) of the bread samples are presented in Table III. All the minerals significantly ($p<0.05$) increased. Calcium increased from 2.24 to 2.97, phosphorus (0.06 to 1.66), sodium (0.09 to 6.29), and potassium (0.04 to 9.04) as well as magnesium (0.95 to 1.40).

Table 2: Effect of Date Syrup on the Proximate Composition (% dry basis) of Bread Samples

Product	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
A	34.76^{a}	16.27^{a}	7.34^{a}	0.31^{e}	1.43^{cd}	64.56^{a}
B	29.92^{b}	15.41^{b}	7.39^{a}	3.38^{d}	1.41^{d}	63.96^{a}
C	28.66^{b}	15.23^{b}	7.40^{a}	3.66^{c}	1.49^{bc}	64.11^{a}
D	25.93^{c}	15.64^{ab}	7.62^{a}	3.92^{b}	1.52^{ab}	64.021^{a}
E	26.07^{c}	15.33^{b}	7.56^{a}	3.62^{c}	1.53^{ab}	64.67^{a}
F	21.49^{d}	14.95^{b}	7.53^{a}	4.57^{a}	1.56^{a}	65.44^{a}

Values are means of two determinations.

Means in the same column with the same superscript are not significantly different at $p \geq 0.05$

Table 3: Effect of Date Syrup on the Mineral Content (mg/100 g) of Bread Samples

Product	Calcium	Phosphorus	Sodium	Potassium	Magnesium
A	2.24^{f}	0.06^{f}	0.09^{f}	0.04^{f}	0.95^{e}
B	2.46^{e}	0.93^{e}	4.12^{e}	4.73^{e}	0.97^{e}
C	2.46^{d}	1.10^{d}	5.14^{d}	5.17^{d}	1.01^{d}
D	2.70^{c}	1.24^{c}	5.48^{c}	6.79^{c}	1.12^{c}
E	2.81^{b}	1.44^{b}	6.01^{b}	7.09^{b}	1.22^{b}
F	2.97^{a}	1.66^{a}	6.29^{a}	9.04^{a}	1.40^{a}

Values are means of two determinations.
Means in the same column with the same superscript are not significantly different at p ≥ 0.05

Physical Properties of Bread Samples

The results of height (cm), weight (g), volume (cm^3) and specific volume of the bread samples as affected by date syrup substitution are presented in Table IV. Sucrose substitution with date syrup significantly (p<0.05) decreased the loaf volume from 1850 to 1525 and specific volume from 4.65 to 3.96 as the quantity of date syrup increased. The loaf height and weight were not affected by the substitution levels.

Rheological (Alveograph) Properties of Bread Samples

The results of the effect of sucrose substitution with date syrup on the alveograph properties of bread samples are presented in Table V with significant (P<0.05) difference in all the parameters tested except for deformation energy (W). The tenacity (mm), extensibility (mm) and distortion increased from 97.25 to 128.60, 88.10 to 101.20 and 0.95 to 1.27, respectively.

Organoleptic Properties of Bread Samples

The results of the effect of sucrose substitution with date syrup on the organoleptic properties of bread samples are presented in Table VI. Significant (P<0.05) difference exists between the samples in terms of appearance (6.33 to 7.20), crust (6.20 to 7.13) and flavour (6.53 to 7.20). Crumb texture and overall acceptability were not significantly (p>0.05) affected by the different levels of date syrup addition.

Table 4: Effect of Date Syrup on the Physical Properties of Bread Samples

Product	Height (cm)	Weight (g)	Volume (cm^3)	Specific Volume (cm^3/g)
A	18.50^{a}	397.50^{a}	1850^{a}	4.65^{a}
B	18.90^{a}	396.00^{a}	1805^{ab}	4.55^{a}
C	18.85^{a}	395.00^{a}	1700^{bc}	4.30^{ab}
D	19.20^{a}	393.00^{a}	1625^{cd}	4.15^{b}
E	18.90^{a}	388.50^{a}	1600^{cd}	4.12^{b}
F	18.60^{a}	387.50^{a}	1525^{d}	3.96^{b}

Values are means of two determinations.
Means in the same column with the same superscript are not significantly different at p ≥ 0.05

Table 5: Effect of Date Syrup on the Rheological (Alveograph) Properties of Dough Samples

Product	P (mm)	L (mm)	W (J)	P/L
A	97.25^{f}	98.05^{b}	454.10^{a}	0.95^{c}
B	109.10^{e}	88.10^{f}	370.10^{a}	1.24^{b}
C	114.20^{d}	89.15^{e}	405.80^{a}	1.28^{ab}
D	123.50^{c}	94.10^{d}	435.50^{a}	1.29^{ab}
E	126.20^{b}	95.10^{c}	442.50^{a}	1.34^{a}
F	128.60^{a}	101.20^{a}	449.50^{a}	1.27^{ab}

Key: P = Tenacity (maximum overpressure), L = Extensibility, P/L = Distortion, W = Deformation energy
Values are means of two determinations.
Means in the same column with the same superscript are not significantly different at p ≥ 0.05

Table 6: Effect of Date Syrup on the Organoleptic Properties of Bread Samples

Product	Appearance	Crust Appearance	Crumb texture	Flavour	Overall Acceptability
A	6.60^{abc}	6.93^{ab}	6.80^{a}	7.33^{a}	7.20^{a}
B	7.20^{a}	6.87^{ab}	6.93^{a}	6.67^{ab}	6.93^{a}
C	6.67^{abc}	6.80^{ab}	6.87^{a}	6.53^{b}	6.87^{a}
D	6.47^{bc}	6.20^{b}	6.47^{a}	6.60^{b}	6.93^{a}
E	6.33^{c}	6.80^{ab}	6.47^{a}	6.73^{ab}	6.67^{a}
F	7.07^{ab}	7.13^{a}	7.00^{a}	6.87^{ab}	7.07^{a}

Means in the same column with the same superscript are not significantly different at p ≥ 0.05

Discussion

Proximate Composition

The results presented in Table 2 indicated that the moisture content of the bread samples decreased significantly (p<0.05) with increase in the concentration of date syrup (DS). The observed decrease in moisture content may be ascribed to the high water binding capacity of date syrup fibre. This agreed with the observation of Ibidapo *et al.* (2015) [16] on fibre enriched bread. The protein content of the samples containing DS are not significantly different but differ from the control. The slight decrease in protein, though not significant, agreed with the findings of Sengev and Oguche (2017) [3]. The fibre and ash content increased significantly (p<0.05) as the level of DS increased. This may be attributed to the high concentration of fibre and minerals in dates. This agreed with Sultana *et al.* (2015) [17] who reported ash and fibre content in the range of 2.13-2.18% and 6.05-6.9%, respectively. The crude fat and carbohydrate were however not affected by addition of DS.

Mineral Content

The mineral content in terms of Ca, P, Na, K and Mg increased significantly (p<0.05) as the level of DS increased (Table 3). The increase in the mineral content may be attributed to their high concentration in dates. This observation is supported by the findings of Bedeir (2014) [18] who reported that DS has high mineral value. Hence, addition of DS in bread samples in increasing quantities is expected to increase the mineral contents of the samples.

Physical Properties of Bread Samples

As shown in Table 4, the volume and specific volume increased significantly (p<0.05) with increased levels of DS substitution. The decrease in volume with increased level of substitution may be due to the increase in fibre content of the bread samples which bound some of the water molecules

thereby making them unavailable for maximum gluten development (Obiegbuna *et al*., 2013) [19]. All the samples statistically met the Standard Organisation of Nigeria's specification for specific volume. The results of specific volume obtained in this work are higher than that reported by Nwanekezi *et al*. (2015) [2]. Substitution of sucrose with date did not significantly affect the height and weight of the bread samples. The non-significant ($p \geq 0.05$) difference in weight was also observed when sucrose was substituted with honey (Babajide *et al*., 2014) [20]

Alveograph Properties of the Dough

The tenacity, P (mm), extensibility, L (mm) and P/L as well as the % wet gluten of the dough samples increased with increase in DS substitution. The P parameter is the maximum pressure in the bubble that causes rupture. Values of P higher than 100 indicate extra strong wheat dough (Aldovrandi and Vitali, 1995) [21]. This implies that samples with DS may form strong dough. Extensibility values of up to 100 are indications of good bakery production. The ratio P/L of 0.50 indicates either resistant and very extensible wheat dough or moderately extensible and less resistant wheat dough. Value of 1.50 indicates very strong and moderately extensible wheat dough, whilst wheat dough with P/L value in the range 0.40-0.80 is suitable for bakery production (Vukic *et al*., 2013) [22]. Therefore, the P/L values reported in this study fell outside the range for suitable bakery production.

Standard quality wheat dough is characterized by (W) value in range 160-200, while good quality wheat dough is characterized by (W) value in the range 220-300 and higher than 300, respectively (Bordes *et al*., 2008) [23]. The results of the deformation energy (W) in this study showed no significant difference between the samples containing DS and the control.

Organoleptic Properties of Bread Samples

The organoleptic assessment indicated that all the samples were at least liked slightly. No significant ($p>0.05$) difference existed between the control (A) and the rest of the samples in all the attributes. This implies that the samples with DS compared favourably with the control in terms of appearance, crust appearance, crumb texture, flavour and overall acceptability. This observation agreed with the findings of Nwanekezi *et al*. (2015) [2]. The authors reported that addition of date palm fruit pulp did not significantly affect the organoleptic properties of bread. Cookies produced with DS also had their sensory attributes impaired (Alsenaien *et al*., 2015) [24]

Conclusion

This study revealed that substitution of sucrose with date syrup for bread production increased the ash and fibre contents. The Ca, P, Na, K and Mg contents of the bread also increased significantly. The dough properties in terms of alveograph also increased with increase in the levels of DS substitution. Therefore, utilization of DS up to 25 g substitution is feasible in bread production.

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