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Effect of honey substitute for sugar on rheological properties of dough and some physical properties of cassava-wheat bread

[1*]Babajide, J. M., [2]Adeboye, A. S. and [1]Shittu, T. A.

[1]*Department of Food Science and Technology, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria*
[2]*Department of Food Science and Technology, Moshood Abiola Polytechnic, P.M.B. 2210 , Abeokuta, Nigeria*

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Abstract

Bread was produced from cassava-wheat (10:90) flour with sucrose sugar: honey at 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50 and evaluated for rheological and physical properties. Water absorption (60.6-62.5%) and valorimeter score (46.9–52.0%) for dough samples were not significantly difference ($P > 0.05$) while 50:50 had the highest dough development time (2.5 min). Dough stability increased from 3.6 to 12.5 min at 30% honey inclusion. No significant difference ($P > 0.05$) in loaf weight (290.04-310.04 g) but volume (1188 – 1643 cm^3) and specific volume (3.95-5.4 cm^3g^{-1}) varied significantly ($P < 0.05$) with 30:70 having the highest values. Bread crumb moisture (30.41-36.15%) and density (0.17-0.32 g/cm^3) increased as honey inclusion increased. The L^* (lightness) values for bread crust (39.18-45.25) and crumb (50.85-64.23) varied significantly ($P < 0.05$). Sucrose sugar substitution with honey in dough formulations did not adversely affect dough properties and 30% honey substitution gave better cassava-wheat composite bread.

Introduction

Bread is one of the most widely consumed food products in the world. It has relatively low cost and gives some of the nutrients missing in majority of carbohydrate foods (Foster, 2008). Bread making technology is among the oldest technologies known (Qunyi *et al*., 2010). Baking technology has developed gradually as new materials, equipment and processes are advancing (Selomulyo and Zhou, 2007). The impacts of various ingredients on sensory and nutritional quality of bread have been widely studied (Plessas *et al*., 2000; Barcenas and Rosell, 2005). Addo (1997) found that at 4–6% liquid or dry honey the rheological properties of frozen dough and the freshness of bread were improved. Frank and Matthew (1999) recommended substitution level of 25% liquid honey as a partial substitute for sugar as the optimum in terms of physical and sensory qualities of fat-reduced muffin.

Honey has been known to have some health benefits and anti microbial properties (Shultz, 2009). Beyond many health claims and ability to mask any taste deficiency that may have resulted from ingredient interactions, inclusion of honey into bread formulation is reported to offer functional benefits, improve water-binding capacity of dough, provide increased volumes and improves shelf life of bake products (Addo, 1997; Foster, 2008). The substitution of a type of sugar by another had typically been studied in food products with the objective of finding a level of replacement that will improve the product's characteristics. In an earlier study, Torley *et al.* (2003) pointed out that individual starch gelation characteristic differs in their response to partial or complete substitution of various sugars. The quality and stability effect of honey in 100% wheat flour bread have been reported in literature. Specifically, increased additions of honey in bread have resulted into a higher water absorption, shorter development and stability time in the dough (Qunyi *et al*., 2010).

In 2005, the Federal Government of Nigeria mandated the use of composite cassava-wheat flour for baking by adding minimum of 10% cassava flour to wheat, to cut the expense on wheat importation and find more use for the increasingly produced cassava roots. One of the studies conducted to understand the performance of composite flour system for bread making focused on the effect of baking time and temperature on some physical properties of bread. It was reported that fresh crumb moisture, density, porosity and softness as well as the dried crumb hardness were significantly affected by both the baking temperature and time (Shittu *et al*., 2007). In previous works (Defloor *et al*., 1993; 1994; 1995; Khalil *et al*., 2000), it was established that inclusion of cassava flour into wheat flour up to about 30% could give an acceptable fresh loaf depending on the flour quality and formulation. Also, 10% substitution of wheat with cassava flour gave bread with quality

*Corresponding author.
Email: *jmbabajide@gmail.com*

not significantly different from 100% wheat bread.

Bread made from 10% cassava-wheat composite flour has been reported to have no quality difference from 100% wheat bread (Defloor *et al.*, 1995). However, no study has been reported on the use of honey as ingredient in cassava-wheat composite bread.

The objective of this research was to evaluate the influence of substituting sugar with liquid honey on the rheological properties of composite cassava-wheat dough and some physical properties of its bread.

Materials and Methods

Materials

Matured sweet variety cassava (*Manihot esculenta*) tubers used for the production of cassava flour was obtained from the farm of Moshood Abiola Polytechnic, Abeokuta, Nigeria. Wheat (white) flour was donated by Honey Well Flour Mills, Lagos, Nigeria. Other ingredients used included granulated sugar (Dangote groups (Nig) Ltd. Lagos, Nigeria), Fermipan baking yeast (DSM bakery ingredient, Dordrecht-Holland), Elden dough conditional (EDC) and baking fat (Pt Intibucá Sejhtera, Jakarta, Indonesia). Pure natural honey used was obtained from Institute of Vocational Beescraft, Abeokuta, Nigeria.

Production of cassava flour

Cassava flour was produced as described by IITA (2005). Freshly harvested matured cassava roots were peeled, washed and grated using a locally fabricated mechanical grater. The pulp obtained was dewatered using a 'muslin' cloth placed in between a screw press. The drained cassava mash was spread thinly on trays and dried in cabinet dryer (Lukas Engineering Nig. Ltd, Name of City, Nigeria) at 70°C to a constant weight of 4% moisture content. The dried pulverized cassava was then milled into flour in a locally fabricated plate mill. The cassava flour obtained was packed in a zip-lock polythene bag and stored in an airtight plastic container.

Recipe formulation

Composite flour was obtained by mixing 10 parts of the cassava flour to 90 parts the wheat flour. Recipe used by Shittu *et al*. (2007) was adapted for dough formulation per loaf (Table 1). Sugar as ingredient was replaced with honey at 0 - 50% levels of substitution.

Farinograph study on cassava-wheat dough

The method described in AACC (2000) was adapted for the analyses. The sugar was thoroughly ground and incorporated into the flour. Two hundred and ninety six grams (296 g) of each prepared composite flour sample on 14% moisture basis was mixed with calculated volume of honey and water in the Farinograph (Brabender Farinograph, Name of City of the Manufacturer, Germany) mixing bowl. The amount of water added (water absorption), dough development time, dough stability, mixing tolerance index, dough degree of softening were recorded.

Table 1. Ingredient formulation for cassava-wheat bread

Ingredients	Honey : Sucrose sugar					
	0: 100	10:90	20:80	30:70	40:60	50:50
Wheat flour (g)	270	270	270	270	270	270
Cassava flour g)	30	30	30	30	30	30
Salt (g)	4.5 (1.5)	4.5 (1.5)	4.5 (1.5)	4.5 (1.5)	4.5 (1.5)	4.5 (1.5)
Honey (g)	-	1.8 (0.6)	3.6 (1.2)	5.4 (1.8)	7.2 (2.4)	9 (3.0)
Sugar (g)	18 (6.0)	16.2 (5.4)	14.4 (4.8)	12.6 (4.2)	10.8 (3.6)	9 (3.0)
Yeast (g)	15 (5.0)	15 (5.0)	15 (5.0)	15 (5.0)	15 (5.0)	15 (5.0)
Vegetable Oil (g)	9 (3.0)	9 (3.0)	9 (3.0)	9 (3.0)	9 (3.0)	9 (3.0)
EDC (g)	0.9 (0.3)	0.9 (0.3)	0.9 (0.3)	0.9 (0.3)	0.9 (0.3)	0.9 (0.3)
Water (g)	145	145	145	145	145	145

Adapted from Shittu *et al.* (2007). Values in parenthesis denotes percentage ingredient, % values are based on the total flour weight (300 g)

Bread Baking

The method described by Vyskocil (2000) for production of honey whole wheat bread was used in the preparation of the dough. The ingredients (yeast, honey, water and butter) were mixed in a large liquid measuring bowl and stirred until the yeast dissolved and the baking fat was melted. The sugar, composite flour and salt were dry mixed in a large bowl. The yeast mixture was thoroughly incorporated into the mixture of dry ingredients. The dough obtained was then transferred into a lightly floured work surface of the kneading machine and kneaded for about 15 - 20 min to form smooth and elastic dough. The dough was cut into uniform sizes (300 g), placed in lightly greased pan and proofed in the proving cabinet at 30ºC and 78-80% RH for 2 h. The bread samples were baked at 220ºC for 30 min.

Loaf weight, volume and specific volume

The weight of each bread sample was determined immediately after cooling using a digital weighing balance (0.01 g accuracy) (Ignition Manufacturing Pty, Name of City, Germany). The loaf volume was determined using rapeseed displacement method, Standard 10-05 (AACC, 2000). The specific volume of each loaf was then calculated as volume to mass ratio (cm^3g^{-1}).

Crumb moisture, density and porosity

The bread moisture for each sample was determined using a moisture analyser (MB23; Ohaus Corp. Pine Brook, NJ USA). A modified method of Saguy *et al.* (2005) was used in determining crumb porosity. Bread samples were kept in ambient air (26 – 29ºC, 72 – 75% RH) for 24 h to allow slow drying for proper setting of loaf in order to prevent possible deformation of loaf in subsequent handling, which can affect the true values of crumb porosity. Each bread crumb 4.5 x 4.5 x 3.8 cm^3 was cut from the central portion of loaves with a razor blade and dried at 50°C for 12 h in a hot air oven (Gallemkamp Pty Ltd, City of Manufacturer, England). The moisture content of dried crumb samples used was between 3.0 and 4.0%. The dried crumb slices were then cooled and weighed (W_1) immediately. The crumbs were milled, sieved using a 100 µm mesh size sieve, and the underflow was weighed (W_2). The sample was then poured into a 20 cm^3 measuring cylinder (accuracy = 0.5 cm^3) and tapped 10 times. The volume occupied by the sample was determined (V_2). The data obtained were used to determine the crumb (ρ_c) and solid density (ρ_s) of the samples as follows:

$$\rho_c = W_1/V_1 \ldots\ldots \text{Eqn. 1}$$

$$\rho_s = W_2/V_2 \ldots\ldots \text{Eqn.2}$$

V_1 (volume of rectangular sample) = length x breadth x thickness

The crumb porosity was calculated as :

$$\text{Crumb porosity} = 1 - \rho_c/\rho_s \ldots\ldots \text{Eqn. 3}$$

Crumb softness

Modified method of Shittu *et al*. (2007) in previous study was used to determine the crumb softness. A bench top cone penetrometer with a 35 g probe (Central Ignition Company, City of Manufacturer, UK) was used. Five centimeter (5 cm) thick bread slices were carefully taken to obtain very flat and undistorted surfaces on the slices. The tip of the cone was made to touch the bread surface by adjusting the hanger position. The cone was later released to fall under gravity and penetrate the bread crumb. The extent of penetration (mm) was determined on the radial dial gauge attached to the instrument after 2 sec of penetration. Measurement was carried out at three points along a diagonal line within the crumb.

Crust and crumb colour

The tristimulus color parameters L^* (lightness), a^* (redness to greenness), b^* (yellowness to blueness) of the baked loaves crust and crumb were determined using a digital colorimeter (Color Tec PCM, Accuracy Micro census Inc., City and State of Manufacturer, USA). Crust colour of bread was measured at the surface (top) of bread loaves while crumb colour was measured at the side and bottom of loaf. In each case, the tristimulus colour parameters L^*, a^*, b^* were determined within each region in triplicate. The brownness index (BI) was calculated according to Maskan (2001).

Statistical analyses

Data generated in all analyses were subjected to analysis of variance (ANOVA) using statistical package for social sciences (SPSS Inc. City and State of Manufacturer, USA) 17.0 version. The calculated mean values were separated using Duncan's multiple range test with significance level of $P < 0.05$.

Results and Discussion

Rheological indices of dough

Data of the rheological indices of dough samples are shown in Table 2. Water absorption ranged from 60.7 to 62.5% with sample containing 100% sugar having the highest value. However, the result indicated that there was no significant difference ($P > 0.05$) in the water absorption of the dough irrespective of the level of addition of honey. As the level of inclusion of honey in dough was increased, the water absorption reduced compared to the control sample. This trend is in contrast with similar work of Qunyi *et al*. (2010) in which water absorption increased as the level of honey powder increased in bread. This means that more honey powder in the flour-water mix demanded more water addition to develop dough of desired consistency, whereas in this present study in which liquid honey was used, less amount of water would be required to develop the dough. This could be as a result of high percentage of water naturally present in liquid honey (13 -19%) (USDA, 2010). The inclusion of liquid honey could reduce the water absorption of flour which may result in lower yield as noted by Purh and D'appolonia (1992).

Similarly, there was no significant difference ($P > 0.05$) in the dough development time of the control sample and honey substituted samples at 10 - 40% level. Dough development time ranged from 2.0 to 2.5 min became significantly longer ($P < 0.05$) at 50% level of substitution at 2.5 min. Thus, the inclusion of honey may not have effect on dough development time. However, the increase of 0.5 min observed in 50:50 dough may imply that at over 50% inclusion of honey, dough development may be delayed.

Dough stability time ranged from 3.6 to12.5 min with 20% and 30% level of honey, having the highest dough stability time while the control sample had the least. Dough stability time is an indication of the strength of the dough. All the samples containing honey gave dough with longer stability time and were significant difference ($P < 0.05$) from that of

Table 2. Farinograph indices of honey-cassava-wheat dough

Sample	Water absorption	Dough development time (min)	Dough stability (min)	Mixing tolerance index MTI (BU)	Dough Degree of softening (BU)	Valorimeter score (%)
0:100	62.50±1.3	2.0_a±0	3.6_a±0.1	81.5_d±0.7	88.0_c±0.2	46.9±0.1
10:90	61.30±0.7	2.2_a±0.2	6.1_b±0.1	61.0_c±0	71.0_b±1.4	50.9±1.2
20:80	60.60±3.1	2.0_a±0	12.5_c±0.7	41.5_b±0.7	61.5_a±0.7	52.0±0
30:70	61.25±1.0	2.0_a±0	12.5_c±0.7	37.0_a±1.4	61.0_a±1.4	52.0±0
40:60	60.90±1.2	2.0_a±0	11.5_c±0.7	41.5_b±0.7	62.0_a±0	52.0±0
50:50	60.70±0	2.5_b±2.4	11.3_c±0.4	37.25_a±0.4	61.9_a±0.1	52.0±0
	NS					NS

0:100=Cassava-wheat composite bread baked with 0% honey (Control), 10:90=Cassava-wheat composite bread baked with 10% honey, 20:80=Cassava-wheat composite bread baked with 20% honey, 30:70=Cassava-wheat composite bread baked with 30% honey, 40:60=Cassava-wheat composite bread baked with 40% honey, 50:50=Cassava-wheat composite bread baked with 50% honey. Mean ± Standard deviation of triplicates. Mean values followed by different superscript within columns are significantly different (P < 0.05), NS = No Significant difference.

the control sample. This is in agreement with Foster (2008) that honey inclusion in dough development boost dough stability. The stability time increased as honey level increased up to 20% but remain constant at 20 - 30% and at ≥ 40%, the stability time was reduced. This may imply that higher concentration of honey may shorten the stability time of dough.

The mixing tolerance index (MTI) ranged from 37.25 to 81.5 BU in sample with 50% level of substitution and the control sample with 100% sucrose sugar, respectively. Mixing Tolerance Index is used by bakers to determine the extent of dough softening over a period of mixing (Charlotte, 2004), as the lower the value, the better. Pliability and smoothness of the dough is greater at lower MTI with progressive addition of honey as against the control sample. The honey substituted samples have better mixing tolerance than the control sample thus higher concentration of honey would suggest higher water content in the honey-sugar mix and hence lowered viscosity. There were significant differences (P < 0.05) in the mixing tolerance index of samples but the values did not follow a regular pattern as honey concentration was increased, this may have resulted from the varied extent of the hygroscopic effect of fructose in such dough.

Degree of softening ranged from 61.0 BU to 88.0 BU with that of control sample significantly higher (P < 0.05) than those containing honey. Degree of softening decreased as the level of honey inclusion was increased up to 20% but was not significantly different (P > 0.05) for samples with 20-50% honey. This could be as a result of the relatively high viscosity of honey which would probably imply that, kneading and pan flour will have to increase accordingly. Dough degree of softening is an indicator of how soft the dough becomes after 12 minutes of mixing (Charlotte, 2004).

Valorimeter scores of the dough samples had similar trend as the water absorption. There was no significant difference (P > 0.05) in the valorimeter score of control and the honey samples. Although, samples containing honey had higher valorimeter

Table 3. Loaf weight, volume and specific volume of honey-cassava-wheat bread

Sample	Loaf weight (g)	Volume (cm^3)	Specific Volume (cm^3g^{-1})
0:100	300.06	1339^{ab}±35.58	4.50^{b}±0.04
10: 90	298.06	1258^{a}±23.58	4.20^{a}±0.05
20: 80	299.05	1218^{a}±10.05	4.10^{a}±0.00
30:70	305.12	1642^{c}±13.10	5.40^{c}±0.02
40:60	310.04	1564^{bc}±33.56	5.10^{bc}±0.02
50:50	300.04	1188^{c} ± 0.1	3.95^{c}±0.04
	NS		

0:100=Cassava-wheat composite bread baked with 0% honey (Control), 10:90=Cassava-wheat composite bread baked with 10% honey, 20:80=Cassava-wheat composite bread baked with 20% honey, 30:70=Cassava-wheat composite bread baked with 30% honey, 40:60=Cassava-wheat composite bread baked with 40% honey, 50:50=Cassava-wheat composite bread baked with 50% honey. Mean+ Standard deviation of three replicates. Mean values followed by different superscript within columns are significantly different (P < 0.05), NS = No Significant difference.

score than the control sample; increasing concentration of honey up to 50% level of substitution did not significantly (P > 0.05) improved the valorimeter score of dough. Valorimeter score is a total quality factor (Charlotte, 2004) of the dough. Increased level of inclusion of honey increased the overall quality of the dough 'behavior'. The values obtained for all the samples is an indication that higher quality of bread with looseness and tenderness could be made with the dough containing all the levels of honey substitution used in this present study.

Loaf weight, volume and specific volume of bread

Table 3 shows the result of loaf weight, volume and specific volume of honey-cassava-wheat bread. Loaf weight ranged from 290.04 g in sample with 50% level of honey substitution to 310.04 g in sample with 40% level of honey substitution. The weight of bread samples with honey at different level of substitution were not significantly different (P > 0.05) from each other and the control sample. Loaf volume and specific volume varied significantly (P < 0.05) from 1180 to 1642 cm^3, and 3.95 to 5.4 cm^3g^{-1}, respectively. The bread samples varied significantly (P < 0.05) in volume of sample with the 50% level of honey substitution having the least specific volume and the sample with the 30% level of honey substitution having the highest specific volume. This volume is however reduced at honey substitution level above 40% most probably due to the poor gas retention caused by the high level of honey. Loaf volume is affected by the quantity and quality of protein in the flour (Ragaee and Abdel-Aal, 2006) as well as proofing time (Zghal, 2002; Shittu *et al.*, 2007). The specific volume, which is the ratio of loaf volume and weight, has been generally adopted as a more reliable measure of loaf size (Shittu *et al.*, 2007). The same composite flour and baking time-temperature regime were used and hence starch gelatinization is not expected to vary significantly. Therefore, the only factor that could possibly have led to the differences observed in the volume and specific volume of the

Table 4. Crumb moisture, density and porosity of honey-cassava-wheat bread

Samples	Moisture (%)	Density (gcm^{-3}) Crumb	Density (gcm^{-3}) Solid	Porosity
0:100	$32.04^{b} \pm 0.00$	$0.017^{a} \pm 0.00$	$0.155^{a} \pm 0.00$	$0.090^{bc} \pm 0.00$
10: 90	$30.41^{a} \pm 0.00$	$0.024^{b} \pm 0.00$	$0.174^{b} \pm 0.01$	$0.086^{ab} \pm 0.00$
20: 80	$32.03^{b} \pm 0.00$	$0.027^{c} \pm 0.00$	$0.176^{b} \pm 0.01$	$0.085^{a} \pm 0.00$
30:70	$34.06^{c} \pm 0.00$	$0.032^{d} \pm 0.00$	$0.197^{c} \pm 0.01$	$0.084^{a} \pm 0.00$
40:60	$34.02^{c} \pm 0.00$	$0.028^{c} \pm 0.00$	$0.178^{bc} \pm 0.01$	$0.084^{a} \pm 0.00$
50:50	$36.15^{c} \pm 0.02$	$0.021^{a} \pm 0.00$	$0.168^{ab} \pm 0.00$	$0.088^{b} \pm 0.00$

bread samples is the varied interaction of the sugar mix systems on the gelatinization and extensibility of the starch mixture of the flour.

Crumb moisture, density and porosity of bread

The crumb moisture, density and porosity of samples are presented in table 4. Crumb moisture ranged from 30.41% in sample containing 10% honey to 36.15% in 50:50 samples. Crumb moisture was significantly ($P < 0.05$) higher in cassava-wheat bread (with ≥ 30% honey substitution) than the control cassava-wheat bread. Frank and Matthew (1999), Torley and Molen (2005) and Slawomir (2006) reported that concentration of honey alone does not guarantee any linear relationship or direct trend in physical and or textural parameters of the product. The concentration of other minor components of honey, water and amylase activity at different substitution level and the implicit manifestation of the interactions of these factors may become apparent.

The crumb density significantly ($P < 0.05$) increased from 0.017 in the control sample to 0.032 in 30% level of honey substitution then reduced from honey substitution level ≥40%. Thus, honey's denser weight was quite apparent in the structural and textural development of the crumbs but up to an optimum level when other factors such as internal pressure (Therdthai, 2002), and aggregate hygroscopic effect of fructose in the sugar mix (Torley and Molen, 2005) presumably became dominant. Crumb porosity varied significantly between 0.084 and 0.090. Although, there were significant differences ($P < 0.05$) among all the samples in terms of crumb moisture, density and porosity; samples with 30% and 40% level of honey substitution were however not significantly different ($P > 0.05$) in crumb porosity. Gas (CO_2) retention and moisture diffusivity greatly determine porosity of bread samples (Zhang, 2007). The perceived variation in moisture content, density and porosity of samples could be attributed mainly to poor gas retention and moisture diffusion abilities of the dough with progressive honey concentration.

Colour measurements of bread crust and crumb

The effects of honey on the colour of samples are shown in table 5. The L^*, a^* and b^* values for bread crust ranged from 41.09, 11.58 and 23.99 to 45.25, 12.39 and 27.88, respectively while those of bread crumb ranged from 50.85, 10.00 and 18.14 to 64.23, 14.05 and 33.65, respectively. The crust of samples with 10 and 30% level of honey substitution had same L^* (lightness) value and were significantly ($P < 0.05$) lighter than all other honey substituted samples. The browning of the crust of all honey substituted samples was higher than that of the control. This is an expected contrast with the observation on the L^* values and it is in agreement with report of Qunyi *et al.* (2010) in which honey powder was used exclusively at 5, 10 and 15% on dry basis in comparison with exclusive sugar formulations. It was reported by Qunyi *et al.* (2010) that honey whole wheat breads gave higher browning index than the control (exclusive sugar). This could be attributed to the more glucose and fructose in honey powder causing a greater extent of Maillard browning and caramelization reaction in the crust, thereby intensifying the crust colour of honey breads. Although partial substitution method used in this study is in line with this claim, irregular trend in the values obtained could be due to the aggregates of glucose and fructose in the honey sugar mix which influence crust colour.

Previous works have shown that instrumental measurement of baked products' color is an inevitable quality check that could be used in determining the effects of ingredient or product formulation, process variable as well as storage conditions on baked products (Sanchez *et al*., 1995; Gallagher *et al.*, 2003a; Gallagher *et al.*, 2003b; Erkan *et al.*, 2006). Most of these works reported the tristimulus CIE color parameters (L^*, a^*, b^*) for the respective products' crust and crumb. The colour of bread is related to physicochemical characteristics of the raw dough and chemical reactions that take place during baking which are dependent on operating conditions, such as Maillard reactions and caramelization which causes browning of baked products during baking Qunyi *et al*. (2010). The control sample had the highest crumb lightness (64.23) which was not significantly different from that of 10% honey substituted sample, and this was expected following values obtained in the crust of both samples which indicated lower Maillard reaction than honey substituted samples while samples with ≥20% honey substitution gave lower L^* values resulting from higher Maillard reactions. The crumb of 50% level of honey substitution bread had the highest yellowness (33.65) but was not significantly different ($P > 0.05$) from the control and other samples except for 40% honey substituted sample. However, sample with 40% and 50% level of honey substitution had the highest crust browning index (BI) of 116.7 and 113.37, respectively. The

Table 5. Crust and crumb colour of honey cassava-wheat bread

Sample	Crust colour				Crumb colour			
	L*	a*	b*	BI	L*	a*	b*	BI
0:100	$45.25^{c} \pm 7.7$	12.25 ± 1.4	$27.88^{c} \pm 5.2$	110.40	$64.23^{c} \pm 2.9$	$12.05^{b} \pm 13.6$	$32.75^{b} \pm 2.8$	82.90
10:90	$39.18^{a} \pm 13.0$	11.86 ± 3.0	$23.99^{a} \pm 1.8$	111.94	$64.0^{c} \pm 3.4$	$10.00^{a} \pm 10.9$	$31.54^{b} \pm 13.3$	77.38
20:80	$44.27^{bc} \pm 3.8$	12.39 ± 0.0	$27.57^{c} \pm 2.9$	112.53	$58.04^{bc} \pm 1.4$	$13.87^{b} \pm 1.3$	$33.61^{b} \pm 4.7$	100.26
30:70	$39.18^{a} \pm 13.0$	11.86 ± 3.0	$23.99^{a} \pm 1.8$	111.94	$53.48^{ab} \pm 1.8$	$13.85^{b} \pm 1.2$	$27.69^{b} \pm 32.8$	89.68
40:60	$41.42^{ab} \pm 6.6$	12.20 ± 3.6	$26.38^{b} \pm 0.9$	116.7	$50.8^{a} \pm 9.3$	$14.05^{b} \pm 2.9$	$18.14^{a} \pm 43.3$	63.60
50:50	$41.09^{a} \pm 11.0$	11.58 ± 3.2	$25.72^{b} \pm 3.5$	113.37	$53.29^{ab} \pm 10.2$	$12.10^{b} \pm 15.5$	$33.65^{b} \pm 19$	110.60
		NS						

0:100=Cassava-wheat composite bread baked with 0% honey (Control), 10:90=Cassava-wheat composite bread baked with 10% honey, 20:80=Cassava-wheat composite bread baked with 20% honey, 30:70=Cassava-wheat composite bread baked with 30% honey, 40:60=Cassava-wheat composite bread baked with 40% honey, 50:50=Cassava-wheat composite bread baked with 50% honey. Mean values followed by different superscript within columns are significantly different ($P < 0.05$), NS = No Significant difference.

honey substituted samples were generally darker in crust colour than the control sample due to the Maillard browning and caramelization reaction in the crust. Investigation into the chemistry of the gelatinization of cassava-wheat composite starch in mixed sugar systems (sucrose-honey) would assist in substantiating the irregular trend observed in some physical properties of samples in this study.

Conclusion

Incorporation of honey in 10% cassava-wheat composite flour did not affect the water absorption and the dough quality. However, the dough stability increased, and better mixing tolerance were obtained as the level of honey inclusion was increased. At 30% honey substitution level, bread loaf volume was the highest. Liquid honey as partial substitute for sucrose at 20% and 30% level of substitution could be recommended for cassava-wheat composite bread making.

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