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Quality of Pan Bread as Affected by the Incorporation of Sweet Potato Flour

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IN THE present study, we investigate the effect of replacing wheat flour with sweet potato flour (SPF) on rheological, physicochemical and sensory properties of pan bread. Sweet potato flour was incorporated into wheat flour at three replacement ratios as10, 20 and 30%.The obtained results revealed that water absorption values ranged from (59.11) to (79.10%) with control pan bread and pan bread 3 (30% SPF) having the lowest and highest values, respectively. Pan bread 3 (30% SPF) represented the highest water absorption and degree of softening values as (79.10) and (110.15), respectively. The stability time values of the blends ranged from (4.00) to (12.00) min.The elasticity values ranged from 240 to 505 with WF and 30% represented the least elasticity in pan bread 3 (30% SPF) and highest elasticity in the control pan bread, while pan bread 3 (30%) had the lowest extensograph properties values.

Pan bread 3 (30% SPF) had the highest weight value (195.26) comparing with the control pan bread which was (151.50) and lowest volume and specific volume contents as 368.90 and 1.87, respectively. Pan bread 1 (10% SPF) had the highest protein content (10.47) after control pan bread which was (10.86) while pan bread 3 (30% SPF) had the lowest protein content as (8.79). Whereas fat content increased significantly with pan bread 3 (30% SPF) being the highest fat content as (7.97) comparing with the control pan bread which was (6.58).

Pan bread 3 (30% SPF) had the highest fiber content as (1.29). A significant change in fibers and fats content was found. There were no significant differences between NFE of pan bread samples which ranged between (97.19) and (79.95). The highest calcium, potassium and zinc contents found in pan bread 3 (30% SPF) as (45.26, 204.54 and 13.67), respectively, comparing with control pan bread which was (36.54, 189.51 and 13.25), respectively. B-carotene ranged from (0.42 to 0.79) with pan bread 3 having the highest β-carotene content as (0.79).

Pan bread 1 containing 10% sweet potato flour was equally acceptable and was significantly better than those with 0, 20 and 30% sweet potato flour as (5.00).By increasing sweet potato *(Ipomoea batatas)* flour levels, ash and crude fiber contents increased but decreased the level of protein.

Keywords: Sweet potato flours, Pan bread, Rheological properties, Chemical composition.

Introduction

After potato and cassava, sweet potato (*Ipomoea batatas* L.) (SP) comes in the third rank in world root and tuber crop production as 127 million metric tons (FAO, 2004) and this is in addition to being an underutilized nutritious food (Bovell-Benjamin, 2007 and Rodriguez-Amaya et al., 2011).SP consumed fried, grilled, baked, boiled or steamed, and the manufacture of SP purees, flours and starches broadens its possibilities for utilization (De Ruiter, 1978).

Sweet Potato(*Ipomoea batatas*) is inexpensive, food-beneficial, and a high source of carbohydrates and calories. Each 100 g of SP contains 7 Io vitamins A, which is 1.5 stimes more than the daily needs of vitamin A for adults(Taneya et al., 2014).Sweet potato has low protein content, and higher lysin content (limit of amino acids in grains) than rice (Winarno, 1982). Color and pulp crust can be a mix of white, yellow, orange or purple. Yellow and orange colors are attributed to carotenoids, especially β-carotene (2.9-150.6 µg / g), vitamin A precursors (Colladoet al., 1997 and Rodrigue-Amaya et al., 2011).

Zhou and Therdthai (2006) and Bayomy (2006), reported that bread is the most basic food consumed in different regions of the world. Population increasing in the universe and particularly in the Egypt, leads to a progressive production of wheat in a higher percentage of the day to day and try to get another source of flour.The bread and its flavors vary from different ingredients and bread styles around the world. To change food habits and reduce pressure on wheat, it was necessary to use commodities other than wheat to produce suitable food products. Noodles, cakes, biscuits, breads,...etc were produced. using SPF mixed with wheat flour. SPF blend could be a valuable raw material to substitute wheat (BBS,2008). Sweet potatoes are produced on a wide geographical scale, a low input crop, short production cycle, marginal condition, sensory qualities and nutritional value in terms of flesh texture, colors and taste. SP are rich in the total phenolics, β-carotene, dietary fiber, anthocyanins, folic acid, minerals and ascorbic acid depending on the flesh color (Woolfe, 1992 and ILSI, 2008).

Sammy (1970) reported that SP 15% in bread and 20-30% in pastries represented no harmful effects, but improvement in baking characteristics using 1% glycerylmonostereate or glycerylmonopalmitate. Collins and Abdul Aziz (1982) replaced wheat flour with 7 to 21% SPF and puree in baked and steam-cooked doughnuts. Overall sensory quality did not decrease, but specific volume and texture were affected. 15% SPF in bread caused good loaf volume and crust and crumb characteristics (Collado et al., 1997). Bread had an acceptable score in overall quality with mashed SP (Bauchamp de Caloni, 1989). The present study was performed to evaluate the suitability of replacing wheat flour using sweat potato flour in pan bread.Chemical, rheological and sensory properties of bread were studied.

Materials and Methods

Materials

Sweet potato tubers (Mabroka species) were obtained from National Center for Agricultural Research, Dokki, Egypt, wheat flour (72% extraction), and other major ingredients were procured from the local market.

Preparation of sweet potato flour

Sweet potato tubers were washed, peeled, trimmed, sliced and blanched for 5 min in boiling water. Then dried in a cabinet dryer at 60-65°C for 8-10 hr and finally milled to produce sweet potato flour(Taneya et al., 2014).The flour was stored in polyethylene bags before used.

Preparation of flour blends

Wheat flour (72% extraction) was well blended with SPF to produce individual mixtures containing 10, 20 and 30% replacement levels. All samples were stored in airtight containers and kept at 5-7C° until requested.

Baking tests

Three blends formulations were baked using the straight dough methods (Trejo-González et al., 2014) with the following baking formula: 300 g flour or composite flour (The study aims to replace potato flour instead of wheat flour by 10% to produce pan bread 1, 20% to produce pan bread 2 and 30% to produce pan bread 3), 15 g sugar, 20.1 g shortening, 10.5 g compressed yeast, 3 g salt and 180 ml water. The dough was mixed for 4 min, raised for 30 min, punched for 5 min, and raised for another 30 min. The dough was divided, punched again for 5 min, rounded and molded. Then it was placed in baking pans and allowed to rise for 60 min at 30°C. Loaves were baked for 10 min at 250°C. The pan bread samples were allowed to cool on racks for about 1hr before evaluation.

Rheological properties of bread dough

Rheological properties of doughs were evaluated using farinograph and extensograph according to AACC (2005) methods.

Physical evaluation

The specific volume of bread was determined by a modification of the rapeseed replacement method according to the AACC method 10-05.01 (AOAC, 2000), using sesame seed instead of rapeseed. Loaf volume was measured by sesame seed displacement immediately after removal from the oven and weighing. Loaves were placed in a container of known volume into which sesame seed were run until the container was full. The volume of seed displaced by the loaf was considered as the loaf volume. Loaf specific volume (SV) was calculated according to the following:

Specific loaf volume (cm^3/gm) = loaf volume (cm^3) / loaf weight (gm)

Weights of bread loaves were measured with a digital weighing scale.

Chemical composition

Moisture content, crude protein, crude fat, ash and crude fiber contents were determined according to the methods described by AOAC (1990).

Sensory evaluation

Pan bread samples were coded and presented to fifteen - member panel of judges who are familiar with the product for sensory evaluation. The panelists scored the taste , colour, odour, texture and overall acceptability of the bread using a five point hedonic scale, where 5 indicates extremely like and 1 extremely dislike (Ihekoronye and Ngoddy, 1985).

Statistical analysis

Data are based on averages from 3 measurements per determination. Pearson regression coefficients were calculated for farinograph and extinsograph parameters, as well for specific volume and loaf firmness, using Windows 95 Excel program. A two-tailed test was used to determine significance levels of the correlation coefficients (O'Mahony, 1986). Sensory data scores were analyzed by analysis of variance with mean separation by LSD ($P < 0.05$).

Results and Discussion

Water absorption (WA) is the amount of water required to develop dough to the point of greatest torque when, for wheat flour, the gluten would have been fully developed. WA values ranged from (59.11) to (79.10) with control pan bread and pan bread 3 (30% SPF) having the lowest and highest values, respectively. Earlier studies (Doxastakis et al., 2002 and Malomoet al., 2011) have also reported that composite blends absorbed more water. The increase in water absorption values in SPF blends unconnected with higher crude fiber, crude fiber has components that are hydrophilic (D'Appolonia and Kim, 1976 and Hu et al., 2007) and capable of forming a solution of high viscosity (Yin et al., 2011).

Flour during mixing exhibited the rheological characteristics (Table 1) and revealed that there were no significant differences between pan bread samples in arrival time, whereas all samples arrived at 1.00 min relatively short times, indicating faster dough development and faster uptake of water (Lorenz, 1990). Arrival time is a measure of the rate at which water was taken up by the flour. AT was the time to the nearest one-half minutes required for the top of the curve to reach the point of the greatest torque after the commencement of mixing (500 BU consistency line) (Shuey, 1990 and Abang Zaidel et al., 2010).

Dough development (DD) began with the addition of water and commencement of mixing operation. All ingredients are hydrated and appeared like a sticky paste in the begining. Belton (1999) and Letang et al. (1999) showed that interactions of glutenin proteins with each other in the loop by disulfide bonds caused gluten development. Because of the imposed shear and stretching forces, more protein was hydrated and the glutenins inclined to align (Abang Zaidel et al. 2010).Cross-links began to break due to the breaking of disulfide bonds when the dough was mixed beyond its peak development. Glutenins became depolymerized and the dough was over mixed.

TABLE 1. Farinograph characteristics of wheat and SPF blends.

SpF samples	Water absorption %	Arrival time (min)	Dough development (min)	Stability time (min)	Degree of softening (B.U)
Control	59.11±4.72^{c}	1.00±0.0^{a}	7.0±1.0^{a}	12.0±0.5^{a}	35±5.0^{d}
SPF 10%	66.36±8.03^{b}	1.00±0.0^{a}	5.5±0.5^{b}	10.0±0.5^{b}	75±10.0^{c}
SPF 20%	71.87±7.84^{b}	1.00±0.0^{a}	3.5±0.5^{c}	4.5±0.5^{c}	100±5.0^{b}
SPF 30%	79.01±6.77^{a}	1.00±0.0^{a}	3.0±1.0^{c}	4.0±0.5^{c}	110±15.0^{a}

Results are average ± SD of duplicates, a–c, Mean in same column with the same subscripts is not significantly different ($P < 0.05$); B.U: Brabender unit.

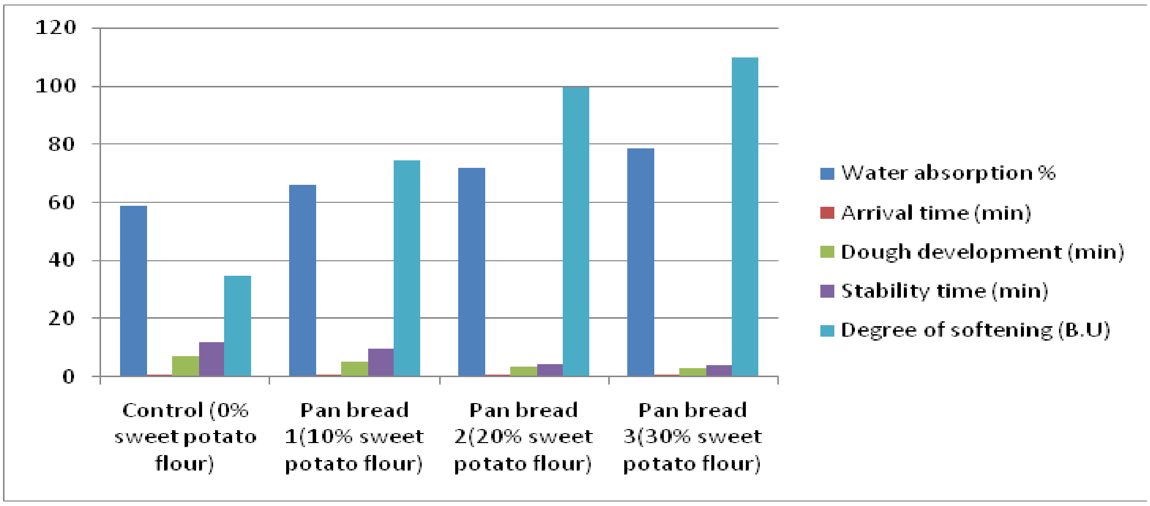

Fig. 1. Effect of sweet potato flour percentage on rheological properties of dough as by farinograph analysis.

We can notice how much tolerance the flour has to over or under mixing from Stability Time (ST) (Schiller, 1984). WF had a ST value of (12.00 min), whereas all samples had significantly lower ST which decreased as WF was replaced with SPF. The ST values of samples ranged from (4.00) to (12.00) min. These ST directions agreed with the reports of Olatunji and Akinrele (1978) for breadfruit and tropical tuber for brown rice pre-germinated (Michiyoet al., 2004). Reverse behavior was observed for degree of softening (DOS). Addition of SPF was the best for DOS of dough. So, there was statistical difference between control and dough supplemented with other ratios of blends concerning DOS. DOS ranged between (35.50) and (110.15). Enzyme activity of fractions and subsequently weakening of mixed dough could be seen in these results (Kim et al., 2003).

Increasing SPF presence in dough stability and dough development time caused reduction in the ability of pan bread samples to sustain the viscoelastic property of the dough.

Extensograph

Results in Table 2 indicate that the addition of SPF to all samples significantly decreased linery elasticity, extensibility, proportional number and energym. To evaluate wheat flours quality for bread making, extensograph is the main dough testing instrument use (Bettge et al., 1989 and Janssen et al., 1996).

The elasticity values sorted from (240) to (505) with WF and the 30% sample had the least elasticity in pan bread 3 (30% SPF) and the highest elasticity was recorded in the control pan bread. The dough on the basis of the elastic resistance were described by elasticity that appeared during their bi-axial deformation (Pyler, 1988 and BaNu et al., 2011). That related with decreasing of SPF substitution levels.

TABLE 2. Extensographcharacteristics of wheat and SPF blends.

SpF samples	Pan bread samples	Elasticity (B.U)	extensibility (min)	Proportional number	Energy (cm^2)
Control	Control	505±34^a	40±8.5^a	12.62±2.35^a	26±3^a
SPF 10%	Pan bread 1	390±51^b	36±4.5^b	10.83±2.03^b	20±2^b
SPF 20%	Pan bread 2	370±29^b	34±7^{bc}	10.88±0.5^b	19±6^b
SPF 30%	Pan bread 3	240±39^c	33±7^c	7.27±1.21^c	14±2^c

Results are average ± SD of duplicates, a–c, Mean in same column with the same subscripts is not significantly different (P < 0.05); B.U: Brabender unit.

For douf extensibility, values ranged from (33) to (40) mm with the 30% sample and WF had the least and highest extensibility, respectively; indicated by the baking strength of the dough by energy required for deformation. It sorted from (14×10^{-4}J) in the 30% blend to (26×10^{-4} J) in the control pan bread. Baking strength decreased as WF was replaced with SPF.

With a note to continuous gluten matrix and starch granules embedded in douf, we can know how the nonlinear viscoelastic behavior of WF dough is (Collar et al., 2007). It possesses the properties of both solid and liquid bodies, and exhibited the rheological properties of ideal solid and fluid bodies. Addition of SPF to samples increased fiber and starsh contents, whereas decreasing protein quality and quantity needed to sustain viscoelastic behavior of their dough (Fig. 1&2) as shown by the significant ($P < 0.05$) Important quality indicators are shown in Tables 1&2.

Physical properties

Results in Table 3 show that there was a significant increase in incorporating pan bread samples with SPF, where pan bread 3 (30% SPF) had the highest weight value as (195.26gm) comparing with the pan bread control which had (151.50gm) and this was to be expected from the increase in absorption observed in the farinograph. The results were consistent with Singh (2008).The effect of treatments on weight, volume and specific volume appeared in Fig. 3. There was a slight decrease in the volume and specific volume after incorporating pan bread with (SPF) where pan bread 3 (30% SPF) had the lowest volume and specific volume contents were (368.90 cm^3) and (1.87cm^3/gm), respectively. Perhaps the reason was the higher water holding capacity of SPF. Volume of SP pan bread decreased linearly by increasing specific volume in the same way by higher fiber content in the flour.

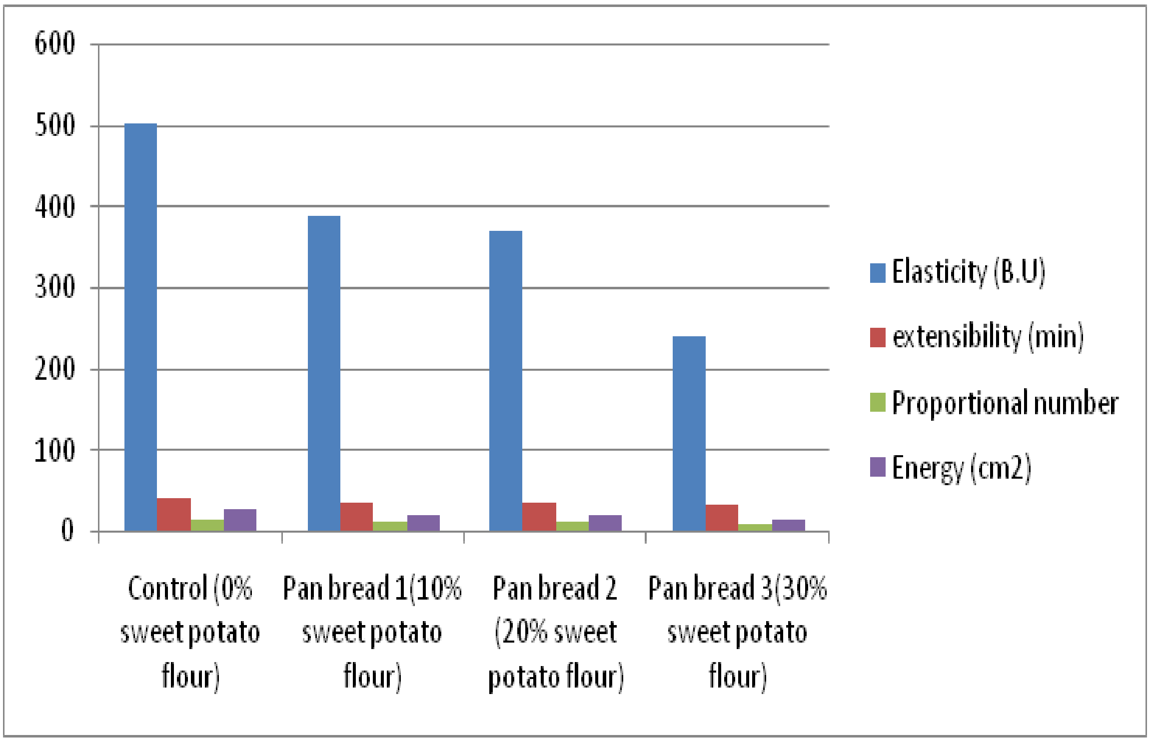

Fig. 2. Effect of sweet potato flour percentage on rheological properties of dough as by extensograph analysis.

TABLE 3. Effect of replacement of wheat flour with sweet potato flour on weight, volume and specific volume of pan bread.

Pan bread	Weight (gm)	Volume (cm^3)	Specific volume (cm^3/gm)
Control	151.5±17.26d	427.50±43.5a	2.82±0.08a
Pan bread 1	177.5±23.10c	403.05±36.0b	2.27±0.03b
Pan bread 2	181.5±9.55b	385.45±16.0c	2.12±0.08c
Pan bread 3	195.26±21.87a	368.90±29.5d	1.87±0.03d

Data are the average± SD of three determinations.

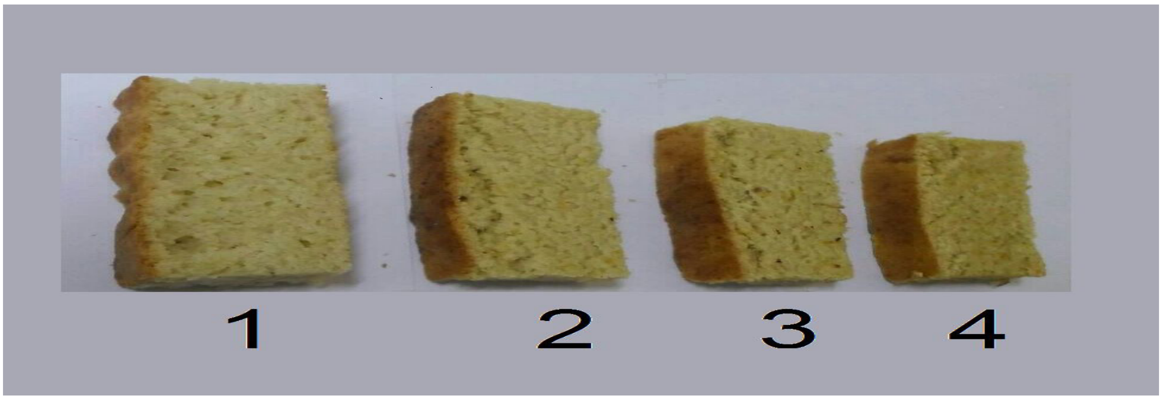

Fig. 3. Pan bread produced from mixing wheat flour with sweet potato flour.
1-Control pan bread without sweet potato flour, 2- Pan bread with 10% sweet potato, 3- Pan bread with 20% sweet potato and 4- Pan bread with 30% sweet potato flour.

Chemical composition of pan bread

The three different samples of the control pan bread (100% wheat flour), pan bread 1 (10% SPF), pan bread 2 (20% SPF) and pan bread 3 (30% SPF) were analyzed for moisture, fat, protein, ash, fiber and total carbohydrate, carotenoids and some minerals and the results are presented in Table 4.

A significant difference happened by increasing SPF in the samples during the present investigation. Pan bread samples moisture content increased mainly with SP increasing because of the high water binding capacity of SP with higher moisture content in samples with pan bread 3 (30% SPF) the highest moisture level was (31.41) comparing with the control pan bread which was (28.11). Moisture content results of pan bread samples agree with Kalpana (2003) results that used green gram flour in biscuits preparation.

The protein content of pan bread samples decreased significantly due to the lower protein content of sweet potato. Pan bread 1 (10% SPF) had the highest protein content as (10.47) after control pan bread (10.86) with pan bread 3 (30% SPF) having the lowest protein content as (8.79). Whereas fat content increased significantly with pan bread 3 (30% SPF) having the highest fat content as (7.97%) comparing with the control pan bread (6.58%). Ash content of pan bread blends increased significantly because of the higher ash content of SP and fat adding during preparation of pan bread. Both refined SPF and wheat flour had lower fat content and hence the total fat content in samples where fat content slightly decreased with SPF increasing (Chauhan and Bains,1985) with pan bread 3 (30% SPF) having the highest ash content as (2.76%).

Fiber content of pan bread samples was increased significantly because of the higher fiber content of SPF. When fiber absorbs more amount of water, it makes the appetite completely satisfied with fullness sensation. Pan bread 3 (30% SPF) had the highest fiber content as (1.29%). There was a significant difference in fat and fiber content because of increasing SPF additions as 00:100%, 10:90%, 20:80%, 30:70% to WF blend. SPF flour had the lowest moisture content and the highest starch and fiber contents,whereas, WF was the highest in moisture, carbohydrate and protein content. A significant difference was found between the blends. There were no significant differences between NFE of pan bread samples which ranged between (79.19%) and (79.95%).

The mineral/ carotenoids composition of pan bread samples is presented in Table 4. Calcium and β-carotene contents in pan bread increased significantly with increasing SPF because sweet potato crop is rich in nutrients (Simonne et al., 1993 and Takahata et al., 1993). Calcium is necessary for supporting bone formation and growth. The highest calcium, potassium and zinc contents were found in pan bread 3 (30% SPF) as (45.26 mg/100gm, 204.54 mg/100gm and 13.67ppm), respectively, comparing with the control pan bread which had (36.54 mg/100gm, 189.51 mg/100gm and 13.25ppm), respectively.

The increased β-carotene content could be from the orange fleshed potato flours (Woolfe, 1992). ß-carotene ranged from (0.42mg ß-carotene/100 gm) to (0.79 mg ß-carotene/100 gm) with pan bread 3 having the highest β-carotene content as (0.79 mg ß-carotene/100 gm). The β-carotene which is pro vitamin A is an essential nutrient required for maintaining the immune function (Stephensen, 2001). It also helps the maintenance of skeletal, soft tissue, mucous membranes, skin and healthy teeth and it is called retinol due to producing the retina pigment of the eye. Bread rich in these nutrients would enhance the health of both children and adults.

Sensory evaluation

Values of taste, colour, odour, texture and overall acceptability of pan bread different samples prepared from SPF are shown in Table 5. Variance analysis was done for taste, colour, odour, texture and overall acceptability of pan breads and panelists accepted all pan bread samples with different acceptability ranks.

As shown in Table 5, pan bread 1 had the highest taste value as (4.83). Pan bread 1 and 2 were higher than that of the control pan bread (4.05) as (4.90) and (4.75), respectively. For odour, pan bread 1 and 2 represented the highest odour scours as (1.00) for both. Table 5 showed that texture score of all pan bread samples are higher than the control (3.00), with pan bread 2 containing 20% sweet potato having the highest score (4.95) for texture.

SPF % and acceptability decreased certainly. As gluten decreased, binding capacity decreased as well. Pan bread 1 containing 10% SPF were more acceptable and was significantly preferred than 0, 20 and 30% SPF as (5.00).

Colour value decreased to (3.80) because of SPF increasing which represented a dark brown color to crust of ban bread for the compounds resulting from the Millard reaction which was not preferred much by panelist. So, taste value, odour and texture decreased. That was due to flavor component and caramelization of free sugar in SPF during baking (Singh, 2008). Data showed pan bread 1 containing 10% SPF the most acceptable. At 10% sample, incorporation of SPF levels improved the sensory attributes and overall acceptability (Singh, 2008).

TABLE 4. Chemical composition of pan bread made with the replacement of the potato flour for wheat flour (on dry weight).

Nutritional composition	Pan bread			
	0% Sweet potato flour	**10% Sweet potato flour**	**20% Sweet potato flour**	**30% Sweet potato flour**
Moisture (%)	28.11±0.17[c]	29.72±0.41[b]	30.31±0.52[ab]	31.41±0.30[a]
Crud Protein (%)	10.86±0.76[a]	10.47±0.27[ab]	9.75±0.40[b]	8.79±0.77[c]
Crude Fat (%)	6.58±0.43[c]	7.01±0.66[b]	7.59±0.17[a]	7.97±0.05[a]
Ash (%)	2.11±0.24[b]	2.31±0.33[b]	2.41±0.19[ab]	2.76±0.40[a]
Crude Fibers (%)	0.50±0.06[b]	0.59±0.12[b]	0.92±0.20[a]	1.29±0.23[a]
NFE*	79.95±2.68[a]	79.62±1.98[a]	79.33±2.30[a]	79.19±4.77[a]
Ca (mg/100 gm)	36.54±5.12[b]	39.07±1.30[b]	43.49±2.73[a]	45.26±4.02[a]
K (mg/100 gm)	189.51±3.82[a]	196.44±26.45[a]	201.80±19.83[a]	204.54±26.88[a]
Zn (ppm)	13.25±0.85[a]	12.78±1.29[a]	13.49±0.74[a]	13.67±1.47[a]
Carotenoids (mg ß-carotene/100 gm)	0.29±0.03[d]	0.42±0.03[c]	0.64±0.07[b]	0.79±0.04[a]

Means± SD in the same row not sharing the same superscript is significantly different at ($P \leq 0.05$).

NFE*= Nitrogen free extract calculated by difference.

TABLE 5. Sensory evaluation of panbread prepared from composite – SPF - wheat flour blends.

Pan bread Samples	Taste	Colour	Odour	Texture	Over all Acceptability
Control	4.20±0.25[b]	4.05±0.36[c]	3.15±0.53[c]	3.00±0.06[d]	4.00±0.27[b]
Pan bread 1	4.83±0.15[a]	4.90±0.10[a]	5.00±0.00[a]	4.05±0.51[c]	5.00±0.00[a]
Pan bread 2	4.27±0.04[b]	4.75±0.23[b]	5.00±0.1[a]	4.95±0.14[a]	4.95±0.05[a]
Pan bread 3	4.04±0.26[c]	3.80±0.41[d]	4.75±0.14[b]	4.75±0.11[b]	3.00±0.52[c]

Means within the same column without a common letter (a-d) are significantly different ($P \leq 0.05$).
Pan bread 1(with 10% sweet potato flour), Pan bread 2(with 20% sweet potato flour), Pan bread 3(with 30% sweet potato flour).

Conclusions

The results obtained indicated that wheat flour could be replaced with sweet potato flour up to 20% without adversely affecting bakong performance of pan bread. Pan bread with SPF yielded good quality breads and it will find widespread acceptance among those interested in food awareness and health attention.

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تأثير دمج طحين البطاطا الحلوة على جودة الخبز

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تتناول هذه الدراسة تأثير الدقيق المركب من القمح ودقيق البطاطا الحلوة على الخصائص الريولوجية والفيزيائية والحسية للخبز. تم دمج دقيق البطاطا الحلوة في دقيق القمح بثلاثة مستويات استبدال ١٠ و ٢٠ و ٣٠٪. تراوحت قيم امتصاص الماء من (٥٩,١١) إلى (٧٩,١٠٪) لخبز القوالب الكنترول وخبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) ذات القيم الأقل والأعلى على التوالي. أما خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) فكان أعلى درجة لامتصاص للماء والتليين (٧٩,١٠) و(١١٠,١٥) على التوالي. وترواح زمن ثبات العجينة من (٤,٠٠) إلى (١٢,٠٠) دقيقة. كما تراوحت قيم المرونة بين (٢٤٠) و (٥٠٥) مع مزيج دقيق القمح و (٣٠٪ دقيق البطاطا الحلوة) الذي يوفر أقل مرونة في خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) وأعلى مرونة في خبز القوالب الكنترول، مع كون خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) ذو أدنى قيم لخصائص الاكستينسوجراف .

كان خبز القوالب (٣٠٪ دقيق البطاطا الحلوة) أعلى قيمة للوزن مقارنة مع خبز القوالب الكنترول وكان أيضاً أقل في الحجم والحجم النوعي بواقع (٣٦٨,٩٠) و(١,٨٧) على التوالي. سجل خبز القوالب ١ (١٠٪ دقيق البطاطا الحلوة) أعلى قيمة للبروتين بواقع(١٠,٤٧٪) بعد خبز القوالب الكنترول الذي كان (١٠,٨٦٪) مع كون خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) أقل محتوى للبروتين (٨,٧٩٪). وعلى النقيض بالنسبة للدهون، حيث زاد محتوى الدهون بشكل ملحوظ مع كون خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) هو أعلى محتوى للدهون مقارنة مع خبز القوالب الكنترول.

سجل خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) أعلى محتوى للألياف (١,٢٩).كان هناك تغيرات نوعية كبيرة في محتوى الألياف والدهون. لم تكن هناك فروقات ذات دلالة إحصائية بين معدل التغذية لعينات خبز القوالب التي تراوحت بين (٩٧,١٩) و(٧٩,٩٥). تواجد أعلى محتوى من الكالسيوم والبوتاسيوم والزنك في خبز القوالب ٣ (٣٠٪ دقيق البطاطا الحلوة) مقارنة مع خبز القوالب الكنترول. تراواح محتوى βكاروتين من (٠,٤٢) إلى (٠,٧٩) حيث سجل خبز القوالب ٣ أعلى محتوى β كاروتين(٠,٧٩).

حاز خبز القوالب ١ الذي يحتوي على (١٠٪دقيق البطاطا الحلوة)على قبول المتذوقين، وكان أفضل بكثير من تلك التي تحتوي على دقيق البطاطا الحلوة٢٠ و ٣٠٪ بواقع (٥,٠٠). أظهر ارتفاع مستويات البطاطا الحلوة في تركيبات خبز القوالب ارتفاعا في الرماد والألياف الخام ولكنها أدت الى انخفاض مستوى البروتين.