Utilization of Baobab (*Adansonia digitata*) Fruit Pulp Flour in Some Bakery Products

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ABSTRACT

The goal of the study was to produce some functional foods using a combination of wheat flour (WF) and baobab pulp flour (BPF), enhancing the nutritional content and using these locally grown crops to lessen the reliance on wheat imports. *Adansonia digitata* L., commonly known as "Baobab," is a magnificent tree that is valued for its nutritional and therapeutic qualities. Baobab fruit pulp was ground into flour and used in various ratios (5,10 and 20%). WF was used as the base flour (control) in a blended flour. The partially substituted composite flour (WF + BPF) was examined for its rheological properties. Mixolab was used to evaluate the composite flours› rheological characteristics. Furthermore, a panel of 20 trained participants evaluated the organoleptic characteristics of the baked products. Biscuit and crackers where prepared in these study. The results of rheological characteristics of composite flour investigated by Mixolab showed that as the amount of BPF increased, the composite flour›s capacity to absorb water was reduced whereas, the development time and the dough stability increase . Up to 5-10%, BPF enhanced nutritional quality without negatively affecting technological or organoleptic properties, and it also had positive effects on health and the economy.

Keywords: composite flour, mixolab, biscuit, crackers.

INTRODUCTION

Many efforts have been made to create new food products that can improve people's health (Galanakis, 2020). Snacks play an important role in reducing hunger between meals among young and adult consumers. The most common and popular dry snack is a grain-based (wheat) snack, which has a low nutritional value (Chavan *et al*., 1993).

Adansonia digitata, also known as the baobab tree, is found in Sudan's arid and semi-arid regions. (Rashford, 1994). African baobab (*Adansonia digitata* L., Malvaceae) is a critical indigenous fruit tree species for food security, nutrition, and income generation in Africa's rural areas. (Chadare *et al*., 2009). The baobab fruit contains prebiotics, vitamin C, thiamine, carbohydrates, dietary fiber, protein, pectin, energy, potassium, calcium, iron, magnesium, zinc, valine, tryptophan, phenylalanine and tyrosine (Africa, 2009, Namratha and Sahithi, 2015). It has a ten fold increase in intrinsic antioxidant capacity over orange pulp. Because of its high nutritional value, baobab has been dubbed a "super fruit" (Rahul *et al*., 2015). It was classified as a "novel food" by the European Commission (Buchmann *et al*., 2010) and a "food ingredient" by the United States of America. Baobab fruit pulp (BPF) has been approved as a food ingredient since 2008, and it was granted Generally Recognized as Safe (GRAS) status in the United States in 2009. Edible parts of the tree provide vitamins, minerals, proteins, and energy that are not commonly obtained from cereal-dominated diets in Africa's dry lands. Baobab fruits are contribute into juice, yoghurt, gruel, sour dough, oil and a coffee-like drink, and dried as food reserves (Saka *et al*., 2001). Baobab fruit pulp is well-known around the world for its high nutritional content and potential for income generation. Studies on flour blends containing baobab pulp powder revealed that cereal flours had improved rheological and mineral content Mounjouenpou *et al*. (2018). The aim of wheat flour fortification is to increase the nutritional value as well as the sensory characteristics of produced bread and other baking products.

International statutory bodies including the European Commission and the United States of America (USA) Food and Drug Administration

(FDA) have approved the use of baobab pulp as a novel food and ingredient in certain nutritional products (Chadare *et al.,* 2009*,* Li *et al.,* 2017*).*

A combination of flours made from starchy tubers such as potatoes, yams, and cassava, as well as flour and grains high in protein is called composite flour. According to Noorfarahzilah *et al*. (2014), this mixture is designed to fulfill certain functional properties and nutritional composition, and it may or may not contain wheat flour. It has higher levels of minerals, vitamins, fiber, and proteins than flour derived from a single grain. Shanthi *et al*. (2005) stated that the composite flour blend can offer a well-rounded source of nutrients. In developing nations like Africa and other parts of the world, the use of composite flours has improved native plant productivity and preserved resources, among other advantages. Additionally, it was noted by Berghofer (2000) and Bugusu *et al*. (2001) that the use of composite flour might help make better use of the agricultural output produced in the country.

The goal of this study was to produce some functional foods using a combination of wheat flour and baobab pulp flour (BPF), enhancing the nutritional content and using these locally grown crops to lessen the reliance on wheat imports.

MATERIALS AND METHODS

Materials

Wheat flour (72%), butter, oil, baking powder, salt and sugar were purchased from the local market in Alexandria, baobab fruit was procured from a local market in Sudan.

Methods

Technological methods

Preparation of BPF

The BPF was produced using a modified version of the methodology (Diop *et al*., 2005).The baobab fruit pulp was softly crushed in a mortar to prevent shattering the seeds and improve the separation of fibers from seed and pulp. The pulp was then violently crushed and sieved through a 200-mesh sieve to produce baobab pulp flour (Benkidra and Zidoune, 2010).

Preparation of composite flours (WBF)

A two-element enhanced combination design was employed to produce the mixtures of wheat (WF) and (BPF) based on sample proportion, which was outlined as WF (a) (100:0)*,* representing 100% (WF) and 0% (BPF)*,* WBFs (b) (95:5)*,* representing 95% WF and 5% (BPF*,* WBFs (c) (90:10)*,* representing 90% wheat flour and 10% BPF and WBFs (d) (80:20)*,* representing 80% wheat flour and 20% baobab pulp flour.

Formulation and production of biscuit

This was done using the Protocol Miller and Methew (1985) with some modifications: Sugar 250 g and butter 250 g were mixed until afluffy texture was obtained*,* after which, 500 g of flour, 10 g of baking powder, and 2 g of salt were sieved and thoroughly combined in a separate container. The dry ingredients were added to the liquid mixture, the mixture was kneaded until it formed uniform dough. After being flattened to a thickness of roughly 3 mm, the dough was cut into the appropriate shapes using a biscuit mold. Then that, it was baked for ten minutes at 200°C. Then biscuits were allowed to cool to room temperature, they were packed in plastic bags.

Formulation and production of cracker

The cracker was prepared according to the method described by Konstantinos *et al*. (2023), with some modifications. The formula for making crackers included 500 g flour, 200 g water, 100 g oil, 10 g baking powder, 1 g of salt and 2 g sugar. All ingredients were mixed to produce a dough, which took 6 min. After quick kneading, the dough was allowed to rest for 30 min at room temperature. Using a roller and pieces, the dough was sheeted for 15 min, the crackers were baked at 170 °C in a baking oven and packed in plastic wraps after cooling at room temperature.

Physicochemical properties of WF and composite of WBFs

Water absorption capacity (WAC)

The technique described by Diniz & Martin (1997) was modified to estimate the water absorption capacity (WAC) of the sample. In centrifuge tubes, 0.5 g of the material was suspended in 10 ml of distilled water and vortexed for 30 s. The dispersions were centrifuged at 3,000 rpm for 25 min after standing at ambient temperature for 30 min. Whatman No. 1 filter paper was used to remove the supernatant and the amount of material recovered was precisely quantified. The difference was estimated between the volume acquired after filtration and the volume obtained when distilled water was first introduced to the sample. The following equation was used to determine the WAC, presented as ml of water absorbed per gram of material:-

$$\text{Water absorption capacity} = \frac{\text{amount of water absorbed}}{\text{weight of sample}} \times 100$$

Gluten parameters

A Glutomatic system (Perten Instruments, Huddinge, Sweden) was used to measure the amount of gluten in accordance with American Association of Cereal Chemists International (AACCI, 2000) Method No. 38–12. In summary, 10 g of flour were added to the machine to make dough. After that, the dough was rinsed with a salt solution (2%, w/v) and separated using standard procedures through a specially made sieve. After weighing the centrifuged dough and leftovers, the weight of the wet gluten was determined. Wet gluten was dried in a freeze dryer for 24 h to determine the dry gluten yield, which was then computed as the weight of the dry gluten divided by the weight of the flour multiplied by 100 (Kaushik *et al.,* 2015).

α-Amylase activity "falling number" and rheological tests

The falling number device was used to measure the α-amylase activity in the flour samples, following the methodology outlined by Shao *et al*. (2019). The rheological properties was conducted using the Alveograph (Chopin, Paris, France) in compliance with of AACCI Method No. 54-30A (AACCI, 2000). The resulting graph was used to calculate the alveo strength of the flour samples.

Damaged starch:

The amperometric SDmatic® approach (AACC 76-33-1) was used to determine damaged starch containing samples underwent double analysis, according to Medcalf & Gilles (1965), who showed that a flour›s ability to absorb iodine is proportionate to the amount of starch damage it contains, the amperometric technique was developed according to approved AACCI (method 76-33-1)

Sensory evaluation

The biscuit and cracker samples were evaluated for colour, flavour, taste, texture and overall acceptability on a nine-point hedonic scale (Chavan, *et al*., 1993), where nine represents like extremely (the highest) and one represents dislike extremely (the lowest).The evaluation was done by 20 semi-trained panelists selected from the staff and students of Food Science and Technology Department, Alexandria University, Egypt.

Statistical methods

Analysis of Variance (ANOVA) was performed on the study data in triplicate to identify any significant differences between the different samples. The version 25 of SPSS was used to analyze the data at the significance level of 0.05 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Rheological properties of wheat and other composite flours:

Gluten parameters and α-amylase enzyme activity

It is well known that the amount of gluten in the flour is one of the essential parameters when evaluating WF. There were only slight variations between WF and its blends with BPF in the wet gluten (31.08–30.59%) as well as in the dried gluten (10.62–11.94%) (Table 1). Wheat flour quality is not solely determined by its gluten content, wheat flour can also be further classified using the gluten index (GI), particularly if the wheat has comparable protein contents (Ortolan *et al*., 2018). The amount of gluten that is left in the strainer after wet gluten centrifugation is known as the gluten index, and serves as a measure of the gluten’s elasticity (Barak *et al*., 2014, Oikonomou *et al*., (2015). The % of GI in this study for WFa was 20.45%. This finding suggests that as the amount of gluten in the flour increases, its capacity to absorb water decreases. This fortified mixture of WBFs (c) (90% WF: 10% baobab pulp flour), could be beneficial in the manufacturing of sweets like confectioneries with the highest GI (20.64%). The flour samples used in this study had relatively high gluten index values, which indicates a strong gluten network and excellent gluten quality. According to Hu and Shang (2007), premium wheat types usually have a higher GI but a lower wet gluten content.

The falling number (FN)

As indicated in Table (1). The FN values for WFa 100% and WBFd 80:20%, respectively, ranged from 424.66 to 348.33, with a significant difference ($P \leq 0.05$). The FN is used to determine how the cereal enzyme α-amylase functions, which

Table 1: Effect of using BPF on the physicochemical, falling number and damaged starch :

Samples \ Parameters	Wet gluten%	Dry gluten%	Gluten index%	Falling NO.	Damaged starch
WFa	31.08[a]±0.09	10.62[b]±0.23	20.45[a]±0.33	424.66[a]±4.50	8.35[d]±0.13
WBFsb	30.84[a]±0.14	10.48[b]±0.19	20.36[a]±0.04	385.33[b]±41.63	9.25[c]±0.05
WBFsc	31.08[a]±0.56	10.44[b]±0.11	20.64[a]±0.54	375.33[b]±4.04	9.88[b]±0.07
WBFsd	30.59[a]±0.10	11.94[a]±0.52	18.65[b]±0.42	348.33[c]±5.85	10.51[a]±0.05

Values followed by the same letters in the same columns are not significantly different ($P \leq 0.05$).

WFa: 100% wheat flour: 0% baobab pulp flour, WBFsb: 95% wheat flour: 5% baobab pulp flour, WBFsc: 90% wheat flour: 10% baobab pulp flourt and WBFsd: 80% wheat flour: 20% baobab pulp flour

is directly related to the flour samples' thickness (Codină *et al*., 2012). Divergences in FN have been linked to differences in starch impairment and dimension (Lijuan *et al*., 2007) and period of flour preservation (Brandolini & Plizzari., 2010). There is a strong correlation between damaged starch and FN's impact on WF's baking performance. Flour with a moderate amount of damaged starch is more susceptible to enzymatic hydrolysis and facilitates easier hydration. However, if too much starch is damaged, it can cause the dough to become over-hydrated, increasing the speed of the dough and enzyme activity, (Antoine *et al*., 2004*,* Lijuan *et al*., 2007). The results in Table1 show that the addition of BPF at different ratios to wheat flour (WF) resulted in significant (P≤0.05) differences in all physicochemical properties except for wet gluten content.

Farinograph properties of WF and different composite dough

The hydration characteristics of a grain material may be determined using the water absorption index (WAI) which is defined as the quantity of water absorbed by a certain amount of flour. It is mostly affected by the starch properties in addition to the dietary fiber and fat content. The wheat blends with BPF had the lowest WAI, which may attributed to its low starch content. The WAI of the doughs was reduced, as shown in Table (2), the WAI of the flour samples varied from 55.10% in WFa to 50.90% in WBFsd. The reason for the high WAI in WFa (55.10%) might be due to the hydrophilically interact between the protein and the starch molecules in wheat flour and the form of hydrogen bonds with the addition of water molecules in the flour. Such farinograph results may be attributed primarily to the following factors: protein content, starch content, and gluten strength. The pattern of decline WAI is dependent on intricate interactions between the constituents of the flour. (Getachew & Admassu, 2022) Additionally, damaged starch and other components, as well as the gluten-forming proteins gliadin and glutenin, are all hydrated by water molecules (Baker, 2021). The lower WAI in different samples, WBFsb (53.80 %), WBFsc (52.60%), and WBFsd (50.90%) may be attributable to the baobab flour's ability to dilute wheat starch and protein. Starch is a hydrophilic natural polymer, and can absorb up to about 50% water (French, 1984) and then increase slowly as the starch content increases. Proteins are capable of attaching to significant quantities of water as they can to create hydrogen connections between polar clusters on the polypeptide sequence and water molecules (Mohajan *et al*., 2018).

The development time provides information about how the flour's constituent parts interact while being mixed. This is a fundamental parameter that shows when water is added for the first time and when the dough reaches its ideal viscosity and elasticity. A short time to the consistency line suggests early dough development and quicker water absorption. The duration of dough development varied between 2.5 min for WFa and 3 min for both WBFsc. WBFsd, this may be attributed to the interaction behavior between flour ingredients.

Dough stability

The time required for the dough to reach its maximum, when its consistency is greater than 500 BU, is known as dough stability. The dough stability time demonstrates the flour's consistency during mixing. In comparison to WFa, WBFd had the highest dough stability time 8.0 min, followed by WBFsc (7.0 min) and finally WBFsb (4.0 min).

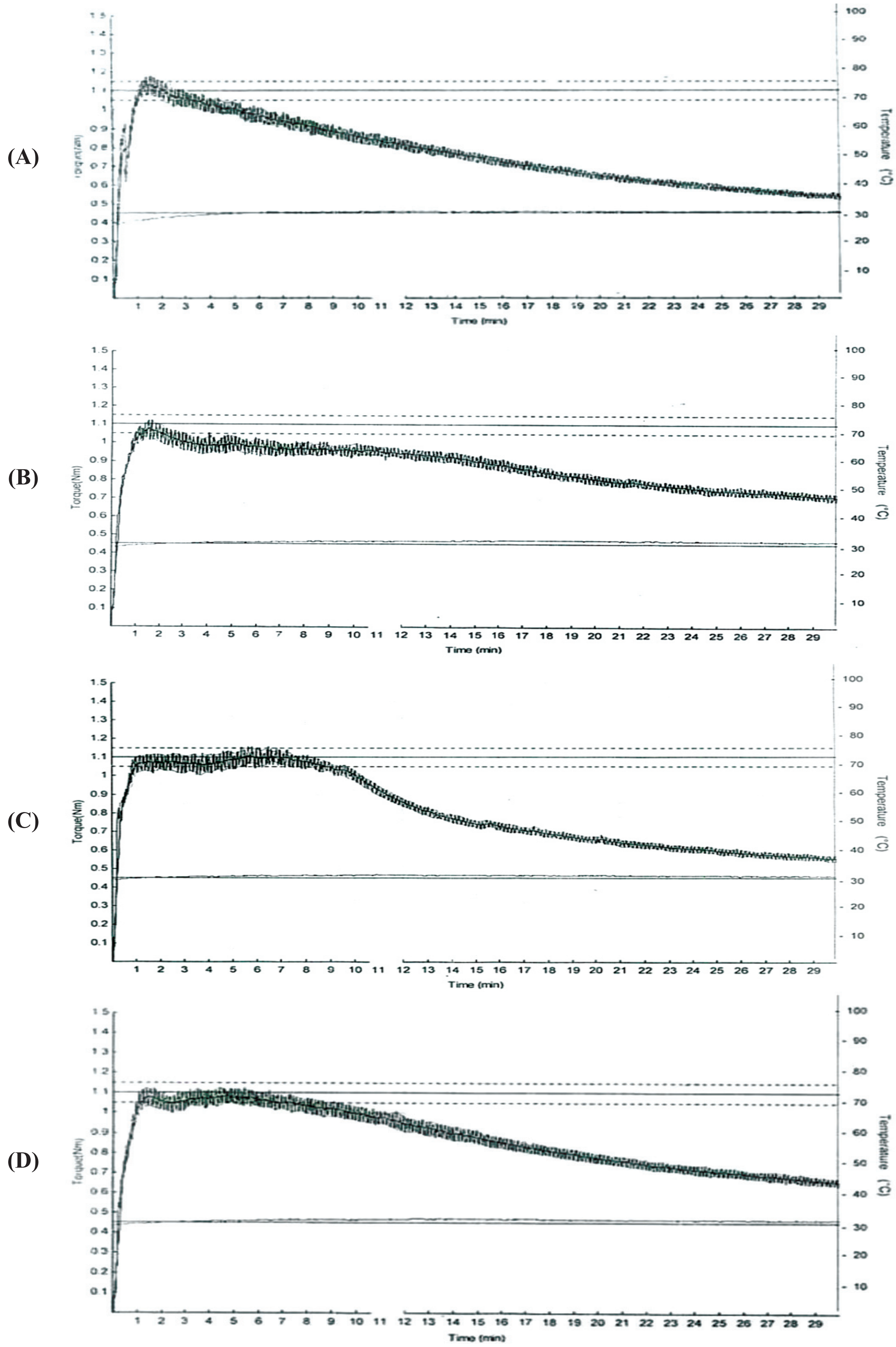

Fig. 1: Mixolab rheological profiles of the analyzed flour sample

A: WFa B: WBFsb C: WBFsc D: WBFsd

This finding suggests that wheat flour was less stable during processing. The flour's properties may be the reason why blend flour at 10 and 20% are tolerant of the mixing process. According to these findings, wheat and baobab composite flour have comparatively good farinograph properties for cookies. Results from Mixolab data sheets showed that replacing WF with BPF changed the rheological characteristics of WF, which in turn changed the behavior of the dough (Table 2).

Sensory properties of bakery products biscuits

Table (3) displays the mean sensory scores for biscuits made from wheat flour (WFa) and after the addition of BPF with different ratios. The inclusion of BPF had a significant ($P \leq 0.05$) effect on the sensory qualities of the products. Appearance and colour are extremely an important sensory attributes for any food because they influence acceptability. Figure (5) shows biscuit samples made from 100% WF and different addition of BPF with different ratios. Sample WBFsd (20% substitution) with BPF had the lowest appearance score (8.0), whereas sample WBFsb (5% substitution) with BPF present the highest score (8.70). The scores given to the appearance indicated that the panelists preferred the light-colored sample (WBFsb and WBFsc), whereas,WBFsd, was less acceptable (8.0). Wheat flour (WFa) samples represent the highest scores for the odor (8.65), the texture (8.6) and the taste (8.55) compared with the other composite flour WBFsb (8.2, 8.1 and 8.1 respectively), WBFc (7.60, 7.65 and 7.25, respectively) as well as WBFsd (7.35, 7.35 and 7.0, respectively. Whereas, WBFsb had the highest score for the overall acceptability (8.22) compared to other samples on the other hand.

Crackers

A panel consisting of 20 people evaluated the sensory qualities of cracker blends that contained 5, 10%, and 20% baobab. Table (4) displayed the average ratings for crackers' texture, flavour, colour, and overall acceptability. According to statistical analysis, the addition of varying amounts of baobab in cracker formulations had a significant ($P \leq 0.05$) impact on the crackers characteristics. The control samples had the highest score of odour than the cracker containing BPF. As shown in (Table 4), no significant difference was observed in colour scores between the crackers containing 5% and 10% BPF. Nevertheless, the crackers with 5% and 20% BPF showed a noticeably different preference for colour. Among the processed bao-

Table 2: Farinograph properties and water binding of WF and different composite dough

Samples \ Parameters	Water binding%	Water absorption%	Development time (min)	Stability (min)
WFa	17.59^{a}±0.30	55.10	2.5	3.0
WBFb	17.51^{a}±0.04	53.80	2.0	4.0
WBFc	17.79^{a}±0.46	52.60	3.0	7.0
WBFd	16.18^{b}±0.38	50.90	3.0	8.0

WFa: 100% wheat flour: 0% baobab pulp fruit, WBFb: 95% wheat flour: 5% baobab pulp fruit, WBFc: 90% wheat flour: 10% baobab pulp fruit and WBFd: 80% wheat flour: 20% baobab pulp fruit.

Table 3: Sensory evaluation of biscuits prepared from WF and after the addition of BPF at different percentages (5, 10 and 20%)

Samples \ Parameter	Appearance	Colour	Odour	Texture	Taste	Overall acceptability
WFa	8.05b±0.94	7.70b±0.73	8.65a±0.48	8.60a±0.47	8.55a±0.51	8.0ab±0.72
WBFb	8.70a±0.47	8.15ab±0.81	8.20a±0.59	8.10b±0.64	8.10b±0.64	8.22a±0.49
WBFc	8.65a±0.48	8.35a±0.48	7.60b±0.86	7.65c±0.65	7.25c±0.89	7.77b±0.71
WBFd	8.0b±1.25	7.50b±0.98	7.35b±0.97	7.35c±0.97	7.0c±0.79	6.97c±0.95

Values followed by the same letters in the same columns are not significantly different ($P \leq 0.05$).
WFa: 100% wheat flour: 0% baobab pulp flour, WBFsb: 95% wheat flour: 5% baobab pulp flour, WBFsc: 90% wheat flour: 10% baobab pulp flour and WBFsd:80% wheat flour: 20% baobab pulp flour.

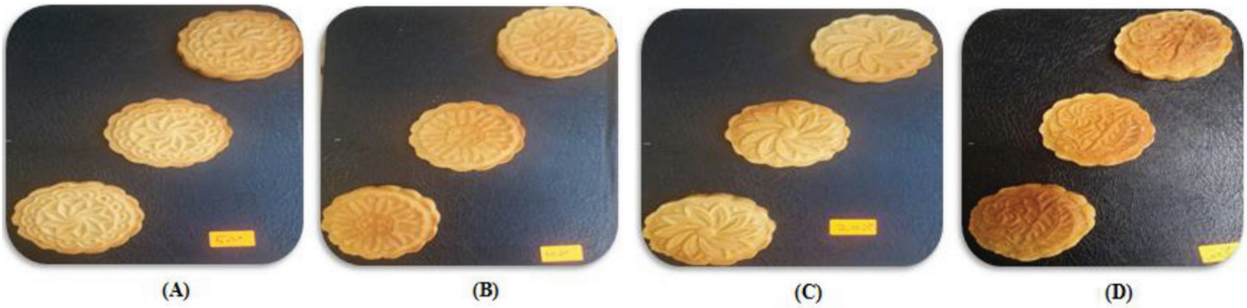

Fig. 2: General appearance of biscuits prepared from wheat flour and after the addition of BPF at different percentages

A: 100% WF B:95% WF:5% BPF C:90% WF: 10% BPF D: 80% WF:20% BPF

Table 4: Sensory evaluation of crackers prepared from WF and after the addition of BPF at different percentages (5, 10 and 20%)

Parameter / Samples	Appearance	Colour	Odour	Taste	Texture	Overall acceptability
WFa	8.87^{a}±0.13	8.40^{a}±0.73	8.50^{a}±0.60	8.15^{ab}±0.46	8.45^{a}±0.60	8.45^{a}±0.45
WBFsb	8.55^{ab}±0.51	8.32^{a}±0.78	8.17^{ab}±0.65	8.47^{a}±0.78	8.40^{a}±0.73	8.40^{a}±0.73
WBFsc	8.05^{b}±0.82	8.0^{a}±0.84	7.90^{b}±0.71	7.75^{b}±0.83	8.07^{b}±0.86	7.90^{b}±0.75
WBFsd	7.55^{c}±1.13	7.40^{b}±0.99	7.32^{c}±1.02	6.65^{c}±1.40	7.95^{b}±0.82	7.0^{c}±0.82

Values followed by the same letters in the same columns are not significantly different ($p \leq 0.05$).
WFa: 100% wheat flour: 0% baobab pulp flour, WBFsb: 95% wheat flour: 5% baobab pulp flour, WBFsc: 90% wheat flour: 10% baobab pulp flour and WBFsd: 80% wheat flour: 20% baobab pulp flour.

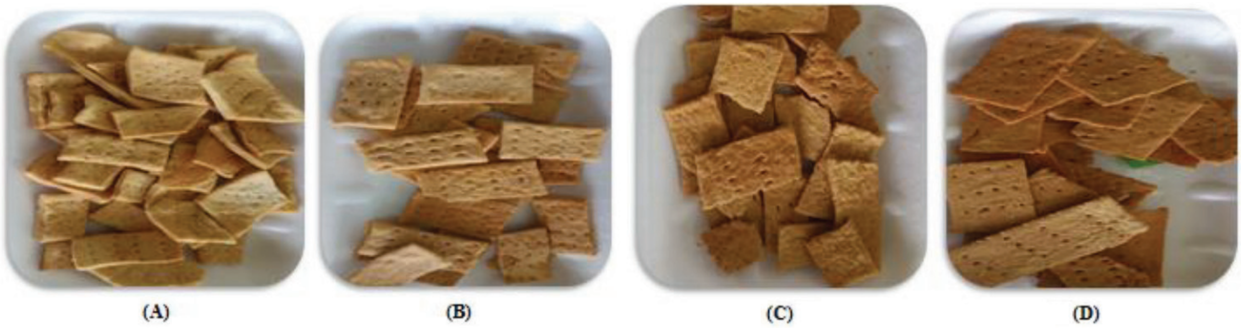

Fig. 3: General appearance of cracker prepared from wheat flour and after the substitution of WF with BPF at different percentages

A: 100% B:95% WF:5% BPF C:90% WF: 10% BPF D: 80% WF:20% BPF

bab incorporated crackers, crackers containing 5% baobab was the most preferable one. The taste of crackers containing 5 % baobab flour was significant (*p*≤ 0.05) better than the crackers containing 10 and 20 % BPF, respectively. No significantly difference could be traced in colour preference between the crackers containing 5% and 10% BPF. The Texture of crackers containing 5 % BPF was the most preferred and significantly (*p*≤ 0.05) better than the crackers containing 10 and 20 % BPF. Overall acceptability of the control crackers and 5% BPF was the highest and it was significantly (*p*≤ 0.05) better than 10 and 20% BPF.

CONCLUSION

It is recommended to intensify research into the use of baobab in food applications and to spread and educat communities about the importance of nutritional and health importance of baobab fruits. It is also recommended that the usage of baobab fruit pulp powder in bakery products could enhance their quality attributes.

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الاستفادة من دقيق لب ثمرة الباوباب في بعض منتجات الخبيز

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الهدف من الدراسة هو إنتاج بعض المخبوزات باستخدام مزيج من دقيق القمح (WF) ودقيق لب الباوباب (BPF)، وتعزيز المحتوى الغذائي واستخدام هذه المحاصيل المزروعة بالسودان لتقليل الاعتماد على واردات القمح. تم طحن لب ثمرة الباوباب وتحويله إلى دقيق واستخدامه بنسب مختلفة (٥، ١٠ و٢٠٪). تم استخدام WF كدقيق أساسي في المخلوط. تم فحص الدقيق المركب المستبدل جزئيا (WF + BPF) لمعرفة خصائصه الريولوجية. تم استخدام ميكسولاب لتقييم الخصائص الريولوجية للدقيق المركب. علاوة على ذلك، قامت لجنة مكونة من ٢٠ مشاركًا مدربًا بتقييم الخصائص الحسية للمنتجات المخبوزة. البسكويت والمقرمشات التى تم تحضيرها في هذه الدراسة. أظهرت نتائج الخصائص الريولوجية للدقيق المركب التي تم فحصها بواسطة ميكسولاب أنه مع زيادة كمية دقيق الباوباب، انخفضت قدرة الدقيق على امتصاص الماء، بينما زاد زمن التطور وثبات العجين. ما يصل إلى ٥–١٠٪، عزز دقيق الباوباب من الجودة الغذائية دون التأثير سلبًا على الخصائص التكنولوجية أو الحسية، كما كان له أيضًا آثار إيجابية على الصحة والاقتصاد.