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Impact of Addition of Tiger nut Tubers Flour on Chemical, Sensory and Nutritional Characteristics of Pan Bread

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ABSTRACT

In the present investigation, partial replacement of wheat flour (WF) with tiger nut tubers flour (TNTF) at extents of 10%, 20%, 30% and 40% were carried out to examine the chemical comprise and physical attributes of the product. The partial replacement of WF with TNTF raised the fat, fiber and ash ($P \leq 0.05$), while, the available carbohydrates and crude protein were reduced. Also, The addition of TNTF raised caloric value. Pan bread that had been fortified with TNTF had lower quality in terms of colour. With only a minor decline in bread quality, TNTF up to 40% could partially replace WF in pan bread and boost its nutritious value in terms of fiber and vital amino acids. When compared to the control, sensory characteristics showed that pan bread enriched with up to 40% TNTF was acceptable to the panelists and significantly different in terms of overall acceptability, crumb texture, appearance, crust colour, crumb grain, and flavor . When TNTF was added, the nutritional benefits and amino acid content were higher than in the control group (for pan bread).

1. Introduction

Tiger nuts, commonly referred to as "underground walnuts," are found all over the world due to its high yield and numerous opportunities for full usage. The small tuber of *Cyperus esculentus* L. known as the "tiger nut" can be roasted and consumed as a sweetmeat in Egypt (Rubert, et al., 2011). Additionally, with an annual yield of 9000 metric tones, it is a significant representative crop of the Spanish Mediterranean region Sánchez-Zapata, et al., (2012). Later, it was transformed into a cooling beverage named "horchata de chufa," which is typically eaten in the summer and has a dairy appearance in the Mediterranean region Rubert, et al., (2011). Currently, "horchata's" popularity has spread beyond Spain to include the United States, France, the United Kingdom, Portugal, China, and other nations (Sánchez-Zapata, et al., 2012).

The edible oils from tiger nuts are a good source of monounsaturated fatty acids. Tiger nut oils are similar to olive oils in terms of its nutritional content (Roselló-Soto, et al., 2018). Starch an abundant and inexpensive food element, is also present in large amounts in tiger nut (dos Santos Silveira Junior and de Francisco, 2020). Ji and Gi (2018) also suggested using fermented tiger nut flours as an inexpensive addition to baking. Tiger nut flour is functionally comparable to wheat flour and can replace WF (up to 60%) in the making of puff (Bolarinwa, et al., 2021). Wheat flour's pasting properties are unaffected by the 30% tiger nut flour addition (Bamigbola, et al., 2016). The ability to absorb water and swell was stronger in the flour from the brown cultivar, whereas the oil absorption and foaming abilities were better in the black cultivar (Nina, et al., 2019). Tiger nut enhances the Acha-tigernut composite used to make biscuits' oil absorption ability, swelling power, swelling index, foaming capacity and bulk density (Ayo, et al., 2018) . Wheat flour's ability to absorb oil and water is dramatically reduced when tiger nut fiber is added in amounts more than 10%.
(Verdú, et al., 2017).

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Wheat flour's ability to absorb oil and water is dramatically reduced when tiger nut fiber is added in amounts more than 10% (Verdú, *et al.* 2017) .

According to Oke, *et al.* (2019) adding 8% tiger nut flour does not influence the bread's acceptability. Beyond a 20% substitution of tigernut for wheat, biscuits' sensory attributes are impacted (Bello, 2021) . Similar findings were published by Oke, *et al.* (2019) who found that 10% of replacement causes refusal in bread. Adebayo-Oyetoro, *et al.* (2017) suggested substituting 20% of the ingredients used to make chin-chin snacks.

There have been claims that tiger nut has anti-diabetic effects. The greater amounts of carbohydrates and fiber are crucial for metabolic activities (Bolarinwa, *et al.* 2021). Adding tiger nut flour to cereals lowers the likelihood that patients may develop diabetes, digestive issues, or lactose intolerance (Adebayo-Oyetoro, et al., 2017).

Tiger nut oil is high in polyunsaturated fatty acids and low in sterol (Aremu, *et al.* 2016). While the brown cultivar has 68.89% oleic acid, 13.33% palmitic acid, and 4.46% stearic acid, the black cultivar includes 77.71% oleic acid, 16.17% palmitic acid, and 11.87% linoleic acid (Nina, *et al.* 2020). Important polyphenols found in the oil include quercetin acid, p-coumaric acid, ferulic acid, protocatechuic acid, gallic acid, sinapic acids and syringic acid (Özcan, et al., 2021) .

Olagunju and Oyewumi (2019) suggested drinking a tigernut-infused beverage to ward off cardiovascular illnesses. Several substances with antioxidant, anti-inflammatory, anti-cancer, antibacterial, and antiseptic effects have been found in the smoke from burned tiger nuts, according to (Gugsa and Yaya 2018). Tigernut consumption enhances antioxidant processes and lowers the risk of diabetes and obesity thanks to its ability to inhibit lipase and α-amylase (Willis, *et al.* 2019) . According to studies, the tigernut milk's phytochemicals either stimulate the generation of glutathione or act as antioxidants to protect rats' livers from drug-induced liver damage (Onuoha, *et al.* 2017) . The goal of the current research was to replace the wheat flour in pan bread with tiger nut tuber flour in order to raise the nutritional properties and enhance the sensory properties of pan bread and, as a result, produce a high-quality bakeries product.

2. Materials and Methods

Materials:

Source of tubers: From the local markets in Tanta City, Egypt, chufa (tiger nut) tubers (*Cyperus esculentus*) were purchased. We bought WF (72% ext) from the North Cairo Flour Mills Company in Egypt. The Egyptian Sugar and Integrated Industries Company (ESIIC), Chemicals Factory, El-Hawamdia City, Giza, Egypt, provided active dry yeast (*Saccharomyces cerevisiae*). At the local market in Egypt, we purchased shortening, salt (sodium chloride), and sugar (sucrose).

Chemicals and reagents:

All chemicals analytical grade were purchased from Sigma Company for medical materials, Giza, Egypt.

Analytical methods:

The average was expressed after each analysis, which was done in triplicate.

Gross chemical composition:

Fat, protein, fiber, and ash content were determined according to (AOAC, 2012) .

Determination of carbohydrates:

The difference from the sample's starting weight was subtracted to determine the amount of carbohydrates in the sample, according to (AOAC, 2012).

Available carbohydrates (on dry weight basis) = 100- (%protein + % fat + % ash+%fiber)

Energy value:

According to (James , 1995), the energy value content was determined

Energy value = 9.1 (% fat) + 4.1 (% carbohydrate + % protein).

Tiger nut tubers oil extraction:

Hexane (40-60 ºC) was used to extract chufa tubers for 6–8 hours using a soxhlet extractor. Rotating vacuum evaporation was used to remove the solvent, and the oil was then collected. A dry weight basis was used to determine the percentage yield (Muñoz-Tebar, et al. 2019)

Determination Fatty Acids Composition:

According to the procedure outlined by Radwan, (1978), the fatty acid composition of chufa tubers oil was estimated at the Faculty of Agriculture, Alexandria University, using gas chromatography (GC Module, Shimadzu-8A, equipped with a FID Chromo Q, Detector temperature 270 ^oC, H2 flow rate 75ml/min, Sensitivity 16x10, Column temperature 150-180^{o}C, at rate 2 c/min, N2 flow rate 20ml/min.

Determination of amino acids:

Amino acids were evaluated in accordance with A.O.A.C. (2012) in the National Research Center, Giza, Egypt, for the concentration of WF (72% extraction) and TNTF.

Pan bread processing:

According to the procedure described by (El-Hadidy, 2020), pan bread was prepared using the straight dough method. 100 g WF, 1.5g instant active dry yeast, 2 g salt, 2 g sugar, 3 g shortening, and water made up the ingredients. Blends 0, 1, 2, 3, and 4 each contain TNTF to varying degrees (0, 10, 20, 30, and 40%) as a partial replacement for WF. The ingredients were then added to a mixing bowl set at 28 degrees Celsius, mixed for 6 minutes, and then the formed dough was manually shaped by folding 20 times. The mass dough was then allowed to rest for 10 minutes. A baking pan that had been lightly oiled received the prepared dough. The dough was baked for 20 minutes at 250°C in an electrical oven after being proofed for 60 minutes in a cabinet at 30°C and 85% relative humidity. The baked pan bread was placed in polyethylene bags after cooling for 60 minutes at room temperature (25°C) before to analyses as shown I Table 1.

Sensory Properties of Pan Bread:

Blends were estimated as described by AACC, (2000).Twenty panelists from the staff of Sakha food Technology Research Laboratory., Agric. Res. Center. Egypt, were requested for sensorial properties of pan bread blends were assessed for overall acceptability (100), aroma (10), taste (20), crumb grain texture (20), crumb color (20), Symmetry (10), crust and color (20).

Color Parameters

According to **Brunton, *et al.* (2006)**, a Hunter Lab Scan Visible colorimeter was used to measure the lightness (*L**), redness (*a**), and yellowness (*b**) of prepared pan bread.

Statistical Analysis

SPSS software (version 26) was employed for the statistical analysis, and Duncan's multiple range tests were employed for mean comparison. To compare between means, Duncan's multiple range tests were performed at the level ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

Chemical analyses of TNTF and WF:

The chemical composition of WF (72 %) and TNTF were showed in Table 2. WF contained 11.70 % protein, 0.60 % ash, 1.90 % fat, 0.55 % crude fiber and 85.25 % available carbohydrate .These findings were lower than El-Hadidy, et al., (2020) presented that the chemical composition of WF (72 % extraction) were 1.75 % lipid, 0.45 % ash, 0.84 % fiber, 11.81 % protein (on dry weight basis).

Table 1. Pan bread constituents.

Constituents	Control	Blend 1	Blend 2	Blend 3	Blend 4
WF (72%)	100	90	80	70	60
TNTF (%)	0	10	20	30	40
Salt (g)	2	2	2	2	2
Yeast (g)	1.5	1.5	1.5	1.5	1.5
Sugar (g)	2	2	2	2	2
shortening (g)	3	3	3	3	3

Nonetheless, given the TNTF result comprised 30.50% crude fibre and 17.50% fat, it can be said to be a high source of fat. In addition, it contained 7.00 % protein, 3.60 % ash and 41.40 % available carbohydrate (Table.2). The findings obtained were remarkably comparable to those found by Arafat, et al. (2009); Muhammad, et al., (2011); Adejuyitan (2011) ; Imam, et al. (2013) and Sabah, et al. (2019) showed that tiger nut comprises 5.08 % protein, 14.80 % crude fiber, 30.01 % crude fat, 2.23 % ash and 45.73 % carbohydrates.

Table 2. The chemical analyses of TNTF and WF (% on dry weight basis)

Components	Tiger nut tubers flour	Wheat flour 72%
protein	7.00±0.16	11.70^{b}±0.14
Ether extract	30.50^{a}±0.65	1.90^{b}±0.05
Ash	3.60^{b}±0.08	0.60^{c}±0.09
Crude fiber	17.50^{b}±0.04	0.55^{b}±0.01
Available carbohydrates	41.40^{b}±1.65	85.25^{a}±1.35
Caloric value (kcal/100g)	475.99^{a}±2.40	414.79^{b}±1.10

-Each value was an average of three determinations ± standard deviation.
- a, b different superscript letters in the same rows are significantly different at LSD at ($p \leq 0.05$).

Fatty acids composition of TNTF oil:

Fatty acids composition of tiger nut tubers oil exposed in Table 3. The saturated fatty acids content of chufa tubers oil was 0.90 myristic acid,, 13.30 palmitic acid,, 5.00 stearic acid, and 0.30% arachidic acid .The result also showed that unsaturated fatty acids content of chufa tubers oil were 1.70 palmitoleic acid, 70.30 oleic acid, 8.00 linoleic acid and 5.00% linolenic acid. The findings obtained were harmony with those obtained by (Arafat, et al. 2009).

Total phenolic and total flavonoids of tiger nut tubers flour and wheat flour

Table 4 offered total phenolic and total flavonoids content of TNTF and WF as mg/ 100g. The results revealed that the mean value of total phenolic contents of TNTF and WF was (250.50 and 165mg/100g), respectively, while total flavonoids were (190.30 and 3.70mg/100g), respectively.

Table 3. Fatty acids composition TNTF oil

%Fatty acid	Tigernut tubers flour
Myristic C14:0	0.90
Palmitic C16:0	13.30
Stearic C18:0	5.00
Arachidic C20:0	0.30
Total saturated acids	19.5
palmitoleic C16:1	1.70
Oleic C18:1	70.30
Linoleic C18:2	8.00
Linolenic C18:3	0.50
Unsaturated fatty acids	80.50

Table 4. Total phenolic and total flavonoids of tigernut and wheat flour

Components	Tiger nut tubers	Wheat flour
Total phenolic (mg /100 g)	250.50^{a}±1.50	165^{b}±1.20
Total Flavonoids (mg / 100g)	190.30^{a}±0.80	3.70^{b}±0.05

-Each value was an average of three determinations ± standard deviation.
-a, b different superscript letters in the same rows are significantly different at LSD at ($p \leq 0.05$).

Amino acids composition of wheat flour and tiger nut tubers

Indispensable and dispensable amino acids (g/100g) of WF (72% extraction) and TNTF presented in Table 5. The findings revealed that the total indispensable amino acids in WF (72% extraction) were 32.85 g/100g which was lower than TNTF (47.70g/100g). Data in the same table recorded that the main essential amino acids of WF was phenylalanine (5.50 g/100g) followed by leucine (5.25 g/100g) then valine (4.60 g/100g). Meanwhile, the lowest level was methionine (1.40 g/100g) followed by tyrosine (1.80 g/100g). On the contrary, the TNTF were considered a poor source of theronine and tyrosine (3.5 g/100g) followed by histidine (4.20 g/100g). On the contrary, leucine (8.00 g/100g), lysine (7.00 g/100g) and methionine (6.50 g/100g) were the predominated indispensable amino acids. Also, dispensable amino acids (g/100g) of (WF 72 % extraction) and TNTF offered in Table 5. The dispensable amino acids content of TNTF was 14, 12, 4.5, 4.0, 5.0, 6.0 and 4.50 g/100g for aspartic, glutamic, proline, serine, glycine, alanine and arginine respectively. In addition, The dispensable amino acids content of WF was 6.50, 32, 7.20, 6.50, 3.50, 3.90, and 2.50 g/100g for aspartic, glutamic, proline, serine, glycine, alanine and arginine respectively (Arafat, et al., 2009).

Table 5. Amino acids profile of WF 72% and TNTF (g/100g of protein)

Amino acids	Wheat flour	Tigernut tubers flour	FAO/WHO/UNU (1985)pattern
Lysine	3.60	7.00	5.80
Isoleucine	4.50	5.40	2.80
Leucine	5.25	8.00	6.60
Phenyl alanine+	5.50	4.60	6.30
Tyrosine	1.80	3.50	
Histidine	4.00	4.20	1.90
Valine	4.60	5.00	3.50
Theronine	2.20	3.50	3.40
Methionine	1.40	6.50	2.20
Total (EAA)	32.85	47.70	
Aspartic	6.50	14	
Glutamic	32.00	12	
Proline	7.20	4.50	
Serine	6.50	4.00	
Glycine	3.50	5.00	
Alanine	3.90	6.00	
Arginine	2.50	4.5	
Total (NEAA)	62.10	50	

Proximate composition of pan bread

Table 6 provides the proximate composition of pan bread prepared from blends containing tigernut tubers flour and wheat flour. The proximate composition of mixed pan bread were affected significantly by blending with different levels of tiger nut tubers flour. The protein content of pan bread was significantly higher when blended with various tigernut tubers flour concentrations compared to the control (10.83%). Adding tiger nut tubers flour to wheat flour decreased the protein content of pan bread to 10.40–9.25 respectively. Blending with different proportions of tigernut tubers flour significantly increased the fat content of pan bread in comparison to control (4.54%). Enrichment of wheat flour with tigernut tubers flour increased the fat content to 7.19–15.13 respectively. Fortification of wheat flour with tiger nut tubers flour significantly increased the ash content of breadsticks to 0.83–1.67 respectively in comparison to control 0.55%. Blending with different Proportions of tiger nut tubers flour significantly ($P \leq 0.05$) decreased

The available carbohydrate content of pan bread in comparison to control (83.77%). Blending wheat flour with tiger nut tubers flour decreased the available carbohydrate content to 79.51–67.16 % respectively.

Blending with different proportions of tiger nut tubers flour significantly (P ≤ 0.05) increased the energy content of pan bread in comparison to control (429.17%). Blending wheat flour with tiger nut tubers flour increases the energy content to 434.06–450.96 kcal / 100g respectively.

Substituting 30% tiger nut tubers flour to wheat flour enhances the flour's fiber, protein, ash, and oil absorption capacities as well as its antioxidant, amylopectin, and amylose contents (Bamigbola, et al. 2016). Hussein, et al. (2022) showed that replacing wheat flour with10, 20 and 30% tiger nut flour increases ash, fiber, fat and caloric value in pan bread.

Table 6. Chemical composition of pan bread samples (%on dry weight basis)

Blends	Protein	Fat	Ash	Fiber	Available Carbohydrate	Caloric value (kcal/100g)
WF 100%	10.83[a]±0.02	4.54[e]±0.04	0.55[e]±0.01	0.51[e]±0.02	83.77[a]±0.08	429.17[e]±0.09
WF:TNTF 90:10	10.40[b]±0.03	7.19[d]±0.10	0.83[d]±0.03	2.07[d]±0.03	79.51[b]±0.05	434.06[d]±0.10
WF:TNTF 80:20	9.96[c]±0.04	9.83[c]±0.20	1.11[c]±0.02	3.65[c]±0.20	75.45[c]±0.20	439.63[c]±0.40
WF:TNTF 70:30	9.52[d]±0.05	12.48[b]±0.30	1.38[b]±0.09	4.83[b]±0.30	71.79[d]±0.07	446.94[b]±0.30
WF:TNTF 60:40	9.25[e]0.01	15.13[a]±0.15	1.67[a]±0.10	6.79[a]±0.25	67.16[e]±0.05	450.96[a]±0.50

WF=Wheat flour TNTF=Tiger nut tubers flour

Sensorial attributes of pan bread

Consumer acceptance of organoleptic qualities such as crust colour, odor, crumb grain texture, taste, symmetry of shape, and crumb colour is thought to be limited by sensory evaluation. Table 7 provides the influence of TNTF on pan bread sensory qualities. The sensory scores for crust colour, aroma, taste, crumb colour, crumb grain texture, symmetry of shape, and overall acceptability of pan bread reduced as the level of TNTF increased in the recipe. Results showed that all experimental goods' characteristics had changed substantially (P< 0.05). Results in Table 7 showed that TNTF blend used to make pan bread had lower scores for most attributes than the other tested items. Moreover, pan bread received the lowest score for overall acceptability (67.30). The controls (100% WF plus 10, 20% TNTF pan bread) had the highest overall acceptability characteristics. The sensory acceptability rating led us to the conclusion that pan bread made from TNTF may be substituted for WF in this study to the extent of 10% without negatively compromising the quality of the senses, which is a substantial finding. These findings harmony with those reported by Hussein, et al., (2022) found that when increase TNTF proportions the overall acceptability, crust color, taste, symmetry of shape, odor, and crumb grain texture, were decreased in bread.

Color characteristics of pan bread

The choice of bakery products by consumers is influenced by color, a quality indicator. The findings of the color parameters are shown in Table (8). As the substitution proportions increased, the crust colour of pan samples of bread substitute with various amounts of TNTF had lower *L** and *b** values. On the other hand, pan bread crust a* values displayed a tendency that was the opposite of L* and b* values. In comparison to the control pan bread, the supplement pan bread mixes' crumb colours had greater a* and b* values. Overall, compared to the control, all supplement pan bread blends produced darker crust and crumbs. These results could be explained by the high fibre content of TNTF and phenolic acid, which speed up the production of Maillard reaction products during baking (Martins, *et al.* 2000) . The findings are in line with those of Kim, *et al.* (1997) and Ramy, *et al.* (2002) . When bran is used in baked goods, the colour that bakeries produce darkens. Hence, either the proportion of bran must be managed, or suitable additives must be employed to reduce this browning.

Table 7. Scores for sensory attributes of pan bread

Blends	Crust color (20)	Crumb color (20)	Crumb grain texture (20)	Symmetry of shape (10)	Taste (20)	Aroma (10)	Overall acceptability (100)
WF 100%	19.50^{a}±0.20	19.30^{a} ±0.10	19.50^{a} ±0.10	9.20^{a} ±0.20	19.70^{a} ±0.10	9.50^{a} ±0.20	96.70^{a} ±0.15
WF:TNTF 90:10	18.50^{b} ±0.15	17.50^{b} ±0.20	18.20^{b} ±0.10	8.40^{b} ±0.10	18.10^{b} ±0.40	8.00^{b} ±0.30	88.70^{b} ±0.20
WF:TNTF 80:20	17.30^{c} ±0.10	15.60^{c} ±0.25	16.45^{c} ±0.15	7.30^{c} ±0.15	16.50^{c} ±0.20	7.50^{bc} ±0.20	80.65^{c} ±0.20
WF:TNTF 70:30	16.60^{d} ±0.30	16.10^{d} ±0.30	14.30^{d} ±0.20	7.40^{d} ±0.20	15.20^{d} ±0.35	7.40^{c} ±0.30	77.00^{d} ±0.30
WF:TNTF 60:40	15.40^{e} 0.40	12.30^{e} ±0.15	12.70^{e} ±0.35	6.50^{e} ±0.40	13.40^{e} ±0.50	7.00^{c} ±0.40	67.30^{e} ±0.40

Mean values in each column having different superscript (a, b, c, d and e) are significantly different at $P < 0.05$.
WF=Wheat flour TNTF=Tiger nut tubers flour

Table 8. Colors of Obtained pan bread

Sample	Crust color			Crumb color		
	L*	a*	b*	L*	a*	b*
WF 100%	55.48^{a}±0.10	13.60^{e}±0.15	31.62^{a}±0.20	73.50^{a}±0.30	1.44^{e}±0.17	24.87^{e}±0.19
WF:TNTF 90:10	53.28^{b}±0.20	14.87^{d}±0.14	29.30^{b}±0.20	70.23^{b}±0.20	2.70^{d}±0.10	25.30^{d}±0.17
WF:TNTF 80:20	52.54^{c}±0.30	15.48^{c}±0.15	27.74^{c}±0.30	68.63^{c}±0.16	3.15^{c}±0.15	26.50^{c}±0.15
WF:TNTF 70:30	51.80^{d}±0.15	16.25^{b}±0.15	25.68^{d}±0.22	66.55^{d}±0.10	3.97^{b}±0.10	27.17^{b}±0.13
WF:TNTF 60:40	49.08^{e}±0.12	17.19^{a}±0.17	24.20^{e}±0.35	60.19^{e}±0.17	4.14^{a}±0.14	28.30^{a}±0.18

Mean values in each column having different superscript (a, b, c, d and e) are significantly different at $P < 0.05$. - Each value was an average of three determinations ± standard deviation.

4. Conclusion

The results of this research showed that pan bread was made using wheat flour added, to various extents, tiger nut tuber flour. The finished products were high in calories, fat, and crude fibre. Essential fatty acids and essential amino acids were abundant in these bakeries product. Pan bread was produced using a technological formula combining a well-balanced combination of supplements, and it has good sensory qualities in terms of crust color, crumb texture, crumb grain, appearance, flavor, overall acceptability, and odor. Ultimately, it might produce some baked goods employing ingredients like wheat flour and tiger nut tuber flour, both of which have great nutritional values.

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