Nutritional evaluation and sensory attributes of biscuit fortified with tiger nut tubers (*Cyperus esculentus L.*) flour

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ABSTRACT

Tiger nut tubers (*Cyperus esculentus L.)* flour have long been recognized as one of the best nutritional crop that can be used to augment a diet. Biscuits are the most popular bakery item consumed by nearly all sections of society .This investigation was performed to study the nutritional quality of tiger nut tubers flour (TNTF) and biscuit blends fortified with varying amounts of TNTF at three levels, (10, 20 and 30%). Proximate chemical composition, minerals, amino and fatty acids composition were determined. TNTF is a good source of protein, oil, ash and crude fiber compared with wheat flour. Furthermore, it also contains valuable amounts of minerals such as phosphorus, potassium, and magnesium (185.33, 216.68, and 169.26 mg/100 g on a dry weight basis) respectively. The major indispensable (essential) amino acids were leucine (0.24 g/100g) and Valine (0.21 g/100g). Also, TNTF contains a high percentage of unsaturated fatty acids (79.94%), especially oleic acid (70.34%). Crude protein, crude oil, ash, and crude fiber contents increased in biscuit products in contrast, moisture and carbohydrate values decreased gradually with an increment of the wheat flour substitution level using the TNTF. Biscuits fortified with different levels of TNTF had the highest amount of all minerals, indispensable and dispensable amino acids, some unsaturated fatty acids like oleic acid followed by linoleic acid and Palmitoleic acid compared with the control biscuit. The results of the sensory evaluation showed that replacement of TNTF until 30% is acceptable, while biscuits fortified with 20% TNTF recorded the highest overall acceptability. This study

reveals that tiger nut tubers flour could be used in the production of biscuits with special dietary needs.

Keywords: bakery industry, proximate composition, amino acid profile, overall acceptability

1. INTRODUCTION

Tiger nut tubers (*Cyperus esculentus L.*) is an underutilized crop in the family of *Cyperaceae* that produces rhizomes from the base and tubers that are somewhat spherical, also classified as nuts, and has been recognized as one of the best nutritional crops that can be used to augment diet **(Afenu, 2008).** Tiger nut tubers (*Cyperus esculentus*) are a rhizomes spherical crop that can be eaten raw, dry or processed **(Bazine and Arslanoğlu, 2020).** There are three cultivars of tiger nut; yellow, brown and black cultivars. The cultivars possessed different physicochemical properties and functional properties (**Nina *et al*., 2019; Ayaşan *et al*., 2021).** The major factors that account for the chemical variation in tiger nut are genetic makeup, production location **(Ihenetu *et al*., 2021)**, environment and growing conditions **(Duman, 2019).**Tiger nut tubers is an underutilized tuber rich in many essential nutrients including proteins, carbohydrates, vitamins, minerals **(Mohdaly, 2019)**, phytochemicals, oil and fiber **(Ihenetu *et al*., 2021)**. Tiger nut was reported to have anti diabetic properties. The higher carbohydrate and fiber contents are essential to metabolic processes **(Bolarinwa *et al*., 2021).** It has been reported to be high in dietary fiber content, and it has been demonstrated to be a rich source of quality oil and contains a moderate amount of protein. It is also an excellent source of some useful minerals such as iron and calcium **(Anderson *et al*., 1994, Oladele and Aina, 2007)**, and it also contains a reasonable amount of methionine lacking in plantain, making it a good supplement for plantain **(Adegunwa *et al*., 2017)**. According to **Adejuyitan *et al*. (2009)**, consumption of tiger nuts is healthy and aids in preventing heart attacks, thrombosis, and activated blood circulation; it also helps in preventing colon cancer and other cancers due to its high content of soluble glucose. Tiger nut tubers are therefore cultivated for both human and livestock consumption. Different kinds of products are obtained from tiger nuts, which include tiger nut tubers flour, tiger nut oil, tiger nut milk, "Dakuwa" and "kunu," and some of them can be eaten as snacks **(Gambo and Da'u, 2014).** The tiger nut tubers can be eaten raw, baked, roasted, or processed further into a drink. It can also be used as a flavoring agent for ice creams and biscuits and can also be used as a substitute for almonds in confectionery (**Cantatejo, 1997).** Tiger nut tubers flour is considered good flour or additive for the bakery industry, as its natural sugar content is high, avoiding the necessity of adding too much extra sugar **(Anderson *et al*., 1994)**. Furthermore, Tiger nuts tubers are excellent sources of minerals such as phosphorus, potassium, vitamins E and C, starch, fat, sugars, and protein **(Belewu and Belewu, 2007).** Tiger nut oil is among the recently discovered edible oils with limited data on its characteristics and functionalities **(Ezeh *et al*., 2016). Nina *et al*. (2020)** recommended the use of oil in cooking and frying. Although many researchers have worked on tiger nut tubers **(Bamigbola *et al*., 2016 and Adegunwa *et al*., 2017),** there is a need for increased utilization and awareness about its health benefits. Currently, the use and acceptability of tiger nut tubers in food formulation is on the increase **(Omoba *et al*., 2015).** Therefore, the aim of the present work was to evaluate the nutritional value of tiger nut tubers and to utilize them in biscuit processing as a new food industry product in the Egyptian market.

2.MATERIALS AND METHODS

Materials:

Tiger nut tubers ***(Cyperus esculents L.)*** varieties of brawn were obtained from the local market in Rosetta or Rashid City, Beheira Governorate, Egypt.

All chemicals and reagents used in this study were purchased from El-Gomhoriya Company for Trading Drugs, Chemicals and Medical Instruments, Tanta, Egypt.

Other ingredients including wheat flour 72% extraction), sugar, vanilla, baking powder, eggs and butter were obtained from a supermarket in Kafrelsheikh city, Egypt.

Methods:

Preparation of tiger nut tubers flour for analysis:

Tiger nut tubers were manually cleaned to remove any visible foreign matter before being ground into fine powder in a laboratory electronic mill (Braun, Model 2001 DL, Germany) and passing through a 60-mesh sieve screen. TNTF was kept in tightly sealed polyethylene bags until it was used.

Preparation of biscuit blends fortified with different levels of TNTF:

Biscuit blends were prepared by adding powdered sugar, eggs and vanilla and mechanically beating with electric beater them for 5 minutes until they creamed. Then unsalted butter added thoroughly and mixed with wheat flour for 2 minutes. Then, baking powder was added and mixed (Table 1). TNTF was fortified with wheat flour at ratios of 10, 20 and 30% (w/w) (Table 2) and the blended biscuits took an ovoid shape. Then, back in an oven at 160^{o} C for 15 min. Following baking, the biscuits were cooled at ambient temperature; the biscuit was packed in polyethylene bags until used to evaluate the organoleptic properties without delay.

Table (1):- *The Basic ingredient formula of biscuit blends

Ingredient	Unit
Wheat flour (72%) (El Manar brand)	800 g
Sugar (Emy food sugar brand)	253 g
Eggs	150 ml
Butter (100% unsalted) (Rotana brand)	400g
Baking Powder (Tag El Melouk brand)	15 g
Vanilla	0.7g

***Biscuits were prepared as **Sapa (1991)** with little modification in wheat flour amount to get the suitable firm dough in control.

Table (2):- Biscuit blends fortified with different levels of Tiger nut tubers flour (TNTF).

Biscuit blends	Wheat flour %	TNTF %
Control	100	0.0
T_1	90	10
T_2	80	20
T_3	70	30

Proximate chemical composition:

The proximate chemical composition including moisture, crude protein, crude lipid, total ash and crude fiber contents was determined as described in the methods of **AOAC (2005).** Total carbohydrates were calculated by differences [100 - (crude protein + crude oil + ash content)]. Available carbohydrate was calculated by differences [100 - (crude protein + crude oil + ash content + crude fiber)].

Energy value (Kcal/100g) = (crude protein × 4.27) + (crude oil × 9.02) + (total carbohydrate content × 4.10).

Determination of minerals:

Minerals including Mg, Ca, Mn, Fe, and Zn, were determined as described in the **AOAC (2005**) using Atomic Absorption Spectrometry (GBC Avanta E, Victoria, Australia) Na and K were determined using Flame Photometer (model PE P7, England), as described in the **AOAC (2005).**

Amino acid composition:

The amino acid composition was determined using HPLC at the Regional Center for Food and Feed (RCFF), Agricultural Research Center, Cairo, Egypt, according to the methods of the AOAC (2005).

Amino acid scores (AAS):

The amino acid score (AAS) of samples was calculated for amino acids according to the **FAO/WHO /UNU (1985**) procedure using the following equation:

$$\text{Amino acid scores} = \frac{\text{Amino acid (mg) in test protein sample (g)}}{\text{Amino acid (mg) in reference protein (g)}} \times 100$$

Computed protein efficiency ratio (C-PER):

The computed protein efficiency ratio was calculated from the amino acid composition using the equation developed by **Alsmeyer (1974).**

C-PER= -1.816 + 0.435 Methionine + 0.780 Leucine + 0.211 Histidine – 0.944 Tyrosine.

Biological value (BV):

Biological values of protein were calculated using an equation reported by **Farag *et al.* (1996)** as follows BV= 4 9.9 + 10.53C-PER.

Daily needs (GDR) of protein and energy:

Grams consumed from food to cover the daily needs of protein and energy for the adult man (25 to50 years) were calculated using the daily requirements for the adult man (63 g/ day) and (2900 Kcal / day) as given by **NRCFN (1989)** using the equation given by **FAO / WHO/ UNU (1985).**

Daily need (GDR) of Indispensable amino acids (IAA):

Grams consumed to cover the daily needs of individual indispensable amino acids were calculated using the daily requirement of the adult man (25-50 years old) as recommended by **FAO/WHO/UNU (1985).** The highest G.D.R value among the individual indispensable amino acids (IAA) indicates restricting amino acids. The GDR of every indispensable amino acid was calculated using the equation given by **FAO/WHO/UNU (1985)**.

Percent Satisfaction (P.S/200):

Percent satisfaction of the daily requirements of protein, energy and, indispensable amino acids for the adult man when consuming 200 g of sample (P.S/200) were also calculated using the equation given by **FAO/WHO/UNU (1985).**

Fatty acid profile:

Fatty acids compositions were determined in the extracted fats by using methyl esters trifluoride method **(A.O.A.C. 2005)**. The fatty acids were methylised with boron tri fluoride in methanol. The fatty acid methyl esters were analyzed using a gas liquid chromatography (GLC) with a flame ionization detector (FID) and (PE Auto System XL) with auto sampler and Ez-chrome integration system. Carrier gas (He); ca 25 Psi-air 450 ml/min-Hydrogen 45 ml-split 100 ml/min. Injector and detector temperatures were set to 200 °C and 250 °C, respectively. Retention times were compared with fatty acid methyl esters of known standards. This analysis was carried out at Agriculture research center, Ministry of Agriculture, Cairo Egypt.

Sensory attributes:

A trained twenty-member panel consisting of students and staff members (both male and female) of the Home Economic Department, Faculty of Specific Education, Kafrelsheikh University, Egypt, was selected based on their experience and familiarity with biscuits blends fortified with different levels of TNTF for the organoleptic evaluation. The tests were performed under fluorescent lighting in the organoleptic evaluation laboratory. Tap water was provided to rinse the mouth between evaluations. The judges evaluated the samples for taste, colour, odour, texture, thickness, softness, size and overall acceptability. Each organoleptic attribute was rated on a 10- point hedonic scale (1 disliked extremely, 5 neither liked nor disliked, and 10 liked **(Abo *et al*., 2014).**

Statistical analysis:

All experiments were performed in triplicate. SPSS statistical software was used to analyses all the collected data. The calculation occurred by analysis of variance (ANOVA) and follow-up Duncan's multiple range tests by SPSS ver.11 according to **Steel *et al*. (1996).**

3. RESULTS AND DISCUSSION

Proximate chemical composition (%) of wheat flour and TNTF

Data presented in Table (3) indicated that TNTF had significantly higher contents of crude protein, crude oil, ash, and crude fiber (10.75, 20.61, 2.9, and 9.29 % respectively) compared to that wheat flour. Consequently, the tigernut tubers flour can be used as a good source of dietary fiber which may be effective in the treatment and prevention of many diseases including coronary heart disease (**Chukwuma *et al*., 2010**).Meanwhile, wheat flour contained higher amounts of moisture, total carbohydrate, and available carbohydrates (11.99, 89.11, and 88.57 respectively) than that of TNTF (10.85, 65.72, and 56.43, respectively). These results agree with those reported by **Reda A. Aamer (2019), Salama *et al*., (2013), Abd-El Hamied (2010), Bamishaiye and Bamishaiye (2011)** while not agree with others like **Djomdi *et al*., (2022).** These differences may be dependent on the varietal origin or the agro-ecological production areas . The major factors that account for the chemical variation in tiger nut are genetic makeup,production location **(Ihenetu *et al.*, 2021**), environment and growing conditions **(Duman, 2019).** The Caloric value content of the TNTF was higher (504.97 kcal/100 g) than the wheat flour (398.47 kcal/100 g). However, TNTF is consumed akin to snack food and could be useful in food technology.

Table (3):- Proximate chemical composition (% on dry weight) of wheat flour and Tiger nut tubers flour.

Constituents %	Wheat flour	Tiger nut tubers flour (TNTF)
Dry matters	88.01^{b}	93.10^{a}
Moisture	11.99^{a}	10.85^{b}
Crude protein	9.64^{b}	10.75^{a}
Crude oil	0.73^{b}	20.61^{a}
Ash	0.52^{b}	2.92^{a}
Total carbohydrates	89.11^{a}	65.72^{b}
Crude fiber	0.54^{b}	9.29^{a}
Available carbohydrates	88.57^{a}	56.43^{b}
Caloric value (Kcal/100g)	413.098^{b}	501.257^{a}

Each value was an average of three replicates. Values followed by the same letters in the same row are not significantly different at $p \leq 0.05$.

Chemical composition of biscuits:-

The results of the chemical composition of biscuits made from different levels of TNTF are recorded in Table (4). The obtained results showed that the protein, crude oil, ash, and crude fiber contents were increased in comparison with control, in contrast, moisture and carbohydrate values were decreased gradually with the increasing amount of the replacement levels for TNTF. These results are in harmony with the findings of **(Ndubuise 2009, Adebayo-Oyetoro *et al.*,2017 and Alaka *et al*., 2020*).*** From the same Table, the moisture content in biscuits was ranged between (4.90 to 7.91%), the lowest value in biscuits fortified with 30% TNTF, and the highest in control biscuits. Moisture content showed slight and gradually decreased in all biscuit blends as compared with control. Biscuit fortified with 20 and 30% TNTF were significantly less $P< 0.05$ than the control biscuit. The current study's findings are consistent with those of **Adebayo-Oyetoro *et al*. (2017),** who reported that the low moisture content could reduce the growth of microorganisms thereby increasing the shelf life of the product. It is also apparent from the same Table that fortified TNTF with wheat flour leads to increased protein content from 6.80% in control to 9.57 % in biscuits fortified with 30% TNTF, respectively. The protein content of the fortified biscuits was increased by increasing the concentrations of substitution TNF. This increment may be due to the TNTF high protein content as compared to wheat flour. The current study's findings are consistent with those of **Abiodun.O.A *et al*. (2017).** Therefore, TNTF tended to improve the protein content of biscuits. On the other hand, it could be noticed that there were significant differences in the crude oil content of the control and fortified biscuits. These results agreed with ***(*Nwaoguikpe, 2010, Bamishaiye and Bamishaiye, 2011*)*.** Ash content for biscuits ranged from 0.44% in control biscuits to 1.13 % in fortified biscuits with 30% TNTF. There were significant differences with higher values in the ash content of the biscuits fortified with TNTF. Furthermore, ash content was decreased in the control, but ash content was significantly increased in the sample that was fortified with TNTF. This increment may be due to the incorporation of TNTF. The current study's findings are consistent with those of these results and agree with those reported by **Mepba *et al*. (2007) and Falola *et al.* (2014).** The data in the same Table revealed that the crude fiber content of biscuits fortified with different levels of TNTF was higher than that of the control sample. This might be due to the high fiber content in TNTF as compared to wheat flour. Fiber content increased from 0.84% in control to 8.67 % in biscuits containing 30% TNTF, respectively. The variation in crude fiber content between the control sample and fortified biscuits with 10, 20, and 30% TNTF is highly significant. This is due to the high content of crude fiber. These results agree with **Ebenezer *et al.* (2019).** In addition**, Mohammed *et al.* (2018)** reported that fiber content could play an important role in the reduction of pressure and transit time of food through the body aiding indigestion. Furthermore, fiber aids in the alleviation of flatulence problems thus, tiger nut fiber could be explored in formulating diets for treating indigestion, constipation, and non-communicable diseases such as colon cancer, diverticulosis, coronary heart disease, and obesity. On the other hand, the total carbohydrate content in biscuit samples was significantly decreased by increasing TNTF. It decreased from 71.83 % in control to 61.34 % in biscuits fortified with 30% TNTF. This is maybe due to TNTF being rich in protein, crude oil, and crude fiber. From the obtained data it could be noticed that energy content increased from (512.328 kcal/100 g) for the control sample to 531.736, 540.011and 549.589 kcal/100 g at 10,20, and 30% replacement respectively.

Table (4):- Proximate chemical composition (g/100g on a dry weight basis) of biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Constituents %	Biscuit blends			
	Control	T_1	T_2	T_3
Moisture	7.91 a	6.10 a	5.26b	4.90c
Crude protein	6.80 c	7.09 bc	7.92 b	9.57 a
Crude oil	20.93 c	24.14 b	25.96 b	27.96 a
Ash	0.44 c	0.63 b	0.91 a	1.13 a
Total carbohydrates	71.83 a	68.14 b	65.21 bc	61.34 c
Crude fiber	0.84 d	4.62 c	6.79 b	8.67 a
Available carbohydrates	70.99 a	63.52 b	58.42 c	52.67 c
Caloric value (Kcal/100g)	512.328c	531.736b	540.011ab	549.589a

Each value was an average of three replicates. Values followed by the same letters in the same row are not significantly different at $p \leq 0.05$.
Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

Mineral's content of biscuits:-

Among the functional food ingredients, minerals have a fundamental function in their indispensable role in a healthy life. Minerals, including trace minerals, are important for helping body metabolism, water balance, bone health, helping heart function, preventing fatigue and muscle spasms, and helping transport oxygen throughout the body. It is very important to include the right amount of minerals in the body

. Results of minerals composition of TNTF and biscuit samples are summarized in Table (5), the data indicate that TNTF contains higher values in all determining elements which were higher in biscuit samples compared with control biscuits. Furthermore, TNTF is very rich in Potassium (216.68 mg/100g), Phosphorous (185.33 mg/100g), Magnesium (169.26 mg/100g), Sodium (86.20 mg/100g), Calcium (18.90 mg/100g), Iron (8.00 mg/100g) and

Zinc (7.10 mg/100g). **Ihenetu *et al*. (2021)** recommended the use of tiger nut in the food of hypertensive and edema patients due to the high potassium to low sodium ratio in both yellow and brown species. The results agree with that reported by **Salama *et al.* (2013), Ekeanyanwu and Ononogbu (2010).** Therefore, it could be mentioned that fortified of wheat flour with TNTF can produce bakery products with high levels of minerals **(Sabah *et al.* 2019).** There was a significant enhancement in the mineral content of biscuit samples. Biscuits which fortified with TNTF for wheat flour has a higher amount of all minerals compared with those of control. In addition, biscuit fortified with 30% TNTF has the highest value of minerals the while control (Biscuit without TNTF**)** has the lowest value of minerals. These results are supported by **Olugbenga *et al*. (2017**) **and Ebenezer *et al.* (2019**) reported that biscuit fortified with TNTF has the highest value for sodium, Iron, Zinc, and Phosphorous while the control sample has the lowest value.

Table (5):- Mineral's content (mg/100 g on a dry weight basis) of biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Samples / Minerals	TNTF	control	T_1	T_2	T_3
Sodium (Na)	86.20	47.32 ^{c}	50.92 ^{b}	54.10 ^{a}	61.21 ^{a}
Potassium (K)	216.68	84.00 ^{d}	106.31 ^{c}	134.02 ^{b}	149.01 ^{a}
Magnesium (Mg)	169.26	154.70 ^{d}	188.01 ^{c}	195.80 ^{b}	217.43 ^{a}
Calcium (Ca)	18.90	162.35^{d}	164.60^{c}	166.70^{b}	171.20^{a}
Manganese (Mn)	0.03	0.02 ^{ns}	0.01 ^{ns}	0.02 ^{ns}	0.03 ^{ns}
Iron (Fe)	8.00	17.34 ^{b}	18.10 ^{a}	18.72 ^{b}	22.40 ^{a}
Zinc (Zn)	7.10	11.73 ^{c}	12.65 ^{b}	13.11 ^{b}	15.22^{a}
Phosphorous (P)	185.33	5.22 ^{d}	21.96 ^{c}	48.34 ^{b}	86.27 ^{a}

Each value was an average of three replicates. Values followed by the same letters in the same row are not significantly different at
$p \leq 0.05$.

Amino acids composition of biscuits:-

The nutritive value of food, especially protein, depends not only on its amino acid profile in general but also on the quantities of indispensable amino acids **(Afify *et al.*, 2012).** The amino acids composition of TNTF and biscuit samples are given in Table (6). The results show that the major indispensable amino acids for TNTF were leucine (0.24g/100g) and Valine (0.21 g/100g). while the lowest indispensable amino acid was Histidine (0.09 g/100g protein). On the other hand, arginine, glutamic and aspartic acids were the major dispensable amino acids present (0.95, 0.51, and 0.38 g/100g protein) respectively. Meanwhile, Serine, Proline and Glycine were the lowest dispensable amino acids recorded (0.12, 0.17, and 0.21 g/100g protein). These results agree with **Arafat *et al.*, (2009); Ekeanyanwu and Ononogbu (2010), Salama *et al.*, (2013) and Djomdi *et al.*, (2022).** As shown in the same Table, biscuits fortified with different levels of TNTF had the highest amount of indispensable and dispensable amino acids (individual and total) than the control biscuit. From the obtained results, it was clear that leucine was the highest amino acid in biscuits fortified with 30% TNTF (0.53%), followed by Methionine + Cystine (0.36%), while Histidine was the lowest value (0.16%) of indispensable amino acids. Meanwhile, biscuit fortified with 20 and 30% TNTF recorded an increased significant amount in total indispensable amino acids as (2.45 and 2.82%) respectively, while biscuit control recorded the lowest value (1.95%). As for dispensable amino acids, it could be observed that glutamic acid was the dominant acid in biscuits fortified with 30% TNTF with recorded (2.01%), followed by a Proline (0.61%), Meanwhile, Glycine was the lowest amino acid recorded (0.47%).

Table (6):- Amino acids composition (g/100 g protein) of biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Samples / Amino acids	TNTF	control	T_1	T_2	T_3	FAO/WHO /UNU pattern (1985)	Daily requirement for adult man
Indispensable Amino Acids							
Threonine (thr)	0.14	0.15	0.17	0.20	0.23	4.0	0.567
Valine (val)	0.21	0.29	0.30	0.32	0.35	5.0	0.819
Methionine + Cysteine (cys)	0.18	0.30	0.32	0.34	0.36	3.5	1.071
Isoleucine (ile)	0.17	0.20	0.23	0.27	0.31	4.0	0.819
Leucine (leu)	0.24	0.34	0.39	0.41	0.53	7.0	1.197
Histidine (his)	0.09	0.11	0.12	0.14	0.16	4.0	1.008
Tyrosine (tyr)	0.18	0.17	0.20	0.27	0.31	7.0	1.197
Phenylalanine (phe)	0.12	0.18	0.22	0.28	0.34	7.0	1.197
Lysine (lys)	0.25	0.21	0.21	0.22	0.23	5.5	1.008
Total indispensable A.A	1.58	1.95	2.16	2.45	2.82		8.774
Dispensable Amino Acids							
Aspartic acid (asb)	0.38	0.44	0.45	0.46	0.47		
Glutamic acid (glu)	0.51	0.94	0.95	0.97	2.01		
Serine (ser)	0.12	0.19	0.23	0.28	0.34		
Glycine (gly)	0.21	0.19	0.20	0.21	0.24		
Arginine (arg)	0.95	0.31	0.34	0.38	0.43		
Alanine (ala)	0.31	0.26	0.27	0.28	0.29		
Proline (pro)	0.17	0.27	0.38	0.49	0.61		
Total dispensable A.A	2.65	2.60	2.82	3.07	4.39		
Total A.A.	4.23	4.55	4.98	5.52	7.21		

Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

The chemical score of indispensable amino acids of biscuits:-

The amino acid scores can be considered an imperfect indicator of protein quality, but it still the best ones based on the amino acids. The nutritive value of a protein depends primarily on its efficiency to satisfy the requirements for essential amino acids. Thus, the amino acids requirements are the logical yardstick by which protein quality can be measured **(Zedan 2012).** the amino acid scores (AAS) of TNTF and biscuit samples are given in Table (7). The data recorded in this Table showed that Phenylalanine (1.71 %) was found to be the first limiting amino acid in TNTF followed by Histidine (2.25%). The amino acids scores of the indispensable amino acids in the control biscuit was ranged from 2.43 to 8.57, the highest value was detected in Methionine + Cystine and the lowest value was presented in Tyrosine, furthermore, biscuit fortified with different levels of TNTF showed an increase in AAS, it ranged between 2.86 to 10.29. The highest values were in Methionine + Cystine in biscuit fortified with 30% TNTF and the lowest value was presented in Tyrosine in biscuit fortified with 10% TNTF.

Table (7):- Amino acids scores (AAS) of Tiger nut tubers flour and biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Samples / **Indispensable amino acids**	**TNTF**	**control**	**T_1**	**T_2**	**T_3**
Threonine	3.50	3.75	4.25	5.00	5.75
Valine	4.2	5.8	6.0	6.4	7.0
Methionine + Cystine	5.14	8.57	9.14	9.71	10.29
Isoleucine	4.25	5.0	5.75	6.75	7.75
Leucine	3.43	4.86	5.57	5.86	7.57
Histidine	2.25	2.75	3.0	3.5	4.0
Phenylalanine	1.71	2.57	3.14	4.0	4.86
Tyrosine	2.57	2.43	2.86	3.86	4.43
Lysine	4.55	3.82	3.82	4.0	4.18
First limiting amino acid	Phenylalanine	Tyrosine	Tyrosine	Histidine	Histidine
Second limiting amino acids	Histidine	Phenylalanine	Histidine	Tyrosine	Lysine

Control: biscuits without TNTF
T1: biscuits fortified with 10% TNTF
T2: biscuits fortified with 20% TNTF
T3: biscuits fortified with 30% TNTF

The Computed protein efficiency ratio (C-PER) and biological value (BV) of biscuits:-

The data for the computed protein efficiency ratio (C-PER) and biological value (BV) are shown in Table (8). The C-PER in TNTF recorded 1.931 and BV recorded 70.229 about metabolizable coefficients of crude protein. The C-PER of the biscuit blend ranged from 2.058 to 2.712, while BV ranged from 71.575 to 78.462. The highest values of C-PER and BV were found in biscuits fortified with 30% TNTF furthermore. values increased gradually from biscuit control to biscuit fortified with 30% TNTF and this may be due to the increase of amino acids in biscuit blends fortified gradually with different levels TNTF. Generally, it was noticed that C-PER and BV, in all studied biscuit blends did not reach the protein references (casein) except in case biscuit fortified with 30% TNTF showed more values of C-PER and BV compared with reference protein (casein).

Table (8):- Computed protein efficiency ratio (C-PER) and biological value (BV) of biscuits fortified with different levels of Tiger nut Tiger nut tubers flour (TNTF).

Samples	C-PER	BV
TNTF	1.931	70.229
Biscuit control	2.074	71.744
T_1	2.096	71.970
T_2	2.058	71.575`
T_3	2.712	78.462
*Casein	2.50	76.22

* C-PER of casein = 2.50, (B.V.) of Casein = 76.22 (FAO/WHO pattern, 1985)
Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

Protein, caloric levels (Grams Daily Requirements), Percent satisfaction (P.S/200) of protein and energy of biscuits:-

As compared with FAO/WHO (1985) pattern, the results in Table (9) show the estimated amounts of biscuit samples to cover daily adult requirements of protein and energy in different samples. The daily adults' requirements of protein could be covered when consuming 6.583 and 9.265 gram of biscuit for adult man from 25-50 years. The highest value was observed in the control, but the lowest value in T_3 was fortified with the maximum level (30%) of TNTF. GDR of energy in biscuit samples ranged between 5.277 and 5.619 grams daily. The highest value was in biscuit control, but the lowest value was in T_3. Percent satisfaction of the daily requirements of protein for the adult man when consuming 200 gm of biscuit samples were shown in the same table. PS /200 of protein ranged from 21.587 to 30.381. The highest value was observed in T_3 and the lowest value in biscuit control. PS /200 of protein values increase gradually with the increase in tiger nut tubers flour. PS /200 of energy values were so closed and ranged from 35.293 to 37.903. The highest value was observed in T_3 and the lowest value in biscuit control.

Table (9):- Evaluation of protein, caloric levels (Grams Daily Requirements), Percent satisfaction (P.S/200) of protein and energy of biscuits fortified with different levels of Tiger nut tubers flour (TNTF):-

Samples	*** GDR g protein adult man (63 g)**	***GDR g calorie adult man (2900kcal)**	****Percent satisfactaion (PS/200) of protein**	****Percent satisfaction (PS/200) of energy**
Control	9.265	5.619	21.587	35.293
T_1	8.886	5.454	22.508	36.671
T_2	7.955	5.370	25.143	37.242
T_3	6.583	5.277	30.381	37.903

* GDR: grams consumed of food to cover the daily requirements of adult males in protein and caloric.
**PS/200: percent satisfaction of the daily requirements protein and energy for adult man when consumed 200 g of food.
Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

Daily needs (GDR) of indispensable amino acids and Percent satisfaction (PS/200) of indispensable amino acids of biscuits:-

Grams of biscuit consumed to cover the daily needs (GDR) of indispensable amino acids for adult (25-50 years) man were calculated for biscuit samples made from different blends fortified with different levels of tiger nut tubers flour. Table (10) was sowed the amount of grams of biscuit blends fortified with different levels of TNTF consumed to cover the daily need (GDR) of an adult man from every indispensable amino acid. Histidine was the restricting amino acids (6.30-9.16 gm.) for all biscuit blends. The GDR of some indispensable amino acids like Threonine, Valine, Methionine + Cystine, isoleucine, leucine, Histidine, tyrosine, phenylalanine and lysine were reduced clearly upon using tiger nut tubers flour in biscuit blends. The highest values were recorded in the control biscuit made so adult man should consume 9.16 gm from it biscuit to fulfill the required amount of indispensable amino acids. The best biscuit blends were T_3 because adult man should consume only 6.30 gm of biscuit blends to cover all required indispensable amino acids compared with other blends in general.

Percent satisfaction of the daily requirement of indispensable amino acids for an adult man when consuming 200 gm (PS/200) of biscuit was calculated for samples made from different levels of tiger nut tubers flour. Table (10) showed percent satisfaction (PS/200) of indispensable amino acids of biscuit blends fortified with different levels of tiger nut tubers flour. The PS/200 values of indispensable amino acids of biscuit blends ranged of 21.83 % (Histidine) to 88.55% (Leucine). Control biscuits presented the lowest values of all indispensable amino acids compared with other biscuit blends fortified biscuit blends with levels of TNTF increased the percent satisfaction of all indispensable amino acids. These effects were more noticed upon using a high percentage of TNTF like 20 or 30 % in the case of T_2 and T_3 respectively. So, it could be concluded that the nutritive values of biscuit blends were improved when using TNTF with a suitable percentage.

Table (10):- Daily needs (GDR) of indispensable amino acids and Percent satisfaction (PS/200) of indispensable amino acids of biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Samples / Amino Acids (g)	* Daily needs (GDR) of indispensable amino acids				**Percent satisfaction (PS/200) of indispensable amino acids				*** Daily requirement for adult man
	control	T_1	T_2	T_3	control	T_1	T_2	T_3	
Threonine	3.78	3.36	2.84	2.46	52.91	59.96	70.55	81.13	0.567
Valine	2.82	2.73	2.56	2.34	70.82	73.26	78.14	85.47	0.819
Methionine + Cystine	3.57	3.35	3.15	2.98	56.02	59.76	63.49	67.23	1.071
Isoleucine	4.09	3.56	3.03	2.64	48.84	56.17	65.93	75.70	0.819
Leucine	3.52	3.07	2.92	2.26	56.81	65.16	68.50	88.55	1.197
Histidine	9.16	8.40	7.20	6.30	21.83	23.81	27.78	31.75	1.008
Tyrosine	7.04	5.99	4.43	3.86	28.40	33.42	45.11	51.80	1.197
Phenylalanine	6.65	5.44	4.28	3.52	30.08	36.76	46.78	56.81	1.197
Lysine	4.80	4.80	4.58	4.38	41.67	41.67	43.65	45.63	1.008

*GDR: grams consumed of food to cover the daily needs of indispensable amino acids
**PS/200: percent satisfaction of the daily requirements indispensable amino acid for adult man when consumed 200 g of food.
***Daily Requirement of Adult Man According to FAO/WHO/UNU (1985)

Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

Fatty acids composition of biscuits fortified with different levels of Tiger nut tubers flour (TNTF):-

Lipids play a primary role from the nutritional point of view and exert a fundamental action in many biological processes, besides the nutritional aspects, lipids also have an important role in the processing technology of various foodstuffs because they influence the rheological properties, organoleptic profile and palatability as well as the shelf-life of foods **(Gurr, 1999).** The fatty acid composition of TNTF and biscuit fortified with different levels of TNTF is shown in Table (11). Data indicated that the major fatty acids in TNTF oil were oleic acid (70.34%), palmitic acid (15.55%), and linoleic acid (8.91%). From the obtained data, it can be observed that TNTF oil was rich in unsaturated fatty acids (79.94%), These results agree with These results were in agreement with those reported by**(Aljuhaimi *et al*., 2018)** and **Sabah, *et al*. (2009).** Tiger nut oil is rich in phytosterols, tocopherols and essential unsaturated fatty acids **(Mohdaly, 2019).** As for biscuit control and biscuit fortified with different levels of TNTF, it could be observed that the highest values in saturated fatty acids were palmitic acid, followed by stearic acid and myristic acid. Furthermore, total saturated fatty acids (TSFA) in biscuit control reached (46.28%), while the lowest was noticed in biscuit fortified with 30% TNTF (36.39%). The biscuit fortified with different levels of TNTF contained a high percentage of some unsaturated fatty acids like Oleic acid followed by Linoleic acid and Palmitoleic acid compared with the control biscuit. In addition, the percentage of total unsaturated fatty acids was recorded as the lowest value in biscuit control (53.72%).

The results of the present study were by those obtained **Salama, *et al*., (2013)** reported that, the addition of TNTF to a biscuit that increases the proportion of unsaturated to saturated fatty acids in a diet will reduce the level of blood coronary heart disease and may be an appealing way to increase the daily intake of functional nutrients, especially antioxidants and polyunsaturated fatty acids, very important to health promotion and prevention of many kinds of disorders such as gastric ulcers, constipation, anemia, hypertension, diabetes, infant malnutrition, and neurosis.

Table (11):- Fatty acids composition (%) of biscuits fortified with different levels of Tiger nut tubers flour (TNTF) .

Samples / Fatty acids	TNTF	control	T_1	T_2	T_3
Saturated fatty acids					
Lauric acid ($C_{12:0}$)	-	0.26	0.22	0.19	0.17
Myristic acid ($C_{14:0}$)	0.13	0.84	0.80	0.77	0.68
Palmitic acid ($C_{16:0}$)	15.55	40.58	38.13	34.61	30.20
Heptadecanoic acid ($C_{17:0}$)	-	0.10	0.10	0.11	0.13
Stearic acid ($C_{18:0}$)	3.91	4.25	4.45	4.76	5.02
Arachidic acid ($C_{20:0}$)	0.47	0.25	0.23	0.21	0.19
Total Saturated fatty acids	20.06	46.28	43.93	40.65	36.39
Unsaturated fatty acids					
Palmitoleic acid ($C_{16:1}$ n7)	0.31	0.69	0.98	1.22	1.86
Oleic acid-ω9 ($C_{18:1}$ n9)	70.34	40.95	42.63	45.12	47.33
Linoleic acid-ω6 ($C_{18:2}$ n6)	8.91	11.56	11.85	12.34	13.56
Linolenic acid-ω3 ($C_{18:3}$ n3)	0.22	0.24	0.33	0.40	0.59
Gadolic acid ($C_{20:1}$ n9)	0.16	0.13	0.14	0.15	0.17
Arachidonic acid ($C_{20:4}$ n6)	-	0.15	0.14	0.12	0.10
Total Unsaturated fatty acids	79.94	53.72	56.07	59.35	63.61
***U/S ratio**	3.99	1.16	1.28	1.46	1.75

*U/S: total unsaturated fatty acids/ total saturated fatty acids

Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

Sensory evaluation of biscuits fortified with different levels of Tiger nut tubers flour (TNTF):-

Consumer quality is a major factor in selecting a product, and among the main characteristics related to quality are texture, taste, and the surface color of a biscuit **(Omoba *et al*., 2013).** The sensory attributes of biscuits fortified with different levels of TNTF presented in Table (12) showed that biscuit control resulted in better taste, color, odor, thickness, and size. Biscuits fortified with 20% TNTF recorded the highest overall acceptability. Similarly, **Bello, (2021)** and **Adebayo-Oyetoro *et al*. (2017)** recommended 20 % substitution in the production of biscuits and chin-chin snacks respectively. which were agree with the results obtained by .The results also showed that an increase in the level of TNTF led to an improved texture and softness of biscuit blends due to TNT fat. Furthermore, biscuits fortified with 20% TNTF had the lowest values of taste and odor recorded (8.12 and 8.14), respectively. Also, from the same Table, no significant differences were noticed in the thickness, softness, and overall acceptability score for all biscuit samples, but there are significant differences ($p \leq 0.05$) in taste, color, odor, texture, and size. All samples were acceptable.

Table (12):- sensory attributes of biscuits fortified with different levels of Tiger nut tubers flour (TNTF).

Samples	**Organoleptic properties**							
	Taste (10)	**Color (10)**	**Odor (10)**	**Texture (10)**	**Thickness (10)**	**Softness (10)**	**Size (10)**	**Overall acceptability (10)**
control	9.16 ^{a}	9.88 ^{a}	9.58^{a}	8.79 ^{b}	9.70 ^{a}	9.12 ^{a}	9.48 ^{a}	9.14 ^{b}
T_1	8.67 ^{a}	9.28 ^{a}	9.04 ^{a}	8.93 ^{ab}	9.11 ^{a}	9.60 ^{a}	9.20 ^{a}	9.52 ^{a}
T_2	8.31^{ab}	8.60 ^{b}	8.32 ^{b}	9.14 ^{ab}	8.98 ^{a}	9.68 ^{a}	9.12 ^{a}	9.73 ^{a}
T_3	8.12 ^{b}	8.45 ^{b}	8.14 ^{b}	9.78 ^{a}	8.76 ^{a}	9.80 ^{a}	8.23 ^{b}	9.27 ^{b}

Each value was an average of three replicates. Values followed by the same letters in the same row are not significantly different at $p \leq 0.05$.
Control: biscuits without TNTF
T_1: biscuits fortified with 10% TNTF
T_2: biscuits fortified with 20% TNTF
T_3: biscuits fortified with 30% TNTF

4. CONCLUSION

Obtained results showed that wheat flour can be fortified with tiger nut flour up to 20% level to produce high nutritional value and acceptable quality biscuits product.

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التقييم التغذوي والخصائص الحسية للبسكويت المدعم بدقيق حب العزيز

تم التعرف على درنات حب العزيز كأحد أفضل المحاصيل الغذائية الغير تقليدية والتي يمكن استخدامها لزيادة النظام الغذائي . يعتبر البسكويت من أشهر أنواع المخبوزات التي تستهلكها جميع شرائح المجتمع تقريبًا. تم اجراء هذا البحث لدراسة الجودة الغذائية لكل من دقيق حب العزيز الي جانب خلطات البسكويت المدعمة بمستويات مختلفة منه بنسبه تدعيم (30,20,10%). تم تقدير التركيب الكيميائي ، والمعادن ، والأحماض الأمينية ، والأحماض الدهنية باستخدام الطرق القياسية. اوضحت النتائج ان دقيق حب العزيز مصدرًا جيدًا للبروتين الخام والزيت الخام ومحتوى الرماد والألياف الخام مقارنة بدقيق القمح. بالإضافة إلى ذلك، يحتوي على نسب قيّمة من المعادن مثل الفوسفور والبوتاسيوم والماغنيسيوم (185.33 و 216.68 و 169.26 مجم / 100 جم على أساس الوزن الجاف) على التوالي. كانت الأحماض الأمينية الرئيسية التي لا غنى عنها الليوسين (0.24 جم / 100 جم) والفالين (0.21 جم / 100 جم). كما يحتوي دقيق حب العزيزعلى نسبة عالية من الأحماض الدهنية غير المشبعة (79.94٪) وخاصة حمض الأوليك (70.34٪). أظهرت نتائج التركيب الكيميائي لخلطات البسكويت المدعمة بمستويات مختلفة من دقيق حب العزيز وجود زيادة معنوية في محتوى البروتين الخام والزيت الخام والرماد و الألياف الخام للخلطات الثلاثة،على النقيض من ذلك إنخفضت نسبة الرطوبة والكربوهيدرات تدريجيا مع زيادة النسبة المئوية لاستبدال دقيق القمح بدقيق حب العزيز. بالإضافة إلى ذلك ، اظهرت عينات البسكويت المدعمة بمستويات مختلفة من دقيق حب العزيز مستويات اعلي في محتوي المعادن ، والأحماض الأمينية الاساسية والغير اساسية، وبعض الأحماض الدهنية غير المشبعة مثل حمض الأوليك يليها حمض اللينوليك وحمض البالمتيك مقارنة بعينة البسكويت الكنترول. أظهرت نتائج التقييم الحسي أن تدعيم دقيق القمح بدقيق حب العزيز حتي نسبة 30٪ يعطي بسكويت مقبولا حسيا. بينما سجل البسكويت الذي تم تدعيمه بنسبة 20٪ دقيق حب العزيز الاعلى قبولا بصفة إجمالية. تكشف هذه الدراسة عن إمكانية استخدام دقيق حب العزيز في إنتاج بسكويت ذي احتياجات غذائية خاصة.