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Evaluation of Selected Properties of Beef-Tigernut Fibre Burger

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Abstract - Tiger nut fibre is a by-product of tiger nut milk processing produced in high quantity with high content of fibre which allows its application in the formulation of foods rich in dietary fibre. Elaboration of Beef-Tiger nut fibre burgers were carried out by inclusion of different percentages (0%-control, 5%, 10% 15% and 20%) of Tiger nut fibre (TNF), in the formulation of beef burgers which were analysed for proximate composition, textural profile, physical and sensory properties. Statistically, beef burgers elaborated with TNF had higher proximate compositions. Carbohydrate and crude fibre content increased significantly in the 20%TNF sample. In colour, redness reduced significant from control sample to 20%TNF sample while brownness increased. Significant changes were observed in certain textural parameters. Chewiness significantly increased across samples while adhesiveness decreased. pH and water activity showed no significant difference at $p \geq 0.05$. Changes due to TNF addition observed in raw burgers were concealed by variation in parameter due to cooking during preparation of sensory samples. Burgers with TNF were less juicy, less tender and with less meaty flavour. Overall acceptability scores were lower in burgers with 10% and 20% TNF, although no significant difference was observed for all samples. TNF inclusion to burgers is a favourable and suitable application based on the improved quality product obtained in this research.

Index Terms - beef, beef burger, by-products, dietary fibre, physical properties, proximate composition, sensory properties, tiger nut

1 INTRODUCTION

IT is important for food materials to be delicious as well as nutritious and natural. Rapidly increasing human population of the world, environmental pollution caused by consistently developing technology, insufficient education and problems caused by wrong nutrition are making supplying of natural food more difficult (Yangilar, 2013). Meat consumption has been accepted as a good indicator of economic and social well-being; it is a prestigious food and its consumption has increased in recent years, especially in developing countries (FAO, 2017). Meat and meat products are important sources of protein, fat, essential amino acids, minerals and vitamin and other nutrients. However, in recent times, the consumer demands for healthier meat and meat products with reduced level of fat, cholesterol, decreased contents of sodium chloride and nitrite, improved composition of fatty acid profile and incorporated health enhancing ingredients are rapidly increasing worldwide (Wangang, 2010). Fibre is one of the most common functional ingredients in food products and has been used as fat replacer, fat reducing agent during frying, volume enhancer, binder, bulking agent and stabilizer (Sánchez-Zapata et al., 2009). Utilization of underutilized food resources or by-products generated by the food industry is a promising source of raw materials that can used for their technological, nutritional, and functional properties (Selani et al., 2011). A study of the physicochemical properties of tiger nut by products by Sánchez-Zapata et al., (2009) concluded that it is rich in fibre and may be considered a potential ingredient in a healthy diet. Furthermore, studies on the impact of this co-product on pork sausages, burgers (Sánchez-Zapata et al., 2010; Sanchez-Zapata et al., 2013) and cereal products (Aguilar et al., 2014, Verdu et al., 2017) also show quite satisfactory results. Nowadays industry is considering improving its processes to recover these by-products, to turn them into an income source, and to also re circulate compounds of healthy and technological interest in other products. These "co-products" can be converted into profitable products as raw materials for secondary processes (intermediate compounds), operating supplies, or the ingredients of new products (Sánchez-Zapata et al., 2009). The use of these ingredients in meat products offers processors the opportunity to improve the nutritional and health qualities of their products. Subsequently, this application would contribute to increase the consumption and exploitation of tiger nut. In addition, edible by-products of food industries are a promising alternative to address the aggravating world food problem in developing countries like Nigeria.

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2. MATERIALS AND METHODS

2.1 Sample Elaboration

Fresh yellow fleshed Tiger nut was obtained from local market while cooled vacuum packed minced meat was obtained from a standard meat processing plant. The tiger nut tubers were soaked in water overnight after it has been sorted and rinsed. The softened tubers were grinded with an electric grinder. The resulting slurry was sieved with a muslin cloth after which the pulp that remained was further dewatered and the dried in a conventional oven. The tiger nut fibre was stored in a Ziploc bag till required. The minced beef was poured in a food processor and then water (15%), salt (1.5%), and pepper (0.5%) was added into the bowl and mixed for 2mins. This mixture was divided into 5 parts and a measured amount of tiger nut fibre (5%, 10%, 15% and 20%) per weight of each part was added to each

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except one (the control). These concentrations were selected based the results obtained in previous assays by Sanchez-Zapata et al., (2010). Each sample part was then mixed again for 5 min. The beef burger was packed in airtight plastic bags. Samples were stored at 4ºC. Samples for sensory analyses were lightly fried in vegetable (refined palm olein) oil with the aid of a cooking gas burner.

Minced Beef
↓
Addition of spices
(salt, pepper and water)
↓
Mixing
↓
Addition of TNF
↓
Mixing
↓
BEEF BURGER

Figure 1: Beef burger Elaboration

Sanchez-Zapata et al., 2010 (modified)

2.2 Proximate Analyses was carried out according to the official methods of analysis described by the Association of analysis described by the Association of Official Analytical Chemist (A.O.A.C. 18th edition, 2005). The carbohydrate content was determined by difference. That is by subtracting sum of moisture%, crude protein%, crude fat%, crude fibre%, and ash% from 100%. Gross energy determination was carried out using Gallen Kamp ballistic bomb calorimeter Association of Official Analytical Chemist (A.O.A.C, 2003**).** Analyses were carried out in triplicate.

2.3 Characterisation of Tiger Nut Fibre

Tigernut fibre was characterised by identification of the neutral sugars and uronic acids present as non-starch polysaccharides (NSP) i.e., monosaccharides units joined through glycosidic linkages using Anthrone Method (Radley J. A., 1997).

Step 1 Sugars hydrolysis and extraction processes

1g of the sample was weighed into a boiling tube with an analytical balance. 25ml of hot 80% Ethanol was added into the boiling tube and shake on a vortex mixer. The material was allowed to settle for 30 minutes and then filtered through a Whatman No. 41 filter paper into a beaker. The above steps were repeated again for complete extraction of monosaccharides and disaccharides 3 times, to this 9ml of 1M NaOH was added to incubate overnight for complete hydrolysis of the polysaccharide. The extract was evaporated until the Ethanol is evaporated. 10ml water was added to dissolve the contents and transferred into 100ml volumetric flask. The beaker's content was washed 3 times and added to the volumetric flask and made up with distilled water to 100ml mark.

Step 2 Determination of sugars

1ml aliquot of the above extract was pipetted into a test tube and 1ml water as blank was pipetted into another test tube. 1ml of 5% phenol solution was added and shaken followed by the careful addition of 5ml 96% H_2SO_4 to shake on a shaker vigorously for 2 minutes and cooled. Standard sugar solutions of range 10 – 50 µg/ml were treated with 5% phenol and H_2SO_4 as above. The absorbances of specific colour solutions of sample and sugar standard were read on a Spectronic 21D Spectrophotometer at a specific wavelength against the blank.

$$\%\text{sugar} = \frac{\text{Absorbance} \times \text{Av. Gradientfactor} \times \text{Dilutionfactor}}{\text{weightofSample} \times 10000}$$

2.3 Colour analysis

Using method by Spectrophotometric Scanning (Glories Y., 1984), 1g of each ground sample was weighed into a 100ml beaker. 25ml of HPLC methanol added to extract the colour by shaking and homogenizing with glass rod for 30mins. The mixture was allowed to stand for 10min; after which it was filtered through hardened Whatman No 42-filter paper. The organic filtrate obtained was used to determine colour by scanning at visible region range of between 400nm and 800nm. The two wavelengths at which maximum optical density or absorbance are obtained was taken to determine the %transmittance corresponding to a particular colour with respect to colour intensity. Colour Intensity is the sum of the Absorbance for each sample at 520nm and 420nm. Six replicate measurements were taken for each sample.

$$\%\text{YELLOW} = \frac{\text{Absorbance@420nm}}{\text{ColourIntensity}} \times \frac{100}{1}$$

$$\%\text{RED/BROWN} = \frac{\text{Absorbance@520nm}}{\text{ColourIntensity}} \times \frac{100}{1}$$

2.4 pH and Water Activity

The pH was measured in a suspension of 15g sample blended with 150 mL deionized water for 2 min with a pHmeter and Water activity (aw) was measured at 25°C with a hygrometer.

2.5 Texture Profile Analysis (TPA)

Selected moulds of samples were analysed with the aid of a textural profile analyser (Testometric material testing machine, 0500-10080) at the National Centre for Agricultural Mechanization (NCAM) Ilorin, kwara state. Samples were tested for hardness, springiness, stringiness, cohesiveness, gumminess, adhesiveness and chewiness using the two-cycle compression test (Magnus Taylor puncture probe test) at depth of 5mm, probe diameter of 120mm and speed of 102mm/min.

2.6 Sensory Analysis

Sensory evaluation was carried out in the sensory laboratory in The Food Technology Department of University of Ibadan. The samples were scored for appearance, aroma, taste, tenderness, juiciness and overall acceptability on a 9 - point hedonic scale to measure degree of likeness for the products. Samples were presented in coded trays and assessed individually in a cubicle under illumination by forty-four panellists.

2.7 Statistical Analysis

Means of data obtained were subjected to analyses of variance (ANOVA) to determine if means are significantly

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different at p<0.05. Separation of means was carried out using Duncan multiple range tests.

3. Results and discussion

3.1 Proximate composition of tiger nut fibre

Values obtained for proximate composition of tiger nut fibre as shown in table 1 revealed that tiger nut fibre has moisture content of 11.60% which is significantly similar to 11.8% reported by Samson and Shehu, (2015). Also, high carbohydrates content of 56.78 % was recorded. This figure is significantly higher than 43.0% reported by Samson and Shehu, (2015) while the lipid content reported 3.88% was significantly lower than value 24.8% reported by Samson and Shehu (2015). Result shows it is a good fibre source at 19.01% which is similar to 18.4% reported by Samson and Shehu (2015). A significant amount of protein (5.58%) and ash (3.15 %) were recorded which is significantly higher than values (protein 1.5% and ash 0.5 %) reported by Samson and Shehu (2015). Gross Energy value of 2.215kcal/g was recorded for the tiger nut fibre which indicates that tigernut fibre will provide usable energy when consumed which is a good quality index in a fibre rich food.

Table 1: Proximate Composition of Tiger nut fibre

Parameter	Percentage Composition	Percentage Composition (%) (Samson and Shehu, 2015)
Moisture (%)	11.60±0.03	11.8 ± 0.76
Ash (%)	3.15±0.02	0.5 ± 0.06
Crude Lipid (%)	3.88±0.03	24.8 ± 0.06
Crude Protein (%)	5.58±0.10	1.5 ± 0.18
Crude Fibre (%)	19.01±0.04	18.4 ± 0.77
Carbohydrates (%)	56.78±0.07	43.0 ± 0.42
Gross Energy (k/cal)	2.22±0.00	-

3.2 Characterisation of Tigernut Fibre

Characterisation of Tiger -nut fibre in this study involved the identification of the neutral sugars and uronic acids present as non-starch polysaccharides which are complex polysaccharides other than the starch which contains several hundred thousand monosaccharides units, joined through glycosidic linkages. Non-starch polysaccharides together form a major part of dietary fibre (DF) of grains and chemically DF is often defined as NSPs (Englyst, 1989). The HPLC method of dietary fibre analysis is most common and measures NSPs as the sum of neutral sugars and uronic acids directly by electrochemical detection (Kumar et al., 2012).

Neutral sugars and Uronic acids a series of pectineus substances commonly found in most plant cell walls. Neutral sugars include monomeric sugars such as cellulose, arabinose, galactose, rhamnose, glucose, xylose etc. Uronic acids are a class of sugar acids with carbonyl and carboxylic acid as functional groups. Some naturally occurring Uronic acids are D-Glucuronic acid also D-galacturonic acid, D-mannuronic acid, and L-iduronic acid. The uronic acids are important constituents of certain natural heteropolysaccharides. Uronic acids along with certain phenolic compounds may have hypocholesteriolemic action on bile in the body.

The result of characterisation of the tiger nut fibre on table 2 shows that the tiger nut fibre contained 16.35% total uronic acid and 5.57% neutral sugars. The sum of which gives the percentage non-starch polysaccharides content of 21.92% present in the tiger nut fibre.

Table 2: Characterisation of Tiger nut fibre

Fibre Components	Percentage Value
%Total Uronic Acids	16.35 ±0.03
%Neutral Sugars	5.57±0.04
%NSP	21.92±0.04

Table 3 shows the percentage of monomeric sugars present as neutral sugars in the tiger nut fibre. Glucose had the highest value 13.16% and this was closely followed by cellulose at 12.39%. Lower values were obtained for rhamnose at 1.52%, mannose at 2.60%, galactose at 4.85% and xylose 6.29%.

Table 3: Monomeric neutral sugars in tiger nut fibre

Neutral sugars	Percentage value
%Mannose	2.60 ±0.03
%Xylose	6.29 ±0.00
%Glucose	13.16 ±0.02
%Galactose	4.85 ±0.02
%Rhamnose	1.52±0.03
%Cellulose	12.39±0.03

3.3 Effect of Tiger Nut Fibre on Proximate Composition of Beef Burger

Results of analysis of proximate composition of five different beef burgers are presented in table 4. The difference in the composition of the different treatments is attributed only to the amount of tiger nut fibre added at different ratios (0%, 5%, 10%, 15% and 20%).

The presence of TNF at all ratios affected the protein content significantly, the higher the level of tiger nut fibre the higher the protein content and it ranged from 17.88% to 19.78%. This result is in contrast with the finding of Choi, et al. (2010) who reported that replacing pork back fat with different grape seed oil levels and 2% rice bran fibre in reduced-fat meat emulsion systems did not significantly affect the protein contents. Choi et al. (2009) also reported similar results for the protein content of low-fat frankfurters, in which different vegetable oils replaced pork back fat, was reinforced with rice bran fibre.

Addition of tiger nut also affected the level of fat in the samples and all values varied significantly; the control sample had the lowest percentage of fat content (5.47%) while the sample with 20% tiger nut fibre recorded the highest percentage of fat (8.26%). This is in contrast with findings of Sanchez-Zapata et al., (2010) who reported that burgers with 10% and 15% TNF added showed lower fat content (p ≥ 0.05) than control burgers and burgers with 5% TNF, with no significant differences between them (p ≥ 0.05). The increase in percentage of fat content in proportion with tiger nut fibre is also in contrast with the finding of Yun-Sang Choi (2014) who reported decrease in fat content of frankfurters replaced by dietary fibre extracted from makgeolli lees and Jairo et al., (2014) who also reported decrease in fat content of pork burger added with albedo-fibre powder obtained from yellow passion fruit

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(Passifloraedulis var. flavicarpa). Control sample recorded highest percentage of moisture content of 71.05% while sample with 5%, 10%, 15% and 20% recorded 62.01%, 55.77% 52.45% and 48.77% respectively thus all samples varied significantly with increasing tiger nut fibre. All the samples showed significant difference in carbohydrate content however the control sample recorded lowest carbohydrate value of 3.51% while 20%TNF sample recorded the highest carbohydrate value of 14.55%.

Ash content of beef burger samples varied significantly across all samples. The lowest value was recorded for the control sample at 2.09% while the highest value was recorded for the 20% tiger nut fibre sample at 3.52%.

Crude fibre of all beef burgers samples varied significantly with increase from 0.00% in the control burger to 5.12% in the 20% tiger nut fibre sample. This result was similar to the finding of Sanchez Zapata et al., (2010) who reported increase in level of fibre content of burger in proportion with the level of tiger nut fibre. Nutritional claim could be included in the label of the burgers: burger with added tiger nut fibre could be labelled as source of fibre. It is of great interest because it well known that dietary fibre intake provides many health benefits, this nutritional claim could encourage consumers to purchase the product.

The energy values of beef burger increased with increase of tiger nut fibre included. The lowest value was recorded for control sample at 2.03% while the highest value was reported for 20% tiger nut fibre sample at 2.31%. This result is similar with the finding of Yun-Sang Choi (2014) who reported increase in energy values with increase in makgeolli lees fibre levels in reduced-fat frankfurters samples.

Other proximate properties have been reported by different researchers in other meat products when different types of dietary fibre were added at different level. Backers and Noli (1997) added soy fibre to bolognas, Gök et al., (2011) ground poppy seeds to meat burgers. The fat content was significantly lower in the frankfurters formulated with reduced-fat and makgeolli lees.

Table 4: Proximate composition of burger (control and experimental value) formulated with different levels of tiger nut fibre (TNF)

Parameter	Control(0%TNF)	5%TNF	10%TNF	15%TNF	20%TNF
Crude Protein	17.88±0.09^{e}	18.18±0.10^{d}	18.88±0.01^{c}	19.38±0.09^{b}	19.78±0.11^{a}
Crude Fat	5.47±0.35^{e}	5.89±0.04^{d}	6.32±0.02^{c}	6.96±0.02^{b}	8.26±0.03^{a}
Crude Fibre	0.00±0.00^{e}	0.92±0.03^{d}	3.29±0.03^{c}	4.71±0.02^{b}	5.12±0.02^{a}
Ash	2.09±0.03^{e}	2.24±0.06^{d}	2.59±0.03^{c}	2.79±0.04^{b}	3.52±0.03^{a}
M.C	71.05±0.03^{e}	62.01±0.06^{d}	55.77±0.0^{c}	52.45±0.04^{b}	48.77±0.06^{a}
Carbohydrate	3.51±0.03^{e}	10.76±0.07^{d}	13.16±0.08^{c}	13.71±0.03^{b}	14.55±0.04^{a}
GE	2.03±0.00^{e}	2.10±0.04^{d}	2.12±0.00^{c}	2.26±0.00^{b}	2.31±0.00^{a}

3.4 Effect of Tiger Nut Fibre on the textural properties of beef burgers

Table 5 shows the effect of TNF on the textural properties of burgers. All textural parameters studied were influenced by different levels of tiger nut fibre addition, except springiness, and cohesiveness which showed no significant difference with addition of tiger nut fibre ($P < 0.05$).

Adhesiveness which is the negative force area for the first bite decreased significantly with the level of tiger nut fibre added. Control sample recorded 8.04Ns adhesiveness and while the lower value of 0.03Ns was observed in sample with 20% tiger nut fibre.

Chewiness which measures the energy required to chew a solid or semi-solid food product to a state where it is ready for swallowing and hardness which is the peak force during the first compression cycle increased significantly with the level of tiger nut fibre added, control sample recorded lower value of chewiness 4.75N while 20% TNF sample recorded 15.79N however the lowest value was recorded for 5%TNF beef burger sample. The results obtained are in agreement with Choi et al. (2010) who reported increased chewiness in reduced-fat meat emulsion systems added with rice bran fibre, Jairo et al. (2014) who studied pork burger added with albedo-fibre powder obtained from yellow passion fruit and Sanchez-Zapata et al., (2010), who studied the effect of tiger nut fibre on quality characteristics of pork burger.

Cohesiveness, the ratio of positive force area during the second compression to that during the first compression recorded no significant difference across all samples though it ranged from 0.38 for the control sample to 0.559 for the 20%TNF beef burger sample. These results are in concordance with Choi et al. (2010) in reduced-fat meat emulsion systems added with rice bran fibre. This is however in disagreement with reports by Alesson-Carbonell et al., (2005) that the addition of non-meat ingredients to meat batter decreased the cohesiveness and gumminess of the meat products.

Gumminess which is the energy required to disintegrate a semi-solid food product to a state ready for swallowing varied independently to the amount of tiger nut fibre added. Gumminess ranged from 8.79N for the 5%TNF beef burger sample to 31.18N for the 15%TNF beef burger. These results are not similar to those recorded by Jairo et al. (2014) in pork burger added with albedo-fibre powder obtained from yellow passion fruit or Choi et al. (2010) in reduced-fat meat emulsion systems added with rice bran fibre.

Hardness which is the force required to compress a food between molars to or force attain a given deformation increased significantly from 26.94N for control sample to 75.20N 15%TNF beef burger sample which is in correlation with increase in hardness observed by Jairo et al.,(2014) in pork burger added with albedo-fibre powder obtained from yellow passion fruit. However, a lower value of 49.07N for the 20%TNF beef burger sample was recorded while Samples 5%TNF and 10%TNF showed no significant difference with value 29.62N and 30.11N respectively. In contrast, Sánchez-Zapata et al. (2010) or Alesón-Carbonell et al. (2005) indicated that the hardness was not modified by the addition of tiger nut fibre or lemon albedo in pork and beef burgers, respectively.

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Springiness, the rate at which a deformed material goes back to its undeformed condition after deforming force is removed, in all burgers samples varied independently to the amount of tiger nut fibre added though no significant difference was recorded across all samples. Values for springiness ranged from 0.37 to 0.58. These results are similar to those reported by Choi et al. (2010) in reduced-fat meat emulsion systems added with rice bran fibre.

Stringiness decreased significantly with the level of tiger nut fibre added. Control sample recorded 4.91mm for stringiness while the lower value of 3.46mm was observed in sample with 20% tiger nut fibre. However, Stringiness was not significantly in Control, 5%TNF and 10%TNF samples. Thus, important to note that in burgers such differences were only significant when a higher amount of tiger nut fibre was added compared to burgers without any fibre.

Similar results in hardness have been reported by García et al. (2007) in cooked meat sausages added with different amounts of peach, apple and orange fibre.

The addition of dietary fibre seems to disrupt the protein–water or protein–protein gel network, which favours a decrease in gel strength of the product (Lin, Keeton, Gilchrist, & Cross, 1988) because the addition of dietary fibre would involve incorporating particles in the protein matrix that would strengthen the binding. The observed effect on the texture of cooked burgers indicate that cooking process masked some changes due to the amount of tiger nut fibre added, which were previously detected in control sample. The significant increases in hardness observed in meat products containing dietary fibre were due to the great binding ability of samples with added dietary fibre. Ferneandez-Gines et al. (2004) reported that due to water binding ability and swelling property of insoluble fibres, they are able to influence food texture and Sanchez-Zapata et al., 2009 reported TNF has 59.71g/100g dry weight of dietary fibre of which 99.8% is insoluble. The texture profile analysis results may define the quality of the finished product and can contribute to selecting the best functional ingredients (Choi et al., 2009). Depending on the amount and type of fibre, controversial results have been reported on textural parameters. For example, both hardening and softening have been observed when fibre is added to various meat products (Sanchez-Zapata et al., 2010).

Table 5: Effect of tiger nut fibre on the textural properties of burgers

PARAMETER	Adhesiveness (N.s)	Chewiness (N)	Cohesiveness	Gumminess (N)	Hardness (N)	Springiness	Stringiness (mm)
Control (0%TNF)	8.04±0.08^{a}	4.75±0.45^{d}	0.380±0.35^{a}	10.23±0.35^{d}	26.94±0.12^{d}	0.46±0.35^{a}	4.91±0.32^{a}
5%TNF	2.63±0.65^{b}	2.97±0.54^{e}	0.301±0.35^{a}	8.79±0.35^{e}	29.62±0.12^{c}	0.37±0.64^{a}	4.86±0.89^{a}
10%TNF	0.59±0.65^{c}	5.22±0.76^{c}	0.425±0.35^{a}	12.80±0.35^{c}	30.11±0.24^{c}	0.41±0.12^{a}	4.57±0.43^{a}
15%TNF	0.35±0.24^{c}	12.89±0.43^{b}	0.415±0.35^{a}	31.18±0.35^{a}	75.20±0.86^{a}	0.41±0.00^{a}	4.38±0.09^{b}
20%TNF	0.03±0.15^{c}	15.79±0.16^{a}	0.559±0.35^{a}	27.44±0.35^{b}	49.07±0.48^{b}	0.58±0.40^{a}	3.46±0.57^{c}

3.5 Physical (colour, pH and water activity) properties of beef burger

Values for colour of burgers formulated with increasing levels of tiger nut fibre are shown in table 6. The addition of tiger nut fibre in burger formulations resulted in significantly decrease in redness (P < 0.05). Control sample recorded highest value for redness (13.99) while the lowest value was recorded by sample with 20% tiger nut fibre (3.86). Increasing fibre addition resulted in increased brownness (P < 0.05). These results may be due to the colour components of tiger nut that remained in the products. This result agrees with report by Alesson- Carbonell et al. (2005) in burgers added with lemon albedo, ingredient that has a great amount of yellow components and Choi et al., (2010), who reported that chicken emulsion systems with increasing makgeolli lees fibre levels displayed significantly decreased lightness and redness values, and increased yellowness values. Decreases in redness have been related to oxidation of lipids and haemopigments (Fernández-López et al., 2006).

No significant difference was observed in pH among the different burger formula. This result is in contrast with the finding of Alesson-Carbonell et al. (2005) and Turhan et al., (2005) who reported decrease in pH of pork burger. However, some authors reported an increased in the pH values of meat burgers added with different fibre types (Gök et al., 2011; Sayas-Barberá et al., 2011). No significant difference was observed in water activity of all beef burger samples. This result is in agreement with Sánchez-Zapata et al., (2009) who reported water activity of 0.99 ± 0.00 for TNF, which is very similar to the water activity of control burger (0.99 ± 0.01). This can be attributed to the similar water activity of the fibre and the meat mixture. (Sánchez-Zapata et al., 2010).

Table 6 Physical properties of beef burgers formulated with different levels of tiger nut fibre

Sample	REDNESS	BROWNESS	pH	Aw
Control	13.99^{a}	86.01^{d}	6.26^{a}	0.99^{a}
5%TNF	7.00^{b}	93.00^{c}	6.25^{a}	0.99^{a}
10%TNF	5.15^{c}	94.85^{b}	6.21^{a}	0.98^{a}
15%TNF	4.24^{d}	95.76^{a}	6.22^{a}	0.98^{a}
20%TNF	3.86^{e}	96.13^{a}	6.20^{a}	0.98^{a}

3.6 Effect of Tiger Nut Fibre on sensory properties of beef burgers

Sensory properties for burgers with different tiger nut fibre levels are shown in table 7. Addition of tiger nut fibre did not

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significantly affect appearance of the burger to the panellist though they were significantly detected by instrumental analysis (brownness). Control samples showed significant difference to other samples at 7.05 while samples with TNF 5% and 20% both had the lowest values at 6.89.

Flavour significantly decreased ($P < 0.05$) with the level of tiger nut fibre added. The decrease in flavour in burgers with respect to the level of tiger nut fibre was attributed by some panellist to the perception of a slight tiger nut flavour. Values for flavour decreased from 6.44 of the control sample to 6.00 of the 20%TNF beef burger sample.

The addition of tiger nut fibre did not significantly affect ($P \geq 0.05$) the taste of beef burger samples and ranged from 6.53 for control sample to 6.56 to 20%TNF beef burger. Control sample showed the lowest score of 6.07 for tenderness and a higher figure of 6.81 in 20%TNF sample, however no statistically differences was found in the samples with 10% and 15% TNF. In other words, for panellists, the addition of tiger nut fibre increased the tenderness. Juiciness significantly decreased ($P < 0.05$) with the level of tiger nut fibre added. The decrease in juiciness acceptability by sensory panellist can be related to the lowest fat and moisture content in burger with tiger nut fibre, control sample was highly acceptable by the panellist with value at 6.91 which sample with 20%TNF had a value of 5.82. This result was in agreement with Fernández-Ginés et al. (2004) who reported a decrease in juiciness perception in cooked sausages with added orange fibre that was attributed to the water-holding capacity of orange fibre.

Control sample was highly acceptable by sensory panellists followed by burger with 15% tiger nut fibre. Finally, it is important to stress that, although some differences had been detected by the panellists in some of the attributes evaluated, all of the burgers were scored high in overall acceptability. This indicates that the panellists would readily consume any of them, irrespective of the amount of tiger nut fibre added, although control and sample with 15% tiger nut fibre are highly acceptable by the panellist. One could highlight that the burgers with added 20% TNF scored slightly lower than the other options, although no significant differences were observed.

Table 7: Sensory evaluation of beef burger with added tiger nut fibre

Sample	Appearance	Flavour	Taste	Tenderness	Juiciness	Over acceptability
Control	7.05^{a}	6.44^{a}	6.53^{a}	6.07^{d}	6.91^{a}	6.96^{a}
5%TNF	6.89^{b}	6.33^{b}	6.55^{a}	6.46^{c}	6.80^{b}	6.75^{b}
10%TNF	6.96^{b}	6.11^{c}	6.52^{a}	6.71^{b}	6.32^{c}	6.43^{c}
15%TNF	6.98^{b}	6.40^{a}	6.55^{a}	6.77^{b}	5.89^{c}	6.88^{ab}
20%TNF	6.89^{b}	6.00^{c}	6.56^{a}	6.81^{a}	5.82^{d}	6.16^{d}

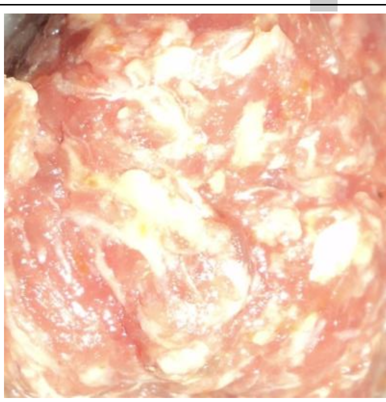
Plate 1 Beef Burger with 0%TNF (Control)


Plate 2 Beef Burger with 5%TNF


Plate 3 Beef Burger with 10%TNF


Plate 4 Beef Burger with 15%TNF

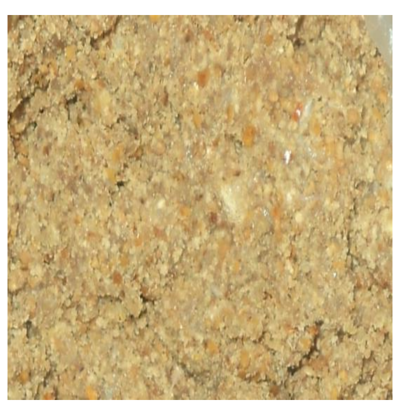
Plate 5 Beef Burger with 20%TNF

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4. Conclusion

The result of the study showed that tiger nuts fibre enriched beef burger had varied properties to the control sample. Proximate composition of all samples improved with tiger nut fibre added. From sensory analysis, after control sample, beef burger sample with 15% tiger nut fibre had the highest overall acceptability while 20% tiger nut fibre shows the least acceptability though it did not vary at $p<0.05$ to other samples thus all samples will give overall acceptable product. The observed changes in the texture profile of the beef burgers indicate that changes occurred due to the amount of tiger nut fibre added compared to the control sample. Tiger nut inclusion adversely affected the colour of the beef burger as the redness reduced with increase in tiger nut fibre.
Utilization of tiger nut by-products from tiger nut milk production in the formulation of beef burgers is a valuable alternative for this processing by-product and can result in meat products with a great acceptance and high nutritional value, this avenue should thus be explored. The study dealt with the development of new products; cost analysis should thus be made on the development of the new product. In view of the dietary fibre content of beef burgers with added TNF, the following nutritional claim could be included in the label of the burgers: burgers with 10% added TNF could be labelled as ''source of fibre", and burgers with 15% added TNF as ''high-fibre food". There is need for further development of products based on tiger nuts and tiger nut fibre for households and commercial purposes to ensure food security. These in turn will increase its production and utilization of tiger nut, thereby making it more popular and more economically important. There is need for further investigation to identify microbial species and enzymes found in tiger nut fibre. Medically, inclusion of tiger nut and tiger nut fibre should be recommended as a dietary supplement for diabetic patients due to its protein quality, easily absorbed monomeric sugars and high fibre content.

References

Aguilar Nu´ria, Albanell Elena, Min˜arro Begon˜a, Guamis Buenaventura and Capellas Marta. 2014. Effect of tiger nut-derived products in gluten-free batter and bread. Food Science and Technology International. 0(0): 1-9

Alesson-Carbonell L., Fernandez-Lopez J., Sendra E, Sayas Barbera E., Perez-Alvarez J. A. 2005. Quality characteristics of non-fermented dry cured sausage formulated with lemon albedo. Journal of Science Food Agriculture. 84:2077 - 2084

AOAC 2003. Official methods of Analysis of Association of Official American Chemists

AOAC 2005. Official methods of Analysis of Association of Official American Chemists International 18th ed.

Backers T. & Noli B. 1997. Dietary fibres meat processing. International Food Market

Choi Y. S., Park K. S., Choi J. H., Kim H. W., Song D. H., Kim J.M., Chung H. J., & Kim C. J. 2010. Physico-chemical properties of chicken meat emulsion systems with dietary fibre extracted from makgeolli lees. Journal of Korean Society for Food Science of Animal Resources. 30: 910-917

Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., & Kim, C. J. 2009. Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fibre. Journal of Journal of Meat Science. 82:266-271.

Englyst, H. N. 1989. Classification and measurements of plant polysaccharides. Animal Feed Science and Technology. 23: 27-42

FAO (Food and Agriculture Organization). 2014. Food and Agriculture Organization Statistics Database. Retrieved on October 04, 2017, from http://faostat3.fao.org/home/E.

Fernández- López J., Jiménez S., Sayas-Barberá M. E., Sendra E., & Pérez-Alvarez J. A. 2006. Quality characteristics of ostrich Struthio camelus burgers. Journal of Journal of Meat Science. 73: 295-303.

Fernández-Ginés J. M., Fernández-López J., Sayas-Barberá M. E., Sendra, E. & Pérez-Alvarez J. A. 2004. Lemon albedo as a newsource of dietary fibre: Application to bologna sausage. Journal of Journal of Meat Science. 67: 7-13.

García M. L., Cáceres E., & Selgas M. D. 2007. Utilisation of fruit fibres in conventional and reduced-fat cooked-meat sausages. Journal of the Science of Food & Agriculture. 87: 624-631.

Glories Y. 1984: La couleur des vins rouge. Mesure, origine et interprétation. Partie II. Connaiss. Vigne Vin. 184: 253-271.

Gök V., Akkaya L., Obuz E. & Bulut, S. 2011. Effect of ground poppy seed as a fat replacer on meat burgers. Journal of Journal of Meat Science. 89: 400-404.

Jairo H. López-Vargas, Juana Fernández-López, José Ángel Pérez-Álvarez, and Manuel Viuda-Martos. 2014. Quality characteristics of pork burger added with albedo-fibre powder obtained from yellow passion fruit Passiflora edulis var. flavicarpa co-products. Journal of Meat Science. 97: 270-276

Kumar Vikas, Sinha Amit K., Harinder P. S. Makkar, Gudrun de Boeck & Klaus Becker 2012: Dietary Roles of Non-Starch Polysachharides in Human Nutrition: A Review, Critical Reviews in Food Science and Nutrition. 52, 10 : 899-935

Lin K. C., Keeton J. T., Gilchrist C. L., & Cross H. R. 1988. Comparisons of carboxymethyl cellulose with differing molecular features in low fat frankfurters. Journal of Food Science. 53: 1592-1595.

Samson Wayah and Shehu Safiya. 2015. Assessment of the nutritional and antinutritionl components of tiger nut residues. International Journal of Science and Research; 436(6): 342-344

International Journal of Scientific and Engineering Research Volume 12, Issue 6, June 2021
ISSN 2229-5518
Sánchez-Zapata E., Díaz-Vela J., Pérez-Chavela M. L., Pérez-Alvarez J. A., & Fernández-López J. 2013. Evaluation of the effect of tiger nut fibre as a carrier of unsaturated fatty acids rich oil on the quality of dry-cured sausages. Food and Bioprocessing Technology. 6: 1181-1190.

Sánchez-Zapata E., Fuentes-Zaragoza E., Fernández-López J., Sendra E., Sayas-Barberá E., Navarro C., & Pérez-Alvarez J. A. 2009. Preparation of dietary fibre powder from tiger nuts Cyperus esculentus milk "horchata" by-products and its physicochemical properties. Journal of Agricultural and Food Chemistry. 57: 7719-7725.

Sánchez-Zapata E., Muñoz C. M., Fuentes E., Fernández-López J., Sendra E., Sayas E., Navarro C., & Pérez-Alvarez J. A. 2010. Effect of tiger nut fibre on quality characteristics of pork burger. Journal of Meat Science. 851: 70-76.

Sanchez-Zapata E., Zunino V., Perez-Alvarez J. A., and Fernandez-Lopez J. 2013. Effect of tiger nut fibre addition on the quality and safety of a dry-cured pork sausage ("Chorizo") during the dry-curing process. Meat Science. 95: 562–568.

Sayas-Barbera E., Quesada J., Sanchez-Zapata E., Viuda-Martos M., Fernandez-Lopez F., Pérez-Alvarez J. A. & Sendra E. 2011. Effect of the molecular weight and concentration of chitosan in pork model burgers. Journal of Meat Science. 88: 740-749.

Selani, M. M. et al. 2011. Wine industry residues extracts as natural antioxidants in raw and cooked chicken meat during frozen storage. Meat Science. 88(3) 397-403.

Turhan S., Sagir I., & Sule Ustun N. 2005. Utilization of hazelnut pellicle in low- fat beef burgers. Meat Science. 71:312-316.

Verdú Samuel, Barat José M., Alava Cecibel, and Grau Raúl. 2017. Effect of tiger-nut (Cyperus esculentus) milk co-product on the surface and diffusional properties of a wheat-based matrix. Journal of Food Chemistry. 224: 69–77

Wangang Zhang, Shan Xiao, Himali Samaraweera, Eun Joo Lee, and Dong U. Ahn. 2010. Improving functional value of meat products. Meat Science. 86: 15-31

Yangilar Filiz. 2013. The Application of Dietary Fibre in Food Industry: Structural Features, Effects on Health and Definition, Obtaining and Analysis of Dietary Fibre: A Review. Journal of Food and Nutrition Research. 1(3): 13-23. DOI:10.12691/jfnr-1-3-1

Yun-Sang Choi, Kwaon-Sik Park , Hyun-Wook Kim , Ko-Eun Hwang , Dong-Heon Song, Min-Sung Choi, Soo-Yeon Lee, Hyun-Dong Paik and Cheon-Jei Kim. 2013. Quality characteristics of reduced-fat frankfurters with pork fat replaced by sunflower seed oils and dietary fibre extracted from makgeolli lees. Journal of Meat Science. 93:652-658.