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QUALITY EVALUATION OF COUSCOUSANALOGUE PRODUCED FROM *ACHA*, SPENT LAYERMEAT AND TURMERIC FLOUR BLENDS

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ABSTRACT

This study evaluated the effects of incorporating spent layer meat and turmeric flour into Acha flour on the functional properties, proximate composition, mineral composition, and sensory characteristics of couscous. Acha flour was blended with spent layer meat flour 88:12) and turmeric flour at varying concentrations (0-12%). The results showed significant improvements in the functional properties, including bulk density (0.96-0.42 g/mL), water absorption capacity (1.25-2.95 g/mL), and oil absorption capacity (0.92-1.85 g/mL). The proximate composition of the couscous moisture, ash, crude fibre, crude protein, and crude fat increased from 4.69- 6.20, 3.80-5.44, 0.38-0.52, 8.82-13.14, 0.96-2.01 %, respectively; while the carbohydrate decreased from 81.21-72.58 % with an increase in the added turmeric powder. Also, the mineral composition: calcium, zinc, iron, magnesium and potassium increased from 0.96-2.02,0.46-1.18,0.02-0.16, 31.8-72.5, and 13.0-123.5 ppm, respectively. Generally, the couscous was acceptable (with a score of more than 5.0), but most preferred it with the addition of 2% turmeric flour. The study demonstrates the potential of acha, spent layer meat and turmeric flour blends in developing nutritious and acceptable couscous products.

Key words: Couscous, Quality evaluation, Spent layer meat, Turmeric flour.

INTRODUCTION

Cereal-based foods constitute a significant portion of the global diet, accounting for approximately 30–70% of daily energy intake (Nishida et al., 2004). Among these, pasta products such as couscous, noodles, and spaghetti are widely consumed due to their affordability, convenience, and sensory appeal (Cappa and Alamprese, 2017; Littardi et al., 2020; Tazrart et al., 2019). Couscous, in particular, is a traditional cereal-based food popular in Africa, Asia, and parts of Europe. It is typically produced using semolina or acha (Ayo et al., 2023). In Turkey, couscous is often made by coating bulgur granules with a mixture of semolina, wheat flour, eggs, and water or milk. Recognising its cultural significance and ancestral preparation techniques, couscous was inscribed in 2020 on UNESCO's list of Intangible Cultural Heritage (UNESCO, 2020). It is also commonly served during special events such as weddings, funerals, and religious festivals (Coskun, 2013).

Recent studies have explored enriching couscous with legume flours or other nutrient-dense ingredients to improve its nutritional profile (Ayo et al., 2023). Pasta products, including couscous, are ideal carriers for nutritional fortification due to their widespread acceptability and ease of processing (De Santis et al., 2020; Fradinho et al., 2020; Kowalczewski et al., 2019). With growing awareness of balanced diets, there is a demand for enriched, convenient foods that meet essential nutrient requirements, particularly protein.

Animal-based proteins, such as those from meat, milk, and eggs, are known for their high biological value and complete amino acid profiles (Hulya et al., 2015). Among them, chicken meat, particularly from spent layer meats (older laying birds), offers a promising source of protein due to its relatively low fat content, high protein concentration, and affordability compared to other meats (USDA, 2014). However, the highly perishable nature of chicken meat, driven by its high moisture and nutrient content, limits its use in shelf-stable products (Amit et al., 2017; Kim et al., 2019). Therefore, integrating chicken meat into processed foods, such as couscous, requires effective preservation strategies.

One promising approach to improving shelf life and nutritional value is the incorporation of natural antioxidants. Oxidative rancidity remains a significant challenge in meat-based products, resulting in flavour deterioration, discolouration, and reduced protein functionality (Ashish et al., 2020). Antioxidants, both synthetic and natural, have been shown to mitigate these effects. However, due to consumer concerns about synthetic additives, the food industry is increasingly exploring plant-based alternatives (Draszanowska et al., 2020; Lishianawati et al., 2022).

Turmeric (Curcuma longa L.), a rhizome in the ginger family, is widely recognised not only for its culinary applications but also for its potent antioxidant properties. Its bioactive compound, curcumin, is primarily responsible for its anti-inflammatory and anti-oxidative functions (Hewlings and Kalman, 2017; Pimentel et al., 2020). In meat and meat-based products, turmeric has demonstrated the potential to delay oxidative spoilage, thereby enhancing product shelf life (Mancini et al., 2015; Bae et al., 2019; De Carvalho et al., 2020). Acha (Digitaria exilis), also known as fonio, is a nutritious African cereal known for its digestibility and essential amino acid content. This study aimed to develop and evaluate the quality of couscous analogues made from blends of acha, spent layer meat flour, and turmeric flour.

MATERIALS AND METHODS

Source of Materials and Preparation

Acha was purchased from Jos Central Market in Jos, Plateau State. Spent layer meats were purchased from poultry farmers in Gboko, Benue State. Turmeric was purchased from the Gboko main market in Gboko Local Government, Benue State, Nigeria.

Acha flour was produced using the method described by Ayo (2007). Acha grains were winnowed to remove chaff and dust. Adhering dust and stones were removed by washing in water (sedimentation) using local calabashes. The washed and destoned grains were dried in a cabinet drier at 60°C to a moisture content of 12%. The dried grains were milled using an attrition milling machine (R175 Nigerian assembled) and the flour sieved to pass through a 0.4mm mesh size. The acha flour was packaged in air-tight containers for use.

The spent layer was slaughtered, deboned, and chopped into smaller sizes using a knife and a chopping board. Chopped meat was steamed for 35 minutes till the meat was thoroughly browned. This precooked meat was dried in a cabinet tray drier at 60 ºC for 9 hours and then milled in a blender (Kenwood BL335) into a powdery form. It was sieved to a particle size of 0.5mm and packed in polyethene material (Surender et al., 2019).

The turmeric rhizome was cleaned (hand picking of foreign materials), washed with portable, sliced and oven dried at a temperature of 60 0C for 24 h, milled in a blender (Kenwood BL335) into a powdery form, sieved to a particle size of 0.4 mm and packed in a polyethene material (Oladimeji et al., 2019).

Formulation of the flour blends

A preliminary sensory evaluation was done to select the best blend of acha and spent layer meat flour couscous. The most preferred sample, based on sensory evaluation, was one with 88% acha and 12% spent layer meat, which was then used to vary the inclusion of turmeric. Turmeric flour was substituted at varying concentrations (0, 2, 4, 6, 8, 10, 12%) into the standardised flour blend. The developed flour blends were used to prepare couscous, which was then subjected to sensory evaluation and other analyses.

Production of couscous

Couscous was produced from developed flour blends of acha-spent layer meat and turmeric flour using the modified Samia et al. (2017) method. The acha-spent layer meat-turmeric blend flour hydration was carried out with portable water. The flour was placed in a "guessâa" (pan). Water was added to the flour to achieve a semi-gel consistency. The gel was rolled for 15 min. After rolling and aggregating, the resulting couscous grains were sieved and sized with appropriate sieves. The mixture was sieved through a 2.9 mm sieve. The passage was sieved through another sieve (1.25 mm) to make couscous granules properly. The product was then sieved a third time (1.0 mm). At each rolling step, products were weighed to determine the couscous yield after rolling. The wet couscous was steam-precooked in a couscous cooker (strainer diameter 16 cm) containing 3 L of water that was brought to a boil at 100 °C and maintained at a boil for 8 min. The precooked couscous was passed through a local sieve (1.8 mm) and dried (for 48 h at 45 °C in an oven dryer).

Methods

Functional properties

Bulk density

Bulk density was determined as described by Onwuka (2005). A graduated cylinder flask (10mL) was weighed dry and gently oiled with the flour sample. The bottom of the cylinder was tapped gently on a laboratory bench several times. This continued until no further diminution of the test flour in the cylinder was observed after filling to the mark. The weight of the cylinder, including the flour, was measured and recorded.

$$\text{Bulk density} \left(\frac{g}{ml}\right) = \frac{\text{weight of sample (g)}}{\text{volume of sample after tappiing}} \quad (1)$$

Water absorption capacity

The water absorption capacity was determined according to the method described by Akubor (2005). A 1-gram sample was mixed with 10mL of distilled water (specific gravity 0.904 kg/m^3) and allowed to stand at ambient temperature for 30 minutes. It was then centrifuged at 3,000 rpm for 30 minutes using a centrifuge model 800D (Hettich, Universal 11, Herford, Germany). Water absorption capacity was expressed as the percentage of water bound per gram of flour.

$$\text{Water absorption capacity} = \frac{(\text{weight of water absorped x density of water})}{(\text{sample weight (g)})} \quad (2)$$

Oil absorption capacity

Oil absorption capacity as determined using the method of Ukpabi and Ndimele (1990). One gram of the sample was weighed into pre-weighed 15mL centrifuge tubes and centrifuged at 300 rpm for 20 min. Immediately after centrifugation, the supernatant was carefully poured into a 10mL graduated cylinder, and the volume was recorded (v2). The oil absorption capacity (in millilitres of oil per gram of sampled material) was calculated.

$$\text{Oil Absorption capacity} = \frac{(\text{weight of oil absorbed (g)x density of water})}{(\text{sample weight})} \qquad (3)$$

Oil absorption capacity was expressed as the grams of oil bound per gram of the sample on a dry basis, referred to as the swelling index. The method was used.

Swelling index and swelling capacity

The Swelling Index (SI) of the flour samples was determined using the method described by Ukpabi and Ndimele (1990). The sample was added up to the 10 mL mark in a pre-weighed 100 mL measuring cylinder. The cylinder was weighed again to obtain the sample weight. Distilled water was added up to the 50 mL mark and mixed thoroughly using a vortex mixer to homogenise the sample. The mixture was allowed to stand for 3 h. The swelling index was calculated

$$\text{Swelling index} = \frac{\text{Volume of sample after soaking} - \text{volume of sample before soaking}}{\text{weight of sample}} \qquad (4)$$

The wet sediment obtained from the swelling index determination was used in calculating the swelling capacity (SC) using the following formula:

$$\text{swelling capacity} = \frac{\text{Weight of wet sediment X100}}{\text{weight of sample}} \qquad (5)$$

Gelatinization temperature

A 10 % suspension of the flour sample was prepared in a test tube. The aqueous suspension was heated in a boiling water bath, with continuous stirring. The temperature was recorded 30 seconds after gelatinisation was visually observed, which corresponded to the gelatinisation temperature (Onwuka 2005).

Proximate Composition

The total carbohydrate content was estimated as the difference between 100 and the total sum of moisture, fat, protein, crude fibre and ash (AOAC, 2012).

$$\%Carbohydrate = 100 - (\%Moisture + \%Fat + \%Protein + \%Ash + \%CrudeFibre) \quad (6)$$

Mineral Content Determination

The AOAC (2012) wet ashing method was used. One gram of the dried powdered sample was digested with 10mL nitric acid and 5mL perchloric acid in a 100mL digestion flask and allowed to stand overnight in a fume cupboard. "The mixture was heated until the yellowish fume and white dense fume of nitric and perchloric acid, respectively, ceased. The contents were cooled and filtered through Whatman filter paper, transferred into sample bottles and made up to 100mL with deionised water. The iron, zinc, calcium, magnesium, and potassium content were analysed using an atomic absorption spectrophotometer.

Sensory evaluation

The 9-point Hedonic scale assessment and the pair comparison tests were used as described by Iwe (2002). A total of 25 untrained panellists from a cross-section of students and staff in the Department of Food Science and Technology at the University of Mkar, Gboko, Benue State, were selected based on their familiarity with couscous pasta. The panellists scored and coded couscous in terms of degree of taste, aroma, appearance, chewiness and general acceptability. The 9-point Hedonic scale used by the panellists for the evaluation ranged from 1-9, representing "disliked extremely "to "like extremely. The coded samples of couscous were served on clean, flat plates in an illuminated boardroom with fluorescent lighting at a time. Water was provided to each panellist for oral rinsing between tasting the samples.

Experimental Design and Statistical Analysis

The experimental design for the study was completely randomised. All the data obtained from this study were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) software version 20. Significantly different means were separated using Duncan's Multiple Range Test (SPSS Statistics, version 20).

RESULTS AND DISCUSSION

Preliminary Investigations

Proximate composition of acha, spent layer meat and turmeric flour

The proximate compositions of acha, spent layer meat and turmeric flours are shown in Table 1. The moisture, crude protein, crude fat, ash, crude fibre, and carbohydrate content ranged from 5.63% to 9.29%, 8.05% to 72.3%, 1.99% to 12.27%, 2.21% to 6.16%, 1.61% to 7.08%, and 0.57% to 78.19%, respectively, for the Acha, spent layer meat, and turmeric flour. Spent layer meat flour had the highest protein content, with ash values of 72.93% and 6.16%, while turmeric flour had the highest fibre value at 7.08%, suggesting that they can be of importance in adding value to acha food products (couscous).

Selection of acceptable samples from acha, spent layer meat flour blends based on preliminary sensory evaluation. Couscous samples were prepared using acha flour and spent layer meat flour in the ratio of 100:0, 96:4, 92:8, 88:12, 84:16, 80:20 and 76:24. The couscous samples were assessed sensorially by a group of 25 panel members using 9 9-point Hedonic scale to select the best sample based on their taste, appearance, aroma, texture, and mouth feel. The average means scores for taste, appearance, and general acceptability of the produced couscous decreased from 6.06 – 4.44, 6.38 – 4.81, 6.31 – 5.38, respectively, while the aroma and chewiness ranged from 5.44 -6.69 and 5.88- 6.69, with an increase (4-24%) in the added turmeric powder. A couscous sample with 88% acha flour and 12% spent layer meat flour had the highest sensory score (Table 2). The effect of the added turmeric powder was significant ($p < 0.05$).

Table 1: Proximate Composition of *Acha*, Spent layer meatand Turmeric flour

Raw materials	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
Acha flour	$9.29^{a}\pm0.04$	$8.05^{c}\pm0.08$	$1.99^{c}\pm0.15$	2.21±0.15	$2.27^{b}\pm0.06$	$76.19^{a}\pm0.02$
Spent LMF	$6.48^{b}\pm0.56$	$72.93^{a}\pm0.06$	$12.27^{a}\pm0.06$	6.16±0.07	$1.61^{c}\pm0.30$	$0.57^{c}\pm0.32$
Turmeric flour	$5.63^{b}\pm0.57$	$8.76^{b}\pm0.04$	$5.80^{b}\pm0.11$	5.08±0.03	$7.08^{a}\pm0.03$	$67.67^{b}\pm0.28$

*Values are means and standard deviation of triplicate determinations. Different Superscripts within the same column are significantly different at ($p<0.05$); Spent LMF: Spent layer meat flour

Table 2: Preliminary Sensory Evaluation of Couscous Produced from *Acha*-Spent layer meat flour Blends

***Acha*: spent Layer meat flour**	**Samples**	**Taste**	**Aroma**	**Appearance**	**Chewiness**	**General Acceptability**
100:0	T1	$7.06^{a}\pm0.93$	$6.94^{a}\pm1.24$	$7.00^{a}\pm1.21$	$7.13^{a}\pm0.96$	$7.50^{a}\pm0.\ 97$
96:4	T2	$6.06^{a}\pm1.44$	$5.44^{a}\pm1.83$	$6.38^{ab}\pm1.82$	$5.88^{b}\pm1.36$	$6.31^{abc}\pm1.25$
92:8	T3	$5.75^{abc}\pm2.18$	$6.13^{a}\pm1.89$	$6.75^{ab}\pm1.65$	$6.31^{ab}\pm1.74$	$6.38^{abc}\pm1.54$
88:12	T4	$6.31^{ab}\pm1.85$	$6.69^{a}\pm1.40$	$6.06^{abc}\pm2.05$	$6.69^{ab}\pm1.08$	$6.69^{ab}\pm1.30$
84:16	T5	$5.63^{bc}\pm1.99$	$5.94^{a}\pm2.14$	$5.56^{bc}\pm2.16$	$6.25^{ab}\pm1.18$	$6.13^{bc}\pm1.89$
80:20	T6	$5.06^{bc}\pm2.11$	$5.75^{a}\pm2.02$	$5.56^{bc}\pm1.63$	$6.06^{ab}\pm2.05$	$5.44^{bc}\pm1.99$
76:24	T7	$4.44^{c}\pm1.89$	$5.44^{a}\pm2.37$	$4.81^{c}\pm1.87$	$5.88^{b}\pm1.99$	$5.38^{c}\pm1.96$

*Values are means and standard deviation of triplicate determinations. Different Superscripts within the same column are significantly different at ($p<0.05$)

Functional Properties of **Acha**, Spent Layer Meat and Turmeric Flour Blends

The results of the functional properties of the flour blends are shown in Table 3. The parameters determined were bulk density, Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), gelatinisation temperature, swelling index and swelling capacity.

The bulk density, water absorption capacity, oil absorption capacity, gelatinisation temperature, swelling index and swelling capacity increased from 0.96-0.42, 1.25-2.95, 0.92-1.85 g/mL,63.5-75.0 oC, 0.17-1.15 g/mL and 111.36-182.45 (%), respectively. Sample A (100 % acha) had the highest bulk density, while sample G (88 % acha-spent layer meat and 12 % turmeric) had the lowest bulk density. Sample G (88% acha-spent layer meat and 12% turmeric) had the highest values for water absorption capacity, oil absorption capacity, gelatinisation temperature, swelling index, and swelling capacity. In comparison, sample A (100% acha-spent layer meat) showed the lowest values for water absorption capacity, oil absorption capacity, gelatinisation temperature, swelling index, and swelling capacity. The effect of adding turmeric powder was highly significant ($p < 0.05$) on the assessed functional parameters.

The bulk density recorded in this study ranged from 0.96 to 0.42 g/mL. The bulk density is the ratio of flour weight to volume in grams per millilitre of the flour blends. Samples A (100 % acha-spent layer meat) exhibited the highest bulk density of 0.96 g/mL, while sample G (88 % acha-spent layer meat and 12 % turmeric) had the lowest bulk density of 0.42 g/mL. There were significant differences ($p<0.05$) among the samples. This result agrees with Makanjuola et al. (2025), who observed a decrease in the bulk density (0.46-0.69 g/mL) of Tapioca fortified with turmeric. The results also agreed with values (0.56-0.71 g/mL) recorded by Eman and Asael (2017). A higher bulk density is required for greater ease of dispersion of flour, while a low bulk density is advantageous in the formation of complementary foods (Akpata and Akubor, 1999). Lower bulk density can indicate higher porosity and potentially greater water absorption capacity, which is beneficial for the texture and digestibility of the food.

There was a significant increase in the water absorption capacity of the flour blends. Sample A (100 % acha-spent layer meat) had the least value of 1.25 g/mL, while sample G (88 % acha, spent layer meat and 12 % turmeric) had the highest value of 2.95 g/mL. The water absorption capacity of the flour samples can be compared with the results reported by Ubbor et al. (2022) for flour blends of acha and wheat. WAC refers to the extent to which water can be bound per gram of flour and is vital for establishing product qualities such as the ability to retain moisture, starch retrogradation and staling. It indicates the product's ability to associate with water under conditions where water is limited, thereby improving its handling characteristics.

The oil absorption capacity of the flour blends increased significantly ($p < 0.05$) with an increase in the proportion of turmeric flour. Sample A (100 % acha-spent layer meat) had the least value of 0.92 g/mL, while sample G (88 % acha-spent layer meat and 12 % turmeric) had the highest value of 1.85 g/mL. This result agreed with the findings of Ubbor et al. (2022), who observed an increase in the OAC of flour blends of acha and wheat. The oil absorption mechanism involves the physical entrapment of oil by food components and the affinity of non-polar protein side chains for lipids. The WAC and OAC of food proteins depend on intrinsic factors, such as amino acid composition, protein conformation, and surface polarity. The ability of proteins in flour to bind with oil makes it useful in food systems where optimal oil adsorption is desired. This makes flour have more functional uses, enhancing flavour and mouthfeel when used in food preparations.
It was observed that the gelatinisation temperature increased significantly among all the samples from 63.5 °C in sample A (100 % acha-spent layer meat) to 75.0 0C sample G (88 % acha-spent layer meat and 12 % turmeric). This is slightly above the range reported by Ubbor et al. (2022) in acha: wheat flour blends. It is noted in the literature that flour with a high starch content requires a low temperature for gelatinisation to occur.

The swelling Index measures the amount of water-soluble solids per unit weight of the sample. There was an increase in the swelling index; sample A (100 % acha-spent layer meat) had the least value of 0.17 g/mL, while sample G (88 % acha-spent layer meat and 12 % turmeric) had the highest value of 1.15 g/mL.

Sample A was the only sample that showed a significant difference; for the other samples, there was no significant difference among them. In the literature, solubility is a measure of protein functionality, including denaturation and its potential applications (Adebowale et al., 2008). This is in contrast to Makanjuola et al. (2025), who observed a decrease in the swelling index with an increase in the proportion of turmeric powder in Tapioca.

Swelling capacity increased from 111.36 % in sample A (100 % acha-spent layer meat) to 182.45 % in sample G (88 % acha-spent layer meat and 12 % turmeric). There were significant differences among all the samples. Sample G (88 % acha-spent layer meat and 12 % turmeric) had the highest mean value, while sample A (100 % acha-spent layer meat) had the lowest mean value. The results indicate that the swelling capacity increased with the incorporation of turmeric flour. High swelling capacity has been reported as part of the criteria for a good quality product (Nlba et al., 2002). The swelling capacity of flours depends on the size of particles, the types of variety and the types of processing method.

Proximate Composition of Couscous Produced from Acha, Spent Layer Meat and Turmeric Flour Blends

The results of the proximate composition of couscous produced from acha-spent layer meat and turmeric proximate composition of couscous produced from acha-spent layer meat and turmeric flour blends are shown in Table 44. The moisture, ash, crude fibre, crude protein, crude fat, and carbohydrates ranged from 4.69% to 6.20%, 3.80% to 5.44%, 0.52% to 0.38%, 8.82% to 13.14%, 0.96% to 2.01%, and 81.21% to 72.58%, respectively. The effect of the added turmeric powder on the proximate composition was significant ($p<0.05$). The moisture content (4.69-6.20%) of acha-spent layer meat-turmeric flour blends in couscous is within the acceptable limit for couscous (<13.5%) (WFP, 2015). These low moisture levels suggest good storage stability and low microbial activity. Eman and Asael (2017) reported a higher moisture content of 9.1-9.6% in couscous made from Egyptian durum wheat flour fortified with inactive dried yeast and skim milk powder. Fatoumata et al. (2016) also reported crude fat and carbohydrate levels ranging from 4.69 to 6.20, 3.80 to 5.44, 0.52 to 0.38, 8.82 to 13.14, 0.96 to 2.01, and 81.21 to 72.58%, respectively.

Table 3: Functional Properties of *Acha*, Spent layer Meat and Turmeric Flour Blends

Samples	Bulk Density (g/mL)	WAC g/mL)	OAC g/mL)	Gelatinization Temprature. (ºC)	Swelling Index (mL/g)	Swelling Capacity (%)
A	0.96^{a}±0.02	1.25^{c}±0.35	0.92^{c}±0.11	63.5^{f}±0.71	0.17^{b}±0.24	111.36^{g}±0.50
B	0.89^{b}±0.01	1.82^{bc}±0.25	0.98^{c}±0.03	66.0^{e}±1.41	0.80^{a}±0.28	142.80^{f}±0.28
C	0.84^{c}±0.12	2.09^{b}±0.13	1.10^{c}±0.14	68.5^{d}±0.71	0.91^{a}±0.13	152.09^{e}±0.13
D	0.79^{d}±0.11	2.15^{b}±0.21	1.15^{bc}±0.21	70.5^{c}±0.71	0.97^{a}±0.04	165.81^{d}±0.18
E	0.60^{e}±0.00	2.27^{b}±0.28	1.24^{b}±0.34	72.5^{b}±0.71	0.98^{a}±0.03	162.64^{c}±0.52
F	0.55^{f}±0.01	2.86^{a}±0.19	1.77^{a}±0.34	74.0^{ab}±0.00	1.03^{a}±0.04	170.54^{b}±0.65
G	0.42^{g}±0.01	2.95^{a}±0.06	1.85^{a}±0.22	75.0^{a}±0.00	1.15^{a}±0.21	182.45^{a}±0.64

*Values are means and standard deviation of triplicate determinations.. Different Superscripts within the same column are significantly different at (p<0.05)
KEY:
Acha-spent layer meat flour contained 88 % *Acha* flour:12 % Spent layer meat flour
A Samples with 100 % *Acha* flour (control).
B Samples with 98 % *Acha*-spent layer meat flour and 2 % Turmeric flour
C Samples with 96 % *Acha*-spent layer meat flour and 4 % Turmeric flour
D Samples with 94 % *Acha*-spent layer meat flour and 6 % Turmeric flour
E Samples with 92 % *Acha*-spent layer meat flour and 8 % Turmeric flour
F Samples with 90 % *Acha*-spent layer meat flour and 10 % Turmeric flour
G Samples with 88 % *Acha*-spent layer meat flour and 12 % Turmeric flour
WAC-water absorption capacity, OAC- water absorption capacity

The effect of the added turmeric powder on the proximate composition is significant (p <). The moisture content (4.69-6.20%) of acha-spent layer meat-turmeric flour blends in couscous was within the acceptable limit for couscous (<13.5%) (WFP, 2015). These low moisture levels suggest good storage stability and low microbial activity. Eman and Asael (2017) reported a higher moisture content of 9.1-9.6% in couscous made from Egyptian durum wheat flour fortified with inactive dried yeast and skim milk powder. Fatoumata et al. (2016) also reported a higher moisture content of 10.63 to 11.22% in couscous based on three formulations of composite flours enriched with soybean.

The ash content (3.80-5.44%) of acha-spent layer meat-turmeric flour blends in couscous was above the range reported for composite flours enriched with soybean. The ash content (3.80-5.44 %) of acha-spent layer meat-turmeric flour blends couscous was above the range reported by Raihanatu et al.(2020), 1.89

to 3.16 % in a study on couscous produced from sprouted wheat fortified with soya bean (Glycine max (L.) Merr) and pumpkin (Cucurbita pepo) Seeds. Garsa (2016) also reported a low level (1.89 to 3.16%) in a study on couscous produced from sprouted wheat fortified with soybean (Glycine max (L.) Merr.) and pumpkin (Cucurbita pepo) Seeds. Garsa (2016) also reported a lower ash content of 0.94-1.99% in sesame-durum wheat flour blends for couscous. The increase in the ash content suggests that turmeric flour may contribute more micronutrients to couscous.

The crude fibre content (0.52-0.38 h content of 0.94-1.99%) in sesame-durum wheat flour blends for couscous. The increase in the ash content suggests that turmeric flour may contribute more micronutrients to couscous. The crude fibre content (0.52-0.38%) aligns with the values reported by Raihanatu et al. (2020), 0.24 to 2.68%, in a study on couscous produced from sprouted wheat fortified with soybean and pumpkin seeds. Agbar aligns with the values reported by Raihanatu et al. (2020), 0.24 to 2.68%, in a study on couscous produced from sprouted wheat fortified with soybean and pumpkin seeds. Agbara et al. (2020) reported a higher fibre content of 2.05 to 2.61% in a study on acha-semolina couscous as affected by pulse flour. Dietary fibre helps decrease the reported higher fibre content of 2.05 to 2.61% in a study on acha-semolina couscous, as affected by pulse flour. Dietary fibre helps to decrease the risk of cardiovascular diseases by reducing serum total and LDL cholesterol concentrations in adults and children (Sanchez, 2012). Dietary fibre promotes gastrointestinal function by building up important microflora, and acting as a prebiotic (substrate for beneficial microorganisms) (Costabile et al., 2010; Carvalho, 2010)

The crude protein content (8.82-13.14%) of couscous reduces the risk of cardiovascular diseases by lowering serum total and LDL cholesterol concentrations in adults and children (Sanchez, 2012). Dietary fibre promotes gastrointestinal function by building up important microflora, and acting as a prebiotic (substrate for beneficial microorganisms) (Costabile et al., 2010; Carvalho, 2010). The crude protein content (8.82-13.14%) of the couscous agreed with the findings of Agbara et al. (2020), who reported similar protein values of 6.74 to 11.12%. Eman and Asael (2017) recorded higher values of 17.46-22.60% in couscous made from Egyptian durum wheat flour fortified with inactive dried yeast, reporting similar protein values of 6.74-11.12%. Eman and Asael (2017) recorded higher values of 17.46-22.60% in couscous made from Egyptian durum wheat flour fortified with inactive dried yeast and skim milk powder. Protein and skimmed milk powder. Protein plays a crucial role in hormone regulation, enzyme production for digestion, maintaining fluid balance, and building and repairing body tissues.

The fat content of 0.96-2.01% aligns with that of Verma et al. (2014), who reported values of 1.39 to 3.89% in a study on the effects of replacing refined wheat flour with chicken meat on the physicochemical and sensory properties of noodles. It also aligns with Surender et al. (2019), who recorded a similar fat content of 0.92 to 3.89 % in a study on the development and evaluation of the quality of noodles enriched with chicken meat powder. Fat is a source of essential fatty acids, which the body cannot make itself. Fat helps give your body energy, protects your organs, supports cell growth, keeps cholesterol and blood pressure under control and helps your body absorb vital nutrients.

The carbohydrate content ranged from 81.21% to 72.58%. These results are consistent with previous studies, such as Eman and Asael (2017), who reported carbohydrate contents ranging from 72.29% to 84.59% in couscous made from Egyptian durum wheat flour fortified with inactive dried yeast and skim milk powder. Thi et al. (2024) reported a lower carbohydrate content of 65.8% to 66.0% in a study on the quality of cookies supplemented with various levels of turmeric by-product powder. Carbohydrates provide heat and energy for all forms of bodily activities. Deficiency can cause the body to convert proteins and body fat to produce the needed energy, thus leading to depletion of body tissues.

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.**Table 4: Proximate Composition of Couscous Produced from *Acha*, Spent layer meat and Turmeric Flour Blends**

Samples	Moisture (%)	Ash (%)	Crude Fibre (%)	Crude Protein (%)	Crude Fat (%)	Carbohydrates (%)
A	$4.69^{b}\pm0.19$	$3.80^{d}\pm0.23$	$0.52^{a}\pm0.06$	$8.82^{d}\pm0.00$	$0.96^{e}\pm0.06$	$81.21^{a}\pm0.03$
B	$5.78^{a}\pm0.46$	$3.97^{d}\pm0.09$	$0.10^{e}\pm0.01$	$9.96^{c}\pm0.23$	$1.39^{d}\pm0.01$	$78.80^{b}\pm0.58$
C	$5.92^{a}\pm0.59$	$4.60^{c}\pm0.23$	$0.22^{d}\pm0.03$	$12.66^{b}\pm0.22$	$1.66^{c}\pm0.08$	$74.96^{c}\pm0.29$
D	$5.79^{a}\pm0.24$	$4.76^{bc}\pm0.23$	$0.28^{cd}\pm0.03$	$13.05^{ab}\pm0.13$	$1.81^{b}\pm0.01$	$74.32^{c}\pm0.31$
E	$6.18^{a}\pm0.22$	$5.15^{ab}\pm0.34$	$0.32^{bc}\pm0.06$	$13.46^{a}\pm0.00$	$1.92^{a}\pm0.01$	$72.98^{d}\pm0.07$
F	$6.09^{a}\pm0.18$	$5.34^{a}\pm0.09$	$0.36^{bc}\pm0.02$	$13.26^{a}\pm0.00$	$1.92^{a}\pm0.02$	$73.03^{d}\pm0.27$
G	$6.20^{a}\pm0.14$	$5.44^{a}\pm0.23$	$0.38^{b}\pm0.01$	$13.41^{a}\pm0.48$	$2.01^{a}\pm0.02$	$72.58^{d}\pm0.54$

*Values are means and standard deviation of triplicate determinations.. Different Superscripts within the same column are significantly different at ($p<0.05$)
KEY:

Acha-spent layer meat flour contained 88 % *Acha* flour: 12 % Spent layer meat flour
A Samples with 100 % *Acha*-spent layer meat flour (control).
B Samples with 98 % *Acha*-spent layer meat flour and 2 % Turmeric flour
C Samples with 96 % *Acha*-spent layer meat flour and 4 % Turmeric flour
D Samples with 94 % *Acha*-spent layer meat flour and 6 % Turmeric flour
E Samples with 92 % *Acha*-spent layer meat flour and 8 % Turmeric flour
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G Samples with 88 % *Acha*-spent layer meat flour and 12 % Turmeric flour

Mineral Composition of Couscous Produced from Acha, Spent Layer Meat and Turmeric Flour Blends

The mineral composition of the study is presented in Table 5. The effect of the added turmeric powder on the mineral compositions of the couscous was significant ($p<0.05$). Ca, Zn, Fe, Mg and K contents of the produced couscous increased from 0.96-2.02, 0.46-1.18, 0.02-0.16, 31.8-72.5 and 13.0-123.5 ppm, respectively, with an increase (1-12%) in turmeric flour. The addition of turmeric flour had a significant effect ($p<0.05$) on all the assessed minerals. There was a significant difference ($p<0.05$) in the calcium content of the couscous samples (Table 5). The calcium content increased with the addition of turmeric flour. Sample G, which was made of 88% acha-spent layer meat flour and 12% turmeric flour, had the highest value (2.02 ppm). This indicates that the addition of turmeric flour increased the calcium content of the produced couscous. In comparison, sample A, with 100% acha-spent layer meat flour (control), had the lowest value (0.96 ppm). Calcium is an essential mineral required for maintaining muscle, heart, and digestive system health, as well as for building bones and supporting the synthesis and function of blood cells (Dinda, 2019).

In zinc sample A (100 % acha-spent layer meat) had the least value 0.46 (ppm), while sample G (88 % acha-spent layer meat flour and 12 % turmeric) had the highest value 1.18 (ppm); there were significant differences ($p<0.05$) among the samples. The Zinc content of the couscous increased with the inclusion of turmeric flour. Zinc is one of the nutritionally essential trace elements that the body requires in small quantities for a healthy life. The safe limit for Zn is 0.41–5 ppm (Kobia et al., 2016). The zinc content of the couscous samples is within the safe limits for zinc.

For iron, sample G (88 % acha-spent layer meat flour and 12 % turmeric) had the highest iron content, 0.16 (ppm), making it the best choice for those needing to boost their iron intake, such as individuals with anaemia or iron deficiency. Sample A (100% acha-spent layer meat) had the lowest value of 0.02 (ppm). There was an increase in the iron content as the inclusion of turmeric flour increased in the samples. The increase in iron content may be attributed to the rise in the proportion of turmeric flour. The body requires iron in small concentrations for normal growth, the proper functioning of the immune system, and DNA synthesis, among other functions (Ujowundu et al., 2014). The recommended levels of iron (Fe) concentration for human consumption are (4.49 ppm to 15.0 ppm) (Kobia et al., 2016).

The magnesium content showed an increasing trend with the addition of turmeric flour. It increased from 31.8 (ppm) in sample A (100% acha-spent layer meat) to 72.5ppm in sample G (88% acha-spent layer meat flour and 12 % Turmeric flour). There was a significant difference($p<0.05$) among the samples, which showed that turmeric flour increased the magnesium content of the produced couscous significantly ($p<0.05$), potentially contributing more significantly to daily intake. Magnesium is an essential mineral involved in various physiological functions, including bone health, cardiovascular function, and metabolic processes (Fatima et al., 2024). It plays a critical role in bone mineralisation and density, assists in regulating calcium and vitamin D levels, and helps prevent osteoporosis and bone fragility (Wang et al., 2025).

The potassium content increased from 13.0 ppm in sample A (100% acha-spent layer meat) to 123.5ppm in sample G (88% acha-spent layer meat and 12 % turmeric). There were significant differences ($p<0.05$) among the samples. Potassium is a systemic electrolyte and is essential in co-regulating ATP with sodium (Dinda,2019).

Blends

The sensory attributes of the produced couscous are shown in Table 6. The average means scores for taste, aroma, appearance, chewiness, and general acceptability of the couscous ranged from 7.18 to 4.36, 7.73 to 4.55, 7.45 to 5.00, 7.45 to 5.45, and 7.27 to 5.27 for samples A, B, C, D, E, F, and G, respectively. The effects of adding turmeric are generally significant, $p < 0.05$. The most preferred of the produced samples is the control, followed by sample B, which contained 98% acha-spent layer meat flour and 2% turmeric flour. The taste of couscous produced from acha-spent layer meat-turmeric flour blends showed a significant difference ($p<0.05$) among the samples. Sample A, with 100 % acha-spent layer meat flour (control), had the highest score (7.18±0.60), followed by sample B, whereas sample G, with 88 % acha-spent layer meat flour and 12 % Turmeric flour, had the

Table 5: Mineral Composition of Couscous Produced from *Acha*, Spent layer meat and Turmeric Flour Blends

Samples	Ca (ppm)	Zn(ppm)	Fe(ppm)	Mg(ppm)	K(ppm)
A	0.96^{d}±0.10	0.46^{e}±0.01	0.02^{c}±0.01	31.8^{e}±0.35	13.0^{f}±0.00
B	1.28^{cd}±0.08	0.66^{d}±0.00	0.07^{bc}±0.04	45.5^{d}±0.00	38.0^{e}±2.12
C	1.34^{cd}±0.04	0.73^{cd}±0.03	0.06^{bc}±0.03	46.0^{d}±0.71	77.5^{d}±0.71
D	1.67^{abc}±0.01	0.82^{c}±0.01	0.10^{ab}±0.00	51.0^{c}±0.00	91.0^{c}±3.54
E	1.59^{bc}±0.19	0.93^{b}±0.01	0.10^{ab}±0.01	52.0^{c}±0.00	95.8^{c}±5.30
F	1.83^{ab}±0.09	1.02^{b}±0.01	0.11^{ab}±0.01	62.5^{b}±0.71	111.8^{b}±2.47
G	2.02^{a}±0.09	1.18^{a}±0.12	0.16^{a}±0.05	72.5^{a}±0.71	123.5^{a}±0.71

*Values are means and standard deviation of triplicate determinations.. Different Superscripts within the same column are significantly different at ($p<0.05$)

KEY:

Acha-spent layer meat flour contained 88%*Acha* flour: 12 %Spent layer meat flour

A Samples with 100 % *Acha*-spent layer meat flour (control).

B Samples with 98 % *Acha*-spent layer meat flour and 2 % Turmeric flour

C Samples with 96 % *Acha*-spent layer meat flour and 4 % Turmeric flour

D Samples with 94 % *Acha*-spent layer meat flour and 6 % Turmeric flour

E Samples with 92 % *Acha*-spent layer meat flour and 8 % Turmeric flour

F Samples with 90 % *Acha*-spent layer meat flour and 10% Turmeric flour

G Samples with 88 % *Acha*-spent layer meat flour and 12 % Turmeric flour

Sensory Properties of Couscous Produced from Acha, Spent Layer Meat and Turmeric Flour

lowest score (4.36±1.91). There was a significant difference ($p<0.05$) among the samples.

There was a significant difference ($p < 0.05$) among the couscous samples in terms of aroma. The aroma scores of the couscous ranged from 7.73 ± 0.79 to 4.55 ± 1.75. Sample A had the highest scores in aroma, whereas the aroma scores of Sample G were the lowest. The appearance of different couscous samples showed a significant difference ($p<0.05$) among the samples. Sample B received the highest score (7.45±0.99) while sample G had the lowest score (5.00±1.14). Additionally, it was observed that the appearance scores increased at sample B and decreased with the addition of turmeric flour.

There was a significant difference ($p < 0.05$) among the treatments in terms of chewiness. Sample A had the highest chewiness scores (7.45 ± 0.82), followed by sample B, while sample G had the lowest scores. There was a decrease in the general acceptability scores of the samples. There were significant differences ($p < 0.05$) among the samples in their general acceptability scores. However, samples A and B were significantly ($p>0.05$) the same, while samples C to G were also significantly ($p>0.05$) the same. Sample A received the highest scores, followed by Sample B, while Sample G had the lowest scores. Nur et al. (2016) reported a decrease in the appearance, aroma, taste, and overall acceptability of cookies prepared with fresh turmeric flower (Curcuma longa L.) extracts as a value-added functional ingredient. Wannee (2020) also recorded a decrease in the appearance (6.84-5.91 %), flavour (7.34 -7.18 %), taste (7.22-6.96 %) and general acceptability (7.13 - 6.81 %) values of the Beef Stick Product in a study on the sensory characteristics of three different levels of turmeric powder on beef stick product.

The findings suggest that acha, spent layer meat, and turmeric flour blends can be used to develop nutritious and acceptable couscous products, with optimal turmeric levels at around 2%. Consumers preferred couscous with a subtler turmeric flavour and aroma, as evident from the higher scores for sample B. Understanding consumer preference can help tailor product development and marketing strategies.

CONCLUSION

A relatively nutritious and acceptable couscous can be produced from acha-spent layer meat and turmeric powder. The most preferred product was one containing 2 % turmeric powder. The use of acha, a local food product, as an alternative to imported wheat flour in the production of couscous could reduce the production cost. Also, the use of spent layer meat in improving the nutrient composition of couscous has opened commercial marketing for the same.

Table 6: Sensory Properties of Couscous Produced from *Acha*, Spent layer meat and Turmeric Flour Blends

Samples	Taste	Aroma	Appearance	Chewiness	General Acceptability
A	$7.18^{a}\pm0.60$	$7.73^{a}\pm0.79$	$6.91^{a}\pm1.48$	$7.45^{a}\pm0.82$	$7.27^{a}\pm0.79$
B	$6.45^{ab}\pm1.13$	$6.36^{b}\pm0.81$	$7.45^{ab}\pm0.99$	$6.64^{ab}\pm0.81$	$6.82^{a}\pm1.08$
C	$5.45^{bc}\pm0.93$	$5.82^{bc}\pm1.08$	$6.00^{bc}\pm1.04$	$6.36^{ab}\pm1.50$	$5.73^{b}\pm0.79$
D	$5.09^{c}\pm1.14$	$5.09^{cd}\pm1.38$	$5.91^{bc}\pm1.70$	$6.18^{b}\pm1.08$	$5.64^{b}\pm1.36$
E	$5.09^{c}\pm1.30$	$4.64^{d}\pm1.57$	$5.91^{bc}\pm1.41$	$6.09^{b}\pm1.22$	$5.55^{b}\pm0.93$
F	$5.00^{c}\pm0.95$	$4.67^{d}\pm1.16$	$5.67^{c}\pm0.93$	$5.75^{b}\pm1.77$	$5.50^{b}\pm1.24$
G	$4.36^{c}\pm1.91$	$4.55^{d}\pm1.75$	$5.00^{c}\pm1.14$	$5.45^{b}\pm1.51$	$5.27^{b}\pm2.10$

Values are means and standard deviation of triplicate determinations.. Different Superscripts within the same column are significantly different at ($p<0.05$)
KEY: *Acha*-spent layer meat flour contained 88 % *Acha* flour: 12 % Spent layer meat flour
A Samples with 100 % *Acha*-spent layer meat flour (control).
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