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Effect of Supplementing Wheat Flour with Multigrain Flour Mixes on the Quality of Noodles Produced from the Blends

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Abstract

For the present study, wheat flour was supplemented with multigrain (0-12.5% of acha, brown rice, millet and cowpea) flours and used for noodles production. The blending ratios used were 100:00, 90:10, 80:20, 70:30, 60:40 and 50:50 (wheat flour: multigrain flour mix). The 100% wheat flour noodles served as the control sample. The produced noodles were analyzed for proximate composition, amino acid profile, minerals, vitamins and antinutrients. The results showed that the moisture, protein, fat, ash and crude fibre contents significantly increased ($p<0.05$) from 9.67-10.74%, 10.14-22.23%,1.64-4.38%, 1.44-3.90% and 2.16-6.73% respectively, while carbohydrate content decreased from 74.75-51.94% with increase in multigrain flours supplementation. The individual amino acids, total amino acids and total essential amino acids increased with increase addition of multigrain flour mixes. The calcium, potassium, iron and zinc contents increased from 38.80-67.33 mg/100 g, 377.00-529.00 mg/100 g, 2.88-3.59 mg/100 g and 1.94-3.00 mg/100 g respectively while the sodium content decreased from 8.98 mg/100 g to 1.97 mg/100 g with increase in multigrain flours supplementation. Vitamin B3 and beta-carotene contents increased from 30.70-65.05 mg/100 g and 0.06-0.19 um/100 g respectively while vitamin B9 decreased from 5.75-2.95 um/100 g with increase in multigrain flours supplementation. Although the tannin, oxalate and phytate contents increased from 0.23-0.64%, 11.55-29.70 mg/100 g and 0.60-1.28% with increase in multigrain supplementation, the values were relatively low and would not affect the bioavailability of essential nutrients in the noodles. The results have shown that supplementation of wheat flour with multigrain flours led to the enhancement of nutrient content in noodles made from the blends, reduce dependency on wheat and increase utilization of locally grown crops.

Keywords: Wheat Flour, Multigrain Flour Mixes, Supplementation, Quality of Noodles.

Introduction

Noodle is a stable food made from unleavened dough which is stretched, extruded, or rolled flat and cut to the desired size (Chigbo, 2023). It is typically made from refined wheat flour and widely consumed at any time of the day by people of all ages globally including Nigeria (Adeoye *et al.*, 2018). The high consumption of noodles could be attributed to their ease of cooking, acceptable taste, relatively low cost and long shelf-life (Sofi *et al.*, 2020). Besides the fact that Nigeria cannot produce wheat grains at commercial scale due to unfavourable climatic conditions, noodles made from refined wheat flour are high in carbohydrate but low in other essential nutrients including protein, minerals and vitamin (Parkare *et al.*,

2018). Regular consumption of such product could contribute to nutritional disorders that are prevalent in most of our communities. Also, annual wheat importation into the country to augment local production has continued to greatly deplete the nation's foreign exchange reserve.

Nowadays, the use of non-wheat flours to partially or wholly replace wheat flour is gaining attention and offers the potentials to optimize the utilization of flours from locally grown crops in order to reduce the demand for wheat. Every grain has it own unique nutritional value and composition. Therefore, when flour is produced from a mixture of two or more grains, more nutritious product is obtained compared to a single grain flour (Dighe *et al*., 2022). According to Vishwakarma and Phadnis (2023), multigrain flour and its products are richer in nutrients and have greater health benefits than single grain flour products. Ud Din *et a*l. (2025) reported that in order to combat malnutrition, multigrain flour can be added to a variety of meals to facilitate the availability of nutritious diets. For the present study, it was anticipated that using multigrain flour obtained from a combination of brown rice, acha, millet and cowpea to partially replace wheat flour for noodle production, the nutritional value of the final product would be enhanced for the benefit of the consumers.

Rice *(Oryza sativa)* is globally important stable food for billions of people and is mainly consumed as polish white rice (Park *et al.*, 2017). Brown rice is the whole grain (unpolished) obtained after removing the inedible husks (Islam *et al*., 2012). It consists of embryo, endosperm and bran and is higher in minerals, vitamins and antioxidant compounds compared to refined white rice (Qadri *et al.*, 2018; Toan and Vinh, 2018; Wu *et al*., 2023). A number of studies have shown that brown rice is a rich source of biofunctional components which are beneficial for human health, including fibre, essential amino acids, functional lipids, phytosterols, phenolic acids, flavonoids, tocopherols, gama aminobutyric acid (GABA), y-oryzanol, minerals and vitamins (Qi *et al.*, 2018; Wu *et al*., 2023).

Acha *(Digitaria exilis)* also known as fonio or hungry rice is an underutilized tiny size cereal grain cultivated in northern states of Nigeria including Plateau State, Bauchi, kaduna, Kebbi, Niger and Nasarawa States (Jideani and Jideani, 2011). It is usually consumed as whole grain and is considered to be nutritionally superior to other cereal grains (Jideeani and jideani, 2011). It is a rich source of mineral, vitamins, dietary fibre, and antioxidant compounds including flavonoids, phenolics, and phytosterols (Annongu et al., 2019). The protein in acha is reported to be unique in that it has greater sulphur containing amino acids (methionine and cystine) than other cereals (Ayo *et al*., 2008).

Millet is a major drought resistant small seeded cereal grain of good nutritional value that serves as a staple food to millions of economically disadvantaged people in African and Asian countries (Udeh *et al*., 2017; Liang and Liang, 2019). It is abundantly grown in the middle belt and northern states of Nigeria but grossly underutilized. Pearl millet *(Pennistum glaucum)* and finger millet *(Eleusine coracana)* are the two major millets species used for food and feed (Hassan *et al.*, 2021). Millets contain high concentrations of macro and micronutrients such as protein, carbohydrate, vital amino acids, minerals, vitamins, dietary fibre and health promoting phyto chemicals including lignans, phenolic acid, flavonoids and

phytosterols (Sarita and Singh, 2016; Devi *et al*., 2024). Due to these nutritional benefits, millets are termed as "Nutri-cereals" (Singh *et al*., 2012).

Cowpea *(Vigna unguiculata L. Walp)* is a popular legume crop cultivated primarily in Africa and used for human and livestock diet all over the world (Abebe and Alemayehu, 2022). It contains 23-32% protein, 50-69% carbohydrate and 1% fat (Kirse and Karklina, 2015). The protein is high in lysine but low in sulphur containing amino acids (methionine and cysteine) (Abebe and Alemayehu, 2022). It also contains a reasonable amount of minerals, vitamins, dietary fibre and phytochemicals (Liyanage *et al.*, 2014). It serves both as available and affordable source of nutrients in Nigeria and in other Sub-saharan Africa (Affrifah *et al*., 2021). According to Jayathilake *et al*. (2018), the high protein and carbohydrate contents with relatively low fat content and a complementary amino acid pattern to that of cereal grains make cowpea an important nutritional food in human diet.

Statement of Problem

Noodles which have fast become staple food for most households in both rural and urban cities are conventionally made from wheat which cannot be grown at commercial level in Nigeria due to unfavourable climatic conditions. Consequently, the country imports substantial quantity of wheat annually to augment local production. This has adverse effects on the economy of the country.

Noodles made from cereal flours are high in carbohydrate content but low in protein content. Regular consumption of the product could lead to protein energy malnutrition.

Also, different cereal grains have different nutrients and health promoting constituents. Hence, noodles made from a single cereal grain flour have lower nutrients and health promoting constituents than those made from multi grains flour (Dighe *et al.*, 2022).

Despite the reported nutritional and health benefits of acha, millet, brown rice and cowpea, they are underutilized in food formulation and product development.underutilized in Nigeria for food product development.

Objectives

The objective of the study was to assess the effect of supplementing wheat flour with multigrain flour mixes on the proximate composition, amino acid profile, minerals, vitamins and antinutrients contents in noodles made from the blends.

Materials and Methods

Source of Materials: Brown rice *(Oryza sativa L),* Acha *(Digitaria exilis),* millet *(Eluesine coracana)* wheat *(Triticum aestivum)* and Cowpea *(Vigna unguiculata)* were all purchased from Itam market, Uyo metrpolis, Akwa Ibom State, together with other needed ingredients for noodle production such as as egg, and salt. The chemical and reagents used were of analytical grade and were obtained from Food Science and Technology Laboratory, University of Uyo, Uyo.

Samples preparation

Production of Brown Rice Flour

The production of rice flour was done using the method described by Eke-Ejiofor (2016). The brown rice (5 kg) was sorted and washed manually with water to remove extraneous materials. The rice grains were oven dried at 50° for 12 hours, milled and seived to pass through 425 um mesh screen. It was packaged in an airtight container and kept at room temperature for subsequent use.

Processing of Acha into Flour

The method described by Mbaeyi-Nwaoha *et al.* (2015), was followed to process Acha into flour. The unwanted materials such as stones, chaffs and other debris were removed by sorting, winnowing and sieving. The grains were thoroughly washed, drained and dried in an oven at 50°C for 6 hrs and then milled and seived to pass through 425 um mesh screen. The flour was packaged in an airtight container kept at ambient temperature (27°C) for subsequent use.

Processing of Millets into Flour

Millet was processed into flour according to the method of Lo *et al.* (2020). Two kilograms (2 kg) of the grains were cleaned by sorting and winnowing. The cleaned grains were dehulled using the traditional method. Hulls were removed by winnowing and the weight of the dehulled grains was noted. The dehulled grains were then washed and dried at 50°C for 24h in an oven. The grains were milled to powder using a hammer mill. It was then sieved to pass through 425 um mesh screen. and packaged in an airtight container and kept for subsequent use.

Production of Cowpea Flour

The method of Emilike *et al.* (2020) was used for the processing of cowpea seeds into flour. Five kilograms (5 kg) of brown cowpea seeds were cleaned, weighed and sorted. The sorted seeds were soaked in potable water for 15 min and the seed coats removed manually. The dehulled seeds were further rinsed in water before drying in an air oven at 60 °C for 12 h, milled and seived to pass through 425 um mesh screen. The flour was kept in a dry, air-tight plastic container for subsequent use.

Blending of Wheat Flour with Multigrain Flours

Wheat flour was supplemented with multigrain (brown rice, acha, millet and maize) flour mixes using the blending ratios shown in Table 1. The 100% wheat flour served as the control sample.

Table 1: Sample Formulation

Flour Samples	Blending ratios					
	A	B	C	D	E	F
Wheats	100	90	80	70	60	50
Acha	__	2.50	5.00	7.50	10.00	12.50
Brown Rice	__	2.50	5.00	7.50	10.00	12.50
Millet	__	2.50	5.00	7.50	10.00	12.50
Cowpea	----	2.50	5.00	7.50	10.00	12.50

Production of Noodles

Noodles was produced following the method described by Omiere *et al*. (2014), with a slight modification. Ingredients (wheat-multigrain flour 200g, Carboxymethylchloride 0.8g, Sodium Chloride 0.2g) were mixed thoroughly using 90 mL of warm water (40°C) to form a dough. The dough was allowed to rest for 20 mins, then kneaded and rolled with a rolling pin to form sheets. The sheets were then extruded into strands. The noodles strands were then oven dried at 60°C for 30 min, cooled and packaged.

Methods of Analysis

Proximate composition and energy value of flour samples determination

The method of AOAC (2010) was followed for the determination of moisture, protein, fat and crude fibre content of the noodles. Total carbohydrates was estimated by difference [100%- (% moisture, fat, protein, crude fiber and ash)] (Onwuka, 2005). The caloric values of the noodle's samples were calculated using Atwater factor as described by Osborne and Voogt, (1978).

Amino acid analysis

Amino acid of the samples was determined using Technicon amino acid analyser (TSM-1 Technicon Instrument, Basingstoke, Hampshire, UK) after hydrolysing the samples with 6 M HCl at 110 °C (Ndam *et al.*, 2018).

Determination of mineral content

This was done using atomic absorption spectrophotometer (AOAC, 2010).

Determination of vitamin composition

Vitamins were analized using a UV spectrophotometer double beam (Ceil 7400, Suffolk, United Kingdom) as described by Maigari *et al.*, (2022)

Determination of anti nutritional factors

Tannin, oxalate and phytate were determined using the methods described by Onwuka (2005).

Statistical Analysis

The data obtained were analyzed using SPSS (version 20.0) Analysis of Variance (ANOVA) was used to establish significant differences among the samples. Difference among means were separated using Duncan multiple range test (DMRT) and significance accepted at 5% level ($P<0.05$).

Results and Discussion

Effect of partial replacement of wheat flour with multigrain flour mixes on the proximate composition of noodles made from the blends

The effect of replacing wheat flour with 0-50% multigrain flour mixes on the proximate composition of noodles made from the blends is presented in Table 2. The result showed that the moisture, protein, fat, ash and crude fibre contents in the noodles increased significantly ($p<0.05$) from 9.67%, 10.14%, 1.64%,1.44% and 2.16% respectively in the 100% wheat flour noodle (control sample) to 10.74%, 22.33%, 4.38%, 3.90% and 6.73% respectively in the sample that was supplemented with 50% multigrain flour mix. The higher moisture content in the multigrain flour supplemented noodles than in the control sample might be attributed to higher water absorption capacity of the multigrain flour mixes than the 100% wheat flour. High moisture content is however detrimental to the stability of the product during storage. The observed increases in protein, fat, ash and crude fibre contents in the noodles with increased in multigrain flour supplementation could be attributed to their higher contents in the multigrain flours than in the 100% wheat flour. According to Dighe *et al.* (2022) and Vishwakarma and Phadnis (2025), multigrain flour and its products are richer in nutrients and have greater health benefits than single grain flour products. Olagunji *et al*. (2021) and Rohi *et al*. (2022) also reported that addition of multigrain flour provides numerous nutritional advantages and changes the nutritional composition of the final product. Similar increased in protein, flat, ash and crude fibre contents in cake husks as a result of supplementation with multigrain flours prepared from millet, corn and gram flour was reported by Ud Din *et al.* (2025). Incorporation of cowpea flour in the multigrain flours might have contributed to the significant ($p<0.05$) increased in protein content in the noodles with increase supplementation of wheat flour with multigrain flours. According to Kirse and Karklina (2015), cowpea has 23-32% protein content. Ugressa (2025) also reported an average of 25.6% protein content in cowpea. Ud Din *et al.* (2025) similarly reported that incorporation of gram flour in multigrain flour mixes resulted in higher protein content in multigrain supplemented cake husks than in 100% wheat cake husks. The result of this study suggests that the consumption of multigrain flour supplemented noodles could help in alleviating the problem of protein – energy malnutrition that exists in most of our communities.

The recorded increased in fat, ash and crude fibre contents in the noodles with increasing levels of multigrain flour supplementation could be attributed to their higher contents in multigrain flour mixes than in 100% wheat flour since the multigrain flours were produced from whole grains. Ud Din *et al.* (2025) reported that multigrain flours are higher in nutrients, minerals, dietary fibre and antioxidant compounds than single grain flour. Ash

content in food products is an index of the mineral content in such product. Increase in the ash content of the noodles with multigrain flour mixes supplementation is an indication of higher mineral content in supplemented noodles than in 100% wheat flour noodles. The higher crude fibre content in the multigrain flour supplemented noodles than in the 100% wheat flour noodles implies that the multigrain flour supplemented noodles would provide more health benefits to the consumers than the 100% wheat flour noodles. Consumption of high fibre diet is associated with various health benefits like lowering of cholesterol, glycemic index level, colon cancer, and bowel disorders (Kumar *et al.*, 2017).

On the contrary, the carbohydrate content decreased with increase in multigrain flour mixes supplementation ranging from 74.75% for the control noodle to 51.94% for the noodle that was supplemented with 50% multigrain flour mix. This could be attributed to lower carbohydrate content in multigrain flour mixes than in the 100% wheat flour. The caloric value ranged from 336.43 kcal/100 g for the 50% multigrain flour mix supplemented noodles to 354.64 Kcal/100 for the 10% multigrain flour mix supplemented noodles. There was no significant difference ($p<0.05$) between the caloric value of the control noodles and 10% multigrain flour mix supplemented noodles but their values were significantly higher than the rest of the samples.

Table 2: Proximate composition and energy values of noodles made from wheat flour supplemented with multigrain flour mixes

Nutrients	Blending ratios (wheat flour: multigrain flour)					
	100:00	**90:10**	**80:20**	**70:30**	**60:40**	**50:50**
Moisture (%)	9.67^{f} ± 0.01	9.82^{e}±0.01	9.88^{d} ± 0.01	10.22^{c}±0.01	10.53^{b}±0.01	10.74^{a}±0.01
Ash (%)	1.44^{f} ±0.01	1.91^{e}±0.01	2.44^{d} ±0.01	2.53^{c} ±0.01	2.94^{b} ±0.02	3.90^{a} ±0.01
Fibre (%)	2.16^{f} ±0.01	2.77^{e} ±0.02	3.91^{d} ±0.01	4.41^{c} ±0.01	5.52^{b} ± 0.02	6.73^{a} ±0.01
Fat (%)	1.64^{f}± 0.01	2.40^{e} ±0.01	2.96^{d} ±0.01	3.23^{c} ±0.01	3.73^{b} ±0.01	4.38^{b} ±0.01
Protein (%)	10.14^{f}±0.01	12.74^{e}±0.02	13.46^{d}±0.06	16.11^{c}±0.01	18.24^{b} ± 0.01	22.33^{a}±0.01
Carbohydrate (%)	74.75^{a}±0.04	70.53^{b}±0.04	67.42^{c}±0.08	63.58^{d}±0.01	59.06^{e}±0.01	51.94^{f}±0.05
Energy (Kcal/100 g)	354.30^{a}± 0.03	354.64^{a}± 0.07	350.11^{b} ±0.05	347.81^{c}± 0.01	342.72^{d}± 0.13	336.43^{e}± 0.09

Values are means ± standard deviation of triplicate determinations. Means with different superscripts within the same row are significantly different ($P<0.05$).

Effect of partial replacement of wheat flour with multigrain flour mixes on the amino acid profile of noodles made from the blends

The effect of supplementing wheat flour with different levels of multigrain flour mixes on the amino acid profile of noodles made from the blends is presented in Table 3. The result showed that a total of eighteen (18) amino acids were detected and quantified. Partial replacement of wheat flour with multigrain flour mixes led to the enhancement of the

amino acid profile of the noodles. The total amino acids, total essential amino acid and sulphur containing amino acids increased with increasing levels of multigrain flour mixes supplementation ranging from 73.20g/100g, 29.01g/100g and 4.78g/100g respectively for the control noodle to 92.89g/100g, 39.93g/100g and 5.71g/100g respectively for 50% multigrain flour mixes supplemented noodles. Glutamic acid was the major contributor to the total amino acid and was followed by proline while leucine was the major contributor to the essential amino acids. The nutritional quality of protein depends on its essential amino acids which cannot be synthesized in the body. Legumes are protein rich crops and have higher amino acid composition than cereals (Arise *et al.*, 2020). Cowpea flour was one of the flours used for multigrain formulation. The increase in the amino acid profile (essential and non-essential) of the noodles with increasing levels of multigrain flour supplementation could be attributed to high quality of protein present in cowpea flour. The high lysine content of cowpea protein is a very important nutritional attribute that makes the legumes a very good supplementary protein to cereals with known deficiency in lysine.

Table 3: Amino acid profile of noodles made from wheat flour supplemented with multigrain flour mixes (g/100 g)

Amino acids	Blending ratios (wheat flour: multigrain flour mixes)					
	100:00	90:10	80:20	70:30	60:40	50:50
Leucine	$6.93^{c} \pm 0.04$	$6.93^{c} \pm 0.01$	$7.06^{c} \pm 0.04$	$7.24^{b} \pm 0.12$	$7.40^{ab} \pm 0.07$	$7.49^{a} \pm 0.01$
Isoleucine	$3.37^{d} \pm 0.04$	$3.41^{d} \pm 0.01$	$3.54^{cd} \pm 0.03$	$3.61^{cd} \pm 0.13$	$3.77^{b} \pm 0.03$	$4.07^{a} \pm 0.19$
Tryptophan	$1.07^{e} \pm 0.06$	$1.47^{d} \pm 0.10$	$1.57^{cd} \pm 0.02$	$1.63^{bc} \pm 0.04$	$1.73^{b} \pm 0.04$	$1.88^{a} \pm 0.01$
Histidine	$2.70^{e} \pm 0.03$	$2.83^{d} \pm 0.03$	$2.85^{cd} \pm 0.04$	$2.93^{bc} \pm 0.01$	$2.96^{b} \pm 0.05$	$3.21^{a} \pm 0.01$
Phenylalanine	$4.88^{d} \pm 0.01$	$4.97^{d} \pm 0.06$	$5.49^{c} \pm 0.01$	$5.83^{b} \pm 0.03$	$5.96^{b} \pm 0.04$	$6.15^{a} \pm 0.14$
Valine	$4.68^{d} \pm 0.08$	$4.80^{cd} \pm 0.18$	$4.98^{bc} \pm 0.00$	$5.03^{bc} \pm 0.03$	$5.12^{ab} \pm 0.05$	$5.30^{a} \pm 0.01$
Methionine	$2.70^{b} \pm 0.06$	$2.71^{b} \pm 0.01$	$2.71^{b} \pm 0.01$	$2.73^{b} \pm 0.02$	$2.88^{a} \pm 0.02$	$2.95^{a} \pm 0.05$
Lysine	$0.92^{f} \pm 0.04$	$1.87^{e} \pm 0.03$	$2.96^{d} \pm 0.04$	$3.91^{c} \pm 0.02$	$4.54^{b} \pm 0.03$	$4.96^{a} \pm 0.00$
Threonine	$1.76^{d} \pm 0.03$	$1.78^{d} \pm 0.01$	$2.00^{c} \pm 0.06$	$2.11^{c} \pm 0.09$	$2.75^{b} \pm 0.05$	$3.92^{a} \pm 0.02$
Aspertic Acid	$4.51^{a} \pm 0.07$	$4.96^{c} \pm 0.08$	$5.43^{b} \pm 0.11$	$5.53^{b} \pm 0.03$	$5.74^{a} \pm 0.04$	$5.05^{c} \pm 0.04$
Arginine	$4.73^{a} \pm 0.06$	$4.93^{b} \pm 0.02$	$4.93^{b} \pm 0.02$	$4.93^{b} \pm 0.01$	$5.03^{a} \pm 0.08$	$5.15^{a} \pm 0.02$
Alanine	$3.32^{f} \pm 0.02$	$3.51^{e} \pm 0.01$	$3.62^{d} \pm 0.02$	$3.93^{c} \pm 0.02$	$4.03^{b} \pm 0.03$	$4.63^{a} \pm 0.03$
serine	$3.87^{c} \pm 0.09$	$3.92^{bc} \pm 0.11$	$3.93^{bc} \pm 0.11$	$4.17^{b} \pm 0.10$	$4.17^{b} \pm 0.10$	$4.45^{a} \pm 0.06$
Proline	$7.24^{c} \pm 0.15$	$7.43^{c} \pm 0.15$	$7.51^{bc} \pm 0.17$	$7.77^{ab} \pm 0.08$	$7.89^{a} \pm 0.01$	$8.02^{a} \pm 0.03$
Cysteine	$2.08^{a} \pm 0.07$	$2.08^{a} \pm 0.03$	$2.11^{a} \pm 0.02$	$2.23^{b} \pm 0.04$	$2.29^{b} \pm 0.03$	$2.76^{a} \pm 0.02$
Tyrosine	$3.39^{e} \pm 0.05$	$3.56^{d} \pm 0.05$	$3.67^{c} \pm 0.00$	$3.90^{b} \pm 0.01$	$4.08^{a} \pm 0.07$	$4.16^{a} \pm 0.01$
Glycine	$5.51^{a} \pm 0.08$	$5.68^{c} \pm 0.11$	$5.73^{c} \pm 0.03$	$5.92^{b} \pm 0.01$	$6.04^{b} \pm 0.01$	$6.24^{a} \pm 0.04$
Glutamic Acid	$9.54^{f} \pm 0.12$	$9.82^{e} \pm 0.01$	$9.94^{d} \pm 0.02$	$10.03^{c} \pm 0.12$	$11.05^{b} \pm 0.01$	$12.50^{a} \pm 0.05$
TEAA	29.01	30.77	33.13	35.02	37.11	39.93
TAA	73.20	76.66	80.00	83.43	87.43	92.89
TSAA	4.78	4.79	4.82	4.96	5.17	5.71
TEAA/TAA	39.63	40.14	41.41	41.98	42.45	42.99

Values are means standard deviation of duplicate determinations. Means with different superscripts within the same row are significantly different ($p<0.05$) TAA =Total amino acid, TEAA = Total essential amino acid, TSAA = Total sulphur containing amino acids.

Effect of partial replacement of wheat flour with multigrain flour mixes on the mineral content of noodles made from the blends

The effect supplementing wheat flour with 0 - 50% multigrain flour mixes on the mineral content of noodles produced from the blends is presented in Table 4. The result showed that the sodium content in the noodles significantly decreased ($p<0.05$) with increase in multigrain flour mix addition ranging from 8.98 mg/100 g for the 100% wheat flour noodles to 1.79 mg/100 g for noodles made from 50% multigrain flour mix supplemented noodles. This could be attributed to lower sodium content in multigrain flours than 100% wheat flour. Conversely, the K, Ca, Fe and Zn contents significantly increased ($p<0.05$) with increase in multigrain flours supplementation ranging from 377.00 mg/100 g, 38.80 mg/100 g, 2.88 mg/100g and 1.94 mg/100 g, respectively for for the 100% wheat flour noodles to 529.00 mg/100 g, 67.33 mg/100 g, 3.59 mg/109 g and 3.00 mg/100 g respectively for the 50% multigrain flour mix supplemented noodles. This could be attributed to higher levels of these minerals in multigrain flours than in 100% wheat flour. Similar increase in minerals (K, Ca, Fe and Zn in biscuit as a result of multigrain addition was reported by Kumar *et al.* (2018). According to Usman (2009), sodium helps transport CO_2 in the blood and also regulates the water content in the body. However, it is also implicated in the aetiology and pathophysiology of hypertension which predisposes someone to stroke and other cardiovascular pathologies (Rust and Ekmekcioghu, 2017). Potassium plays a significant role in maintaining homeostasis, zinc has its role in enzymatic processes whereas iron and calcium are important in blood formation and bone development respectively. Waugh and Grant (2000). The values recorded for Iron and Calcium in this study suggest that consumption of multigrain flour supplemented noodles could help in the prevention of Iron Deficiency Anemia and Osteomalacia/rickets respectively.

Uday and Höggler (2020).

Table 4: Mineral composition of noodles produced from wheat flour supplemented with multigrain flour mixes (mg/100 g)

Minerals	Bending ratios (wheat flour: multigrain flour mixes)					
	100 : 00	**90 : 10**	**80 : 20**	**70 : 30**	**60 : 40**	**50 : 50**
Na	$8.98^{a} \pm 0.07$	$4.86c^{b} \pm 0.21$	$4.75^{c} \pm 0.28$	$4.38^{d} \pm 0.01$	$2.99^{e} \pm 0.07$	1.97 ± 0.02
K	$377.00^{f} \pm 1.41$	$420.50^{e} \pm 0.71$	$422.00^{d} \pm 2.12$	$436.50^{c} \pm 3.54$	$505.50^{b} \pm 4.24$	$529.00^{a} \pm 1.41$
Ca	$38.80^{f} \pm 0.14$	$45.70^{e} \pm 0.14$	$60.00^{d} \pm 0.14$	$63.60^{c} \pm 0.14$	$65.60^{b} \pm 0.14$	$67.33^{a} \pm 0.01$
Fe	$2.88^{f} \pm 0.01$	$3.16^{e} \pm 0.01$	$3.25^{d} \pm 0.02$	$3.33^{c} \pm 0.00$	$3.41^{b} \pm 0.01$	$3.59^{a} \pm 0.14$
Zn	$1.94^{c} \pm 0.01$	$1.98^{bc} \pm 0.02$	$2.92^{cd} \pm 0.02$	$3.13^{a} \pm 0.01$	$2.87^{d} \pm 0.02$	$3.00^{b} \pm 0.01$

Values are means standard deviation of duplicate determinations. Means with different superscripts within the same row are significantly different ($p<0.05$)

Effect of partial replacement of wheat flour with multigrain flour mixes on the vitamin content of noodles made from the blends

The effect of replacing wheat flour with 0 - 50% multigrain flour mixes on the concentration of vitamins in noodles produced from the blends is presented in Table 5. The result revealed that the vitamin B3 and beta carotene contents increased significantly ($p<0.05$) from 30.70 mg/100 g and 0.06 ug/100g respectively in 100% wheat flour noodles to 65.05 mg/100 g, 0.19 ug/100g respectively in noodles supplemented with 50% multigrain flours. Kumar *et al* (2018) similarly reported that partial replacement of wheat flour with multigrain flour mix resulted in increased vitamin content (thiamine and riboflavin) in biscuit made from the blends. The recorded increase in vitamin B3 and beta-carotene content in the noodles with increased supplementation with multigrain flours could be attributed to higher levels of these vitamins in the multigrain flours than in 100% wheat flour. On the other hand, the concentration of Vitamin B9 decreased from 5.75 ug/100g in 100% wheat flour noodles to 2.95 ug/100 g in noodles samples supplemented with 50% multigrain flour mix. Vitamins are one of the micronutrients necessary for bodily functions. Beta carotene is a precursor of vitamins A and it enhances vision and prevents night blindness (Waugh and Grant, 2022). Vitamin B3 (niacin or nicotinic acid) aids metabolism, enhances cell respiration and also inhibit production of cholesterol while vitamin B9 (folate or Folic acid) helps in fetal development, DNA synthesis and cell division (Waugh and Grant, 2022).

Table 5: Vitamins composition of noodles produced from wheat flour supplemented with multigrain flour

Vitamins	Bending ratios (wheat flour: multigrain flour)					
	100:0	90:10	80 : 20	70 : 30	60 : 40	50 : 50
Vitamin B_3 (mg/100 g)	30.70^{f}± 0.14	38.00^{e}± 1.41	43.35^{d}± 0.21	50.60^{c} ±1.41	58.25^{b}±0.07	65.05^{a} ± 0.07
Vitamin B_9 (ug/100 g)	5.75^{a}± 0.01	4.74^{b}± 0.03	4.81^{b}± 0.01	4.00^{c} ± 0.03	4.07^{c} ± 0.01	2.95^{d} ± 0.85
Beta Carotene (ug/100 g)	0.06^{b}± 0.01	0.08^{b}± 0.01	0.09^{b}± 0.01	0.09^{b} ±0.00	0.16^{a} ± 0.01	0.19^{a} ± 0.01

Values are means ± standard deviation of triplicate determinations. Means with different superscripts within the same row are significantly different ($P<0.05$).
Vitamin B3 = Nicotinic Acid, Vitamin B9 = Folic Acid, Beta Carotene (Vitamin A Precursor).

Effect of partial replacement of wheat flour with multigrain flour mixes on the anti-nutrients concentration in noodles made from the blends

The effect of replacing wheat flour with 0 - 50% multigrain flour mixes on the anti-nutritional factors in noodles produced from the blends is presented in Table 6. The result showed that tannin, oxalate and phytate contents increased with increasing amount of multigrain flour in the noodles. Tannin, Oxalate and phytate increased from 0.23%, 11.55 mg/100 g and 0.60% respectively in 100% wheat flour noodles to 0.64%, 29.70 m/100 g and 1.28% respectively in the sample supplemented with 50% multigrain flour mx. Anti-nutrients in food could impede the efficient and effective digestion, absorption or

utilization of some nutrients thereby reducing their bioavailability (Adeniji *et al.*, 2007). The significant ($p<0.05$) increase in tannin, oxalate and phytate contents with increase in multigrain flour addition could be attributed to the high levels of these compounds in cowpea. Tannins are known to inhibit digestive enzymes activities. Thus, their presence even at a low levels are nutritionally undesirable (Daffodil *et al.*, 2016). Tannins also have ability to form complexes with carbohydrates, proteins and mineral ions in food (Kunyanga *et al.*, 2011). The complexes formed by tannins have been reported to depress growth, decrease bioavailability of amino acid and increase fecal nitrogen (Waghorn, 2008; Woodward *et al.*, 2009; Dijkstra *et al.*, 2013; Grosse-Brinkhaus *et al.*, 2016) However, tannin content could reduce during cooking as reported by Vadivel and Pulglendhi (2008). Although there is no standardized safe limit for legume tannins (Ojo, 2022), the result of the present study study showed concentration of tannin negligibly low.

According to Habtama and Negussie (2014), if food with excessive amount of oxalic acid is regularly consumed, nutritional deficiencies are likely to occur as well as severe irritation of the lining of the gut. However, the concentration of oxalate recorded in this study was below the established lethal concentration of 200 - 500 mg/100 g (Ekanah and Obueh, 2013). Phytate which is a common anti-nutrient in legume seeds oftentimes chelate minerals like calcium and zinc and hinder their bioavailability (Weaver and Kannan, 2002; Gibson *et al.*, 2014).

Table 6: Anti-Nutritional Factors in noodles produced from wheat flour supplemented with multigrain flour

Bending ratios (wheat flour: multigrain flour)	ANTI - NUTRITIONAL FACTORS		
	Tannin (%)	Oxalate (mg/100 g)	Phytate (%)
100:00 (Control)	$0.23^{d} \pm 0.03$	$11.55^{f} \pm 0.07$	$0.60^{c} \pm 0.02$
90 : 10	$0.26^{d} \pm 0.01$	$14.34^{d} \pm 0.02$	$0.61^{c} \pm 0.14$
80 : 20	$0.28^{cd} \pm 0.01$	$15.18^{e} \pm 0.01$	$0.97^{b} \pm 0.01$
70 : 30	$0.34^{c} \pm 0.02$	$18.35^{c} \pm 0.00$	$1.07^{ab} \pm 0.01$
60 : 40	$0.45^{b} \pm 0.01$	$24.75^{b} \pm 0.07$	$1.13^{ab} \pm 0.01$
50 : 50	$0.64^{a} \pm 0.01$	$29.70^{a} \pm 0.14$	$1.28^{a} \pm 0.01$

Values are means ± standard deviation of duplicate determinations.

Means with different superscripts within the same column are significantly different ($P<0.05$).

Conclusion

The study showed that supplementing wheat flour with 0 – 50% multigrain (acha, brown rice, brown beans and pearl millet) flours led to enhancement of both the macro and micro nutrient composition of the noodles made from the blends. Enhancement of both the total amino acids and total essential amino acids in the noodles as a result of multigrain flours supplementation is significant as the product could be used to tackle the problem of protei-energy malnutrition.

Recommendations

i. Based on the result of the study, it is recommended that noodle should be produced from wheat flour supplemented with multigrain flours in order to improve the nutritional quality.
ii. Further study should be carried out to assess the acceptability and shelf life stability of the noodles.

References

Abebe B. K. and Alemayehu, M. T. (2022). A review of the nutritional use of cowpea *(Vigna unguiculata L. Walp*) for human and animal diet. Journal of Agriculture and Food Research, https://doi.org/10.1016/j.jafe.2022.100383.

Adebiyi, J. A., Obadina, A. O., Adebo, O.A., and Kayitesi, E. (2017). Comparison of nutritional quality and sensory acceptability of biscuits obtained from native, fermented and malted Pearl millet *(Pennisetum glaucum)* flour. *Food Chemistry,* 232: 210–217.

Adekola, M. B. (2021). Comparative analysis of the proximate composition, vitamin content and mineral profile of Nigerian rice *(Oryza glaberrima)* and imported rice *(Oryza sativa).* http://dx.doi.org/10.2139/ssrn.3900334

Adeniji, T. A., Sanni, L. O., Barimalaa, I. S. and Hart, A.D. (2007). Anti-nutrients and heavy metals in some new plantain and banana cultivars. *Nigeria Food Journal,* 25(2):.165-170.

Adeoye, B. K., Bello, M. A., Ani, I. F., Akinlade , A. R., Ajuzie, N. C. and Ngozie, E. O. (2018). Factors influencing noodles consumption and nutrients intake of Nigerian University undergraduate students. *International Journal of Medical and Applied Biosciences.* 3(2): 71-79.

Adeyeyo, E. I. and Agesin, O. O. (2007). Dehulling the African yam bean (Sphenostylis stenocarpa Hochst.ex A. Rich) seeds: Any nutritional importance? *Bangladesh Journal of Science and Industrial Research.* 42(2): 163-174.

Affrifah, N.S., Phillips, R.D. and Saalia, F.K (2021) Cowpeas: Nutritional profile, processing methods and products. A review. *Legume Science,* 4(3): 131. https://doi.org/10..1002/leg3.13

Amadou, I., Gounga, M. E. and Le, G. (2013), Millet: nutritional composition, some health benefits and processing- A Review. *Emirates Journal of Food and Agriculture,* 25 (7): 501-508.

Annongu, A. A., Edoh, J. H., Kayode, R. M. O., Gawati, A. O., Aremu, J. O., Bello-Bukoye, Z. O., Yusuf, A. T. and Eifediyi, E. K. (2019). Phytochemical and nutrients constituents in varieties of hungry rice and their significance in nutrition. International Journal of Research Publications, 1-12

A.O.A.C. (2010). Official Method of Analysis (18th edition) Association of Official and Analytical Chemist, Washington, D.C., U.S.A.

Arise, A. K., Taiwo, G. O. and Malomo, S. A (2020). Amino acid profile, pasting and sensory properties of croissant snacks produced from wheat — fermented bambara flour. Legume Science, 2(4): https://doi.org/10.10002/leg3.53

Ayo, J. A., Nkana, I., Hauna, U. S., Britus, Y. and Onafaife F. (2008) Effect of Dough Improves on the Physical and Sensory Quality of Acha (digitrian exilis) flour bread. *Nigeria Food Journal*. 26:102-110.

Barber, V., Obinna-Echem, P. C., and Ogburia, E. M. (2017). Proximate composition,micronutrient and sensory properties of complementary food formulated from fermented maize,soybeans and carrot flours. *Sky Journal of Food Science.* 6(3): 33-39.

Chaudhary, V., Kumar, V., Singh, V.K., Sharma, H. P., Verma, S., Arya, A. M., Paul, A. S., Suniil and Vaishali (2024). Development of major millets (Finger, Pearl, sorghum) bakery Products and its quality evaluation. *International Journal of Statistics and Applied Mathematics,* 9(2): 111-117.

Chigbo, D. C. (2023). Quality evaluation of therapeutic noodles made from water yam, millet and wheat composite flour and its effect on lipid profile and blood glucose concentration using albino rats. World Journal of Advanced Research and Reviews, 19(03) : 1428-1437

Choudhary, T. (2024). 14 Benefits of cowpea (Lobia) for your skin, hair and health. https://www.stylecraze.com/articles/benefits-of-cowpeas-for-skin-hair-and-health/

Chukwu, O. and Abdulkadir, A. J. (2008) proximate chemical composition of Acha (Digitania exilis Grains. *Journal of Food Technology* 6(5): 214-216, 2008 (c) medwell journals, 2008.

Daffodil, E. D., Tresina, P. S. and Mohan, V. R. (2016) Nutritional and antinutritional assessment of Mucuna pruriens(L.) DC var. utilis (Wall ex. Wight) Bak. Ex Burck and Mucuna deeringiana(Bort) Merril: An underutilized tribal pulse. *International Food Research Journal,* 23(4):1501-1513

Devi, M. P., Nandakumar and Kumarakuru, K. (2024). Nutritional significance and utilization of millet grains in the preparation of value-added products – A review. *International Journal of Novel Research and Development*, 9(1): 538–542

Dighe, P. Rasane, P., Gavahne, A., Kour, A and Nakra, A. (2022). Importance of multigrain consumption over single grain: A Review. The Pharma Innovation, SP 11(6): 2707- 2714.

Dijkstra, J., Oenema, O., van Groenigen, J. W., Spek, J. W., van Vuuren, A. M. and Bannink A. (2013). Diet effects on urine composition of cattle and N2O emissions. Animal. 7: 292-302.

Ekanah, K. and Obueh, H. (2013). A study of the oxalate, phytate and cyanide contents of selected Nigerian foods and diet in Akwa Ibom and Cross River states of Nigeria *a. Journal of Food Science and Technology -Mysore-. 4. 2141-5455.

Eke-ejiofor, J. (2016). The effect of variety and processing on the functional and chemical properties of rice flour. *International Journal of Nutrition and Food Sciences.* 5(1): 80. Doi: 1011648/j.ijnfs.20160501.22

Emilike, N. J. T., Njong A. E. and Achienewhu, S. C. (2020). Proximate and sensory properties of moi-moi developedfrom cowpea and Avocado Pear seed flour blends. *Journal of Food Technology Research.* 7(2):136-143. Doi:10.18488/journal. 58.2020.72.136.143.

Garfinkle, M. A. (2017). Salt and essential hypertension: pathophysiology and implications for treatment. *Journal of the American Society of Hypertension*, 11(6): 385-391. https://doi.org/10.1016/j.jash.2017.04.006.

Gibson, R. S., Heath, A. L. M. and Szymlek-Gay, E. A. (2014). Is Iron and Zinc Nutrition a concern for vegetarian infants and young children in industrialized countries? *The* American *Journal of Clinical Nutrition,* 100(1): 4595-4685.

Grosse-Brinkhaus A., Bee, G., Silacci, P., Kreuzer, M. and Dohme-Meier, F. (2016). Effect of exchanging Onobrychis viciifolia and Lotus corniculatus for Medicago sativa on ruminal fermentation and nitrogen turnover in dairy cows. *Journal Dairy of Science. 99:4384-4397.*

Habtamu, F.G and Negussie, R. (2014). Antinutritional factors in plant foods: potential health benefits and adverse effects. International Journal of Nutrition and Food Science. 3(4): 284-289.

Hassan, Z. M., Sebola, N. A and Mabelebele, M. (2021). The nutritional use of millet grains for food and feed: a review. *Agriculture and Food Security*. 10(1):16; doi:10.1186/540066-020-00282-6

Into, G. (2022). Phyto chemical properties of brown rice and its nutrigenomic. *Journal of Rice Research*, 10(5); Doi.10.4172/2375–2338.10003000

Islam, M. Z., Shamus - Ud-Din, M. S.and Haque, M.A. (2012). Studies on effect of brown rice and maize flour on quality of bread. *Journal of Bangladesh Agricultural University,* 9: 297-304.

Iwe, M. O. (2002). Handbook of sensory methods and analysis, Projoint Communications Services Ltd, Enugu, 70-72.

Iwe, M. O., Onyeukwu, U. and Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO 44, African yam bean and brown cowpea seeds composite flour. *Cogent Food and Agricultural Journal*, 2: 5-6.

Jayathlake, C., Visvanathan, R., Deen, A., Bangamuwage, R., Jayawardana, B. G , Nammi, S. and Liyanage, R. (2018). Cowpea: an overview on its nutritional facts and health benefits. *Journal of Science of Food and Agriculture*, 98(13): 4793-4806

Jideani, I. A. and Jideani, V. A. (2011). Development on the cereal grains Digitaria exilis (acha) and Digitaria iburua (iburu). *Journal of Food Science and Technology*, 48(3): 251–259

Kirse, A. and Karklina, D. (2015). Integrated evaluation of cowpea *(Vigna unguiculata L. Walp)* and maple pea *(Pisum sativum var. arvense L.)* spreads. *Agronomy Research*, 13: 956-968

Kumar, K. A., Sharma, G. K. and Anilakumar, K. R. (2018). Influence of multigrain premix on nutritional, in-vitro and in-vivo protein digestibility of multigrain biscuit. *Journal of Food Science and Technology*, 56(2): 746-753

Kumar, R., Kumar, V., Shalini, Singh, A., Singh, Y. and Sharma, A. (2017). Development and quality evaluation of multigrain based biscuit and their sensory characteristics during storage. *Journal of Pure and Applied Microbiology*, 11(1): 427–432

Kunyanga, C. N., Imungi, J. K., Okoth, M., Momanyi, C., Biesalski, H. K. and Vadivel, V. (2011). Antioxidant and antidiabetic properties of condensed tannins in acetonic extract of selected raw and processed indigenous food ingredients from Kenya. *Journal of Food Science.* 76: 560-567.

Liang, S. and Liang, K. (2019). Miller grain as a candidate antioxidant food resource: a review. International *Journal of Food Properties*, 22(1): 1652–1661

Liyanage, R., Perera, O.S., Wethasinghe, P., Jayawardana, B.C., Vidanaarachchi, J. K. and Sivakanesan, R. (2014). Nutritional properties and antioxidant content of commonly consumed cowpea cultivars in Sri Lanka. *Journal of Food Legumes*, 27(3): 215-217

Lo, A., Nwosu J. N., Nwakanma, J., Odimegwu, E. N. and Nzemechi, V. N. (2020). EC NUTRITION Research Article Millet Flour Potential in Enriching Wheat Flour for Biscuit Production. https://www.researchgate.net/publication/342048089_EC_NUTRITION_EC_NUTRITION_Research_Article_Millet_Flour_Potential_in_Enriching_Wheat_Flour_for_Biscuit_Production/citation/download

Mahmoud, E. A. M., Nassef, S. L. and Basung, M. M. (2012).Production of high protein quality noodles using wheat flour fortified with different protein products from lupine. *Annals of Agricultural Science* 57(2): 105-112.

Mbaeyi-Nwaoha, I. and Uchendu, N. (2015). Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). *Journal of Food Science and Technology*. 53(1): 50–70. Doi.10.1007/s13197-015-2032-8.

Maigari, F., Goje, L.J., Marafa, F.A. and Sabo, U. S. (2022). Determination of some levels of vitamins and mineral elements in cooked jollof pasta, served in public schools in Gombe State, Nigerian. *Jewel Journal of medical sciences.* 3(1):54-6

Murano, P. S. (2003). *Understanding Food Science and Technology.Brooks* Cole Learers Publishers, Belmont University, USA. 150p.

Ndam, G. N., Gomerep, B., Dewan, G., Igwebike, S. I., Ngamarju, A. T. and Dapel, A. S. (2018). Nutritional, elemental and amino acid profile analyses of the seeds of Aspilia Africana. A neglected and underutilized species. Asian Food Science Journal. 6(1): 1-8.

Ojo, M. A. (2022). Tannins in Foods: Nutritional Implications and Processing Effects of Hydrothermal Techniques on Underutilized Hard-to-Cook Legume Seeds—A Review. Preventive Nutrition and Food Science, 27(1):14-19

Olagunji, A. I., Oluwajuyitan, T. D. and Oyeleye, S. I. (2021). Multigrain bread: dough theology, quality characteristics, in vitro antioxidant and antidiabetic properties. *Journal of Food Measures and Characterization*, 15: 1851–1864

Omiere, G, Uwoji, O. F. and Obasi, N. E. (2014). Acceptability of noodles produced from blends of wheat, acha and soybean composite flours. *Nigerian Food Journal.* 32(1):31-37. Doi: 10.1016/s0189-7241(15)300093-x.

Onyeka E. U., Aka, N., Aloka, L. and Onyeneakeya, N. (2007). Fractionation and Functional properties of carbohydrates from five common cowpea cultivars in Nigeria. *Niger Agricultural journal*. 38:100-107.

Onyeka, U. (2007). Glycemic and physicochemical properties of five common cowpea (*Vigna Unguiculata*) cultivars in Nigeria. *Journal of food processing and preservation*, 31(5): 618-631.

Osborne, D. R. and Voogt, P. (1978). Analysis of Nutrient in food. Academic press, 5: 126-140.

Pakhare, K. N., Dagadkhair, A. C., and Udachan, I. S. (2018). Enhancement of nutritional and functional characteristics of noodles by fortification with protein and fiber: a review. *Journal of Pharmacognosy and Phytochemistry*. 7(1): 351-357.

Qadri, T., Hussain, S.Z., Rather, A.H., Amin, T. and Naseer, B. (2018). Nutritional and storage stability of wheat-based crackers incorporated with brown rice flour and carboxymethyl Cellulose (CMC). *International Journal of Food Properties*, 21(1): 1117-1128.

Qi, J., Lyu, Y., Wang, Y., Chen, J. and Hou, P. (2018). Formula and Quality Study of Multigrain Noodles, *Grain & Oil Science and Technology,* 1(4):157-162.

Ratnawati, L., Desnilasari, D., Surahman, D. N. and Kumalasari, R. (2019). Evaluation of physicochemical, functional and pasting properties of soybean, mung bean and red kidney bean flour as ingredient in biscuit. In IOP Conference Series: Earth and Environmental Science. IOP Publishing, 251:12026.

Rust P. and Ekmekcioglu (2017) Impact of salt intake on the pathogenesis and treatment of hypertension. Advance *Exponential Medical Biology* 956:61-84.

Rohi, M., Sattar, M. A., Tehseen, S. and Saleem, B. (2022). Ameliorative effect of multigrain on nutritional and sensorial profile of muffins. *Emirates Journal of Food and Agriculture*, 34(3): 213–219

Rust P. and Ekmekcioglu (2017) Impact of salt intake on the pathogenesis and treatment of hypertension.Advance *Exponential Medical Biology* 956:61-84.

Saleh, A. S. M., Zhang, Q., Chen, J. and Shen, Q. (2013). Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. Comprehensive Reviews in Food Science and Food Safety. 12: 281-295.

Sarita, E. S. and Singh, E (2016). Potential of millet: nutrients composition and health benefits. *Journal of Science, Innovation and Research*, 5 : 46–50

Shivakumara, K. M. and Uma, G. M. (2020). Millet Scenario in India. *Economic Affairs,* 65(3): 363-370.

Siddhuraya, P. and Becker, K. (2001). Effect of various domestic processing methods on antinutrients and in vitro protein and starch digestibility of two indigenous varieties of indian tribal pulse, mucuna purines var. utilis. *Journal of Agriculture and Food Chemistry.* 49(6):3058-3067.

Singh, K., Mishra, A. and Mishra, H. (2012). Fuzzy analysis of sensory attributes of cookies prepared from millet based composite flour. *LWT Food Science and Technology*, 48(2): 276–282

Sofi, S. A., Singh, J., Chhikara, N. and Panghal, A. (2020). Effect of incorporation if terminated flour and protein isolate from chickpea on different quality characteristics of rice based noodles. *Cereal Chemistry*, 97(1): 85–94

Toan, N.V.A and Vinh, T. Q. (2018). Production of nutritional bars with different proportions of Oat flour and brown rice flour. *Clinical Journal of Nutrition and Diabetics,* 1(1): 1-11.

Ud-Din, G., Usmani, W., Hussain, A., Bilal, M., Najam, A., Zia, M., Raza, M., Aziz, T., Zahra, N., Alshammari, J., Alharbi, M., and Al-Asmari, F. (2025). Effect of multigrain flour mixes on the physicochemical, nutritional, textural, and sensory quality of cake rusks. *Italian Journal of Food Science.* 37. 261-275.

Uday, S. and Högler, W. (2020). Nutritional rickets & osteomalacia: A practical approach to management. *Indian Journal of Med Research.* 152(4):356–367

Udeh, H. O., Duodu, K. G. and Jideani, A. I. O. (2017). Finger millet bioactive compounds, bioaccessibility, and potential health effects — a review. *Czech Journal of Food Science*, 35(1): 7–17

Ugressa, L. (2023). Review on Cowpea Production, Utilization and Research Achievements in Ethiopia. *International journal of Advanced Researches in Biological Sciences*. 10(1): 172 -180. DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.01.014.

USDA, (2008). World agricultural supply and demand estimates. Agricultural Marketing Service Farm Service Agency, Washington, D.C. USA. 624p.

Usman, G. O. (2009). Production and evaluation of breakfast cereals from blends of African yam bean *(Sphenostylis stenocarpa),* Maize (Zea mays) and defatted coconut (Cocos nucifera). 11(2): 054-063.

Vadivel, V. and Pugalenthi, M. (2008). Effect of various processing methods on the levels of antinutritional constituents and protein digesibility of *Mucuna pruriens* (L.) Dc. var. utilis (wall.Ex wight) baker ex burck (velvet bean) seeds. *Journal of Food Biochemistry,* 32:795-812.

Waghorn, G. (2008). Beneficial and detrimental effects of dietary condensed tannins for sustainable sheep and goat production—progress and challenges. *Animal Feed Science and Technology*. 147: 116-139.

Waugh, A. and Grant, A. (2022). Ross & Wilson Anatomy and Physiology in Health and Illness. Edinburgh. Elsevier. 14: 273-277.

Weaver, C. M. and Kannan, S. (2002). Phytate and mineral bioavailability. In: Reddy, N.R.and Sathe, S.K.(Eds.). Food phytates. CRC Press, Florida, USA. 223.

Wikipedia (2024). Rice. https://en.m.wikipedia.org/wiki/Rice.

Woodward, S. L., Waghorn, G. C., Watkins, K. A. and Bryant, M. A. (2009). Feeding birdsfoot trefoil (Lotus corniculatus) reduces the environmental impacts of dairy farming. NZSAP. 69:179-183.

World Health Organisation (2011). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. https://www.who.int/vmnis/indicators/haemoglobin.pdf

World Health Organization (2023). Malnutrition. Fact Sheet. https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/child-mortality-and-causes-of-death.