Proximate, microbiology and nutritive properties of wheat-mango flakes

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Abstract

In this study, the proximate composition, microbiological, and nutrition evaluation of wheat-mango flakes was studied. A preliminary research work was done to ascertain the optimum acceptable levels of mango pulp addition to wheat flake production using 0 to 80 % (w/v) of wheat and mango pulp. Sensory evaluation was done and the most accepted flake samples were selected. Consequently, in the main research, the level of mango pulp was varied in a ratio of 0 to 50 giving rise to a total of five (5) samples. Proximate composition and microbiological analyses were done using standard analytical methods; furthermore, nutritive composition of the resultant flakes was also done using standard analytical procedures. The Flakes from 50:50 W: M had the highest protein content 14.4±0.02 %. The feed conversion efficiency (FCE), protein efficiency ratio (PER), net protein ratio (NPR), and apparent digestibility (AD) increased with the incorporation of mango pulp, yeast and mould counts ranged from 4 to 23 Cfu/g with 50:50 W: M having the highest count of 23 Cfu/g.

Keywords: flakes, wheat, mango

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Introduction

Wheat flakes are delicious and nutritious whole grain hot cereals that are easy to prepare. Flakes are made from the highest quality steamed, dried, and flattened whole grain wheat. Wheat flakes has a mild, nutty flavor and it is a good source of dietary fiber.[1] The flakes also add desirable texture to baked goods. Wheat flakes are similar to corn flakes, but are made of whole wheat and wheat bran. Whole wheat are rolled and made into flakes which helps retain their fiber content along with other vital nutrients. Wheat flakes are a healthy and popular breakfast cereals originally manufactured by Kellogg's through the treatment of whole wheat grains. Wheat flakes are also fortified with other nutrients like iron, calcium, and fiber etc. Wheat bran is commonly added to enhance the nutritional value of wheat flakes. These flakes provide the value of all parts of the grain and only suffer a slight nutritional loss from heating. They may be eaten after soaking or cooking in milk or vegetable broth. They form part of the famous *muesli* breakfast food.[2]

Wheat flakes are cold breakfast cereals that are low in calories but rich in nutrients, such as vitamins and minerals. Wheat bran flakes are distinct from other breakfast cereals because there are relatively low in sugar and rich in fiber that can be beneficial for overall health. Additionally, the nutritional profile of wheat flakes may encourage weight loss. Other grains that are processed in a similar manner to produce flakes are rye, oats, spelt, and kamut.[3]

Apart from satisfying the taste buds of consumers, it is a good source of vitamins, minerals, folate, dietary fiber, protein, and carbohydrates. Flakes are good sources of folate, beneficial for the formation of new cells, and help in preventing birth defects, colon cancer, and heart diseases.[4] Thiamine is good for carbohydrate metabolism, energy production, and cognitive function. Wheat flakes are also rich in fiber which helps to reduce cholesterol constipations and the risk of colon cancer. The very low saturated fat contents and gives a good satiety. Wheat flakes have no cholesterol. Low cholesterol reduces the risk of heart attacks and heart disease.[4] The flakes have very high iron content. Iron is a main component of hemoglobin. A high iron diet is needed to maintain healthy blood levels which helps keep the brain alert. When wheat flakes are consumed with milk, they provide a high protein rich food. Protein is essential to the structure of red blood cells for the proper functioning of antibodies, resisting infections, and for the regulation of enzymes and hormones for the growth and repair of body tissues.[4] However, whole wheat products have low contents of vitamin C, carotenoids, and essential minerals. Because of these limitations, wheat products require fortification and complementation for balanced diets. This can be achieved using mango fruits.

Mango fruits contain amino acids, carbohydrates, fatty acids, minerals, organic acids, protein, and vitamins and rich in ascorbic acid (vitamin C). Ripe mangoes contain moderate levels of vitamin C, other essential vitamins, and minerals but are fairly rich in pro-vitamin A,[4] information on the production of flakes from mango puree and wheat is limited hence this study seeks to produce wheat-mango flakes and verify the qualities with the purpose of increasing utilization of the raw materials and minimizing wastes.

Materials and methods

Procurement of raw material

Wheat grains and firmly riped mango fruits (*Mangifera indica)* (Julie and peter varieties) were purchased from Makurdi Modern market, Benue state. Nigeria.

Equipments used

Oven ,weighing balance, rolling pins, trays, drum dryer, milling machine, blender, knives, spatula, packaging material, conical flakes, beaker, measuring cylinder, distillation apparatus, soxhlet apparatus, desiccators, crucibles, digestion flask.

Reagents were used for analysis

Concentrated Tetraoxo sulphate IV, Toluene, distilled water, Diethyl ether, NaOH solution, Sodium sulphate ($NaSO_4$), Copper Sulphate ($CuSO_4$),

Sample preparation

Preparation of wheat flour

The wheat grains were prepared as shown in Figure 1. Essentially; the grains were sorted and washed with tap water followed by draining. The clean grains were then precooked, boiled in a water bath

maintained at 92 ^{0}C for 10 min, and then drained for 20 min followed by drying in an electric oven (Uniscope sm N9053 laboratory Oven) at 70 ^{0}C for 1 hour. After allowing to cooling, the grains were milled using a milling machine and sieved to pass through a 0.5 mm mash.

Preparation of mango fruit pulp

Firmly ripe mango fruit (*Mangifera indica*) was prepared using the traditional method of precleaning including sorting, hand-picking, and washing which helps to remove sand and any foreign matter that can contaminate the fruit. The fruits were peeled, and the mesocarps milled into pulp; as shown in Figure 2. The blend formulation is shown in Table 1. The production of flakes was done following the method as described by Enenche[1] with some modifications as shown in Figure 3.[1]

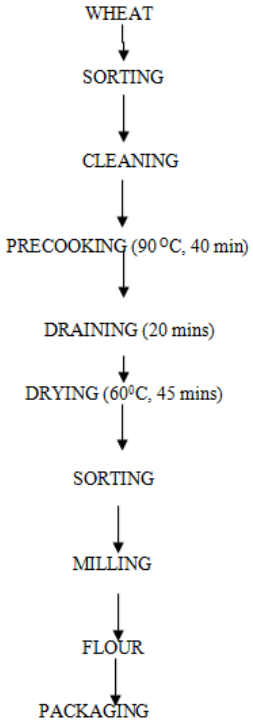

Figure 1 Production of Wheat Flour.

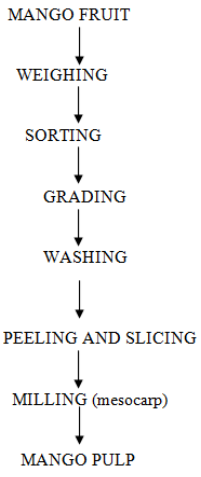

Figure 2 Production of Mango Pulp.

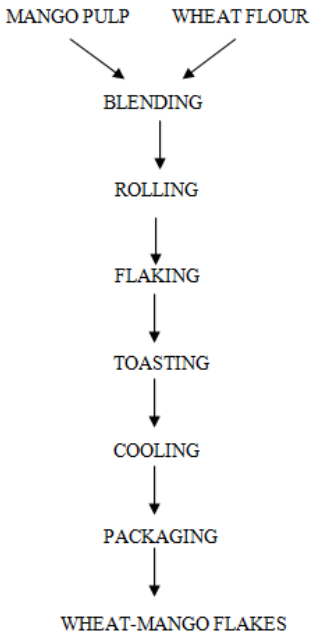

Figure 3 Production of Wheat-mango flakes.

Table 1 Formulation of blends

Wheat flour (%)	Mango pulp (%)
100	0
90	10
80	20
70	30
60	40
50	50

Methods of analysis

Proximate composition

Determination of moisture content

Moisture content was determined by the method described by AOAC (2012). Cleaned crucibles were dried in a hot air oven at 150 ^{0}C for 3 hours to obtain a constant weight and then cooled in a dessicator. Afterwards, 2 grams of each of the samples was weighed into different crucibles in duplicates and dried at 100 ^{0}C until constant weights were obtained. The loss in weight from the original weight (before heating) was reported as the moisture content.

$$\%\ moisture\ content\ =\ \frac{W_3 - W_1}{W_2} \times 100$$

Where W_1= initial weight of the empty crucible

W_2= weight of dish + sample before drying

W_3= weight of dish + sample after drying

Determination of crude fat

The fat content of the sample was determined by Soxhlet extraction method.[5] Extraction flask was weighed, two grammes (2g) of each sample were weighed into a filter paper and introduced into the extraction thimble. The thimble was placed into the soxhlet extractor; some quantity of petroleum ether was placed into the flask

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and connected to the soxhlet apparatus. The extraction lasted for about 6 hours at 40-60 ^{0}C after which the solvent (Petroleum ether) was recovered leaving only the extract in the flask. The extract was dried at 100 ^{0}C to expel the remaining solvent, and then cooled in the desiccators, and weighed. The weight of the flask and sample were noted. The percentage crude fat was calculated using:

$$\%\ fat\ = \frac{(weight\ of\ flask\ +\ oil)\ -\ (weight\ of\ flask)}{Weight\ of\ sample} \times 100$$

Determination of protein

Protein was determined by the automated micro-Kjeldahl method described by AOAC.[5] One gram of each sample was weighed into the micro- Kjeldahl flask and 20 ml concentrated H_2SO_4, 2g Na_2SO_4, 0.5 $CuSO_4$ (as catalyst) and 0.1 g selenium were added in the flask. The mixture was heated in a digester until the black solution became clear, after which it was made up to 100ml with distilled water. About 5 ml samples were drawn from the solution and subjected to steam, boric acid, blue methyl, and red methyl. The end product was titrated with 0.01 M HCl. The percentage nitrogen was obtained from the formula:

$$\%\ Nitrogen\ = \frac{Titre\ x\ M\ x\ DF\ x\ NWN\ x\ 100}{Weight\ of\ samples\ in\ Mg}$$

Titre = Final burette reading - Initial burette reading

M = Molarity of acid

DF = Dilution factor

NMN =Molecular weight of nitrogen.

Percentage protein = % Nitrogen x 6.25 (conversion factor)

Determination of total ash

The ash content was determined using the official method of the AOAC.[5] Two grammes (2 g) of each sample were weighed into a weighed crucible and incinerated in a muffle furnace at 600^{o}C for about 6 hours. The crucible was removed and cooled in a desiccator and reweighed. The weights of the crucible and sample were noted.

$$\%\ Ash\ content = \frac{(Weight\ of\ crucible\ +\ Ash)\ -\ (Weight\ of\ crucible)}{Weight\ of\ sample} \times 100$$

Determination of crude fiber

The method of AOAC[5] was used. Two grammes (2g) of the defatted samples were hydrolyzed in a beaker with 200 ml of 1.25 % H_2SO_4 for 30 minutes, and then filtered under suction, washed with hot distilled water and boiled again for another 30 minutes with 200ml of 1.25 % NaOH. The digested samples were washed with 1% HCl to neutralize the NaOH with hot distilled water. The residue collected was put into a weighed crucible and dried at 100 ^{o}C for 2 hours in an air oven. It was cooled and weighed. The ash was cooled and weighed. The % crude fibre was calculated using the expression:

$$\%\ crude\ fibre\ = \frac{loss\ in\ weight\ after\ ignition}{Weight\ of\ sample} \times 100$$

Determination of carbohydrate

The total percentage carbohydrate content was determined by the difference as reported by Ihekoronye and Ngoddy.[6] This method involved adding the total values of crude protein, lipid, crude fiber, moisture, and ash constituents of the sample and subtracting it from 100. The value obtained was the percentage carbohydrate constituent of the sample.

Thus, % carbohydrate = 100 – (% moisture + % crude fiber + % protein + % lipid + % ash)

Determination of energy content

The energy content of the sample was determined by using the at water factor where 4, 9, and 4 multiplied the values of crude protein, fat, and CHO, respectively, and their products summed. The result was expressed in kilocalories per 100g.

Energy value (kcal/100 g) = [(Available CHO x 4) + (%fat x 9) + (%protein x 4)]

Functional properties determination

Determination of bulk density

The bulk density was determined according to the method of Obiakor.[3] A calibrated measuring tube was weighed and the samples were filled to 10ml with constant tapping until there was no further change in the volume. The content was weighed and the volume taken. Bulk density is calculated as:

$$Bulk\ density\ (g/ml)\ =\ \frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ after\ tapping\ (ml)}$$

Nutritional evaluation (feeding trials)

The nutritional qualities of the wheat-mango flakes were evaluated following the method described by Pellet and Young.[7] Flakes were evaluated based on the growth performance of animals (feeding trials) as described by Pellet and Young.[7] Each product was used with a basal diet to formulate a test diet containing 10 % protein. The basal (protein free) diet was used as the control. A 21 day feeding experiment was performed using 32 weanling male albino rats after 4 days feeding on a commercial starter feed for acclimatization. The animals were randomly distributed into 8 metal cages with 4 rats per cage. Each group was fed with a given diet. Weights of the rats and food consumed were taken daily for the first seven (7) days, then at 7 days intervals for the remaining 14 days. Cages were placed on card board papers to enable the collection of faces. Faeces was collected daily for the last seven days and stored in a freezer. The feaces for each group were pooled together, thawed, and air-dried. Weighed ground and nitrogen content were determined by standard Kjeldahl method.[5] The data collected from the feeding trials were used to compute the Protein Efficiency Ratio (PER), Relative Protein Efficiency Ratio (RPER), Net Protein Ratio (NPR), Relative Net Protein Ratio (RNPR) and Apparent Digestibility (AD) as reported by Bender and Bender and Rasco as follows:

$$PER = \frac{Weight\ gain\ of\ test\ animals}{Protein\ consumed}$$

$$RPER = \frac{PER\ of\ test\ protein}{PER\ of\ casein}$$

$$NPR = \frac{Average\ weight\ gain\ of\ test\ animals\ +\ Average\ weight\ loss\ of\ control\ animal}{Protein\ consumed\ by\ test\ animals}$$

RNPR= NPR of test protein expressed relative to a value of 100 for NPR of the reference protein

$$AD = \frac{Nitrogen\ in\ feed\ -\ Nitrogen\ in\ Feaces}{Nitrogen\ in\ feed} \times 100$$

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Microbiological analysis

Determination of total viable counts (pour plate method)/yeast and mould

The method described by Potter and Hotchkiss[7] was used. By this procedure, 1 gram of the sample was homogenized with distilled water. This was used for serial dilution by taking 1 ml of the test sample to the first tube containing 9 ml of the diluents. Using another pipette, 1 ml from the first dilution was transferred into the 2nd tube of sterile diluents. This was repeated in another 2 test tubes forming a serial dilution. The pipette was subsequently used to transfer 1ml of each of the dilutions into sterile petri dish containing 10-15 ml of molten agar tempered at 45 ^{0}C and the medium immediately mixed carefully. The plate was allowed to set, then invented and incubated at 37 ^{0}C for 48 hours. A dilution which yields less than 300 colonies per plate was selected and counting was done using a colony counter.

Results and discussions

The crude fat contents of the flakes were 0.5±0.03 %, 0.56±0.03 %, 0.9±0.02 %, 1.0±0.21 %, 1.2±0.01 % and 1.38±0.10 % for 100:0, 90: 10, 80:20, 70:30, 60:40 and 50:50W:M respectively. Flakes from 50:50 W: M had the highest protein content 14.4±0.02 %, The moisture content ranged from 4.46±0.01 to 5.05±0.01 %, with the highest and lowest value observed in 100:0 W:M and 50:50 W:M respectively as the blend increases. This increase in moisture content shows the certainty of a prolonged shelf life of the wheat mango flakes and besides, the range of moisture content implies that the flakes had a good storage potential since it is known that the moisture and water activity of the product determines greatly the keeping quality of the flakes and this low moisture is as a result of the drying process during production. This is similar to the work carried out by Kellogg.[8]

The crude fat content of the flakes ranged from 0.5±0.03 to 1.25±0.10 %, this slight increase in fat may be attributed to the fat content of the wheat flour, but although the values are minimal since less fat content implies the consumption of fewer calories which is beneficial from the health standpoint as obesity, coronary heart diseases and other illnesses attributed to consumption of too much fat could be minimized.[9] Moreover, low fat food products are less susceptible to rancidity and hence more shelf stable. Dietary fats that provide essential fatty acids (EFA) have been shown to enhance the taste and acceptability of foods slow down gastric emptying and intestinal motility, thereby prolonging satiety and facilitating the absorption of lipid-soluble vitamins. The lipid component also helps to determine the texture, flavor, and aroma of foods.[6]

There is a slight increase in the protein content with the increase in the blends. This could be attributed to the protein content of the mango pulp (Table 3) and hence protein is an important component that determines the rheological properties of the wheat mango flakes. This equally enhances body growth, repair of worn-out tissues of the body of both adults and children, including the diabetic patients. Sample 50:50 had the highest protein content, 14.4±0.02% greater than sample 10:0 W: M.

The results obtained for ash content showed a significant difference ($p<0.05$) among flakes samples. Values increased with increase in the blends suggesting that the flakes are high in minerals which is in agreement with Kellogg's wheat flakes. This increase will improve the nutritive value of the flakes and will be an advantage in the preparation of weaning food formulations and can also contribute to the dietary intake of the consumers or serve as a special diet/meal.

The crude fiber content of the flakes ranged from 0.92±0.02 to 2.3±0.02 %. Samples had dissimilar crude fiber characteristics and were significantly different ($p<0.05$) from each other. Crude fiber is essential in adding bulkiness to food and for the prevention of some diseases of the colon.[9] Fiber is important for the removal of waste from the body, thereby preventing constipation and many health disorders. Consumption of vegetable fiber has been shown to reduce serum cholesterol levels, risk of coronary heart disease, colon and breast cancers, and hypertension, enhance glucose tolerance, and increase insulin sensitivity (Hassan and Umar, 2004). As a result, CODEX associated dietary fiber with properties such as decreased intestinal transit time and increase in stools, bulk, fermentable colonic micro flora, reduced blood total cholesterol levels and reduced postprandial blood glucose and insulin levels.[9] The flakes therefore have a great potential for application as diabetic food because of their fiber source.

The carbohydrate contents of the flakes ranged from 80.9±0.07 to 76.2±0.08% This implies that the flakes are good sources of energy needed for body metabolism and might find application in food formulation for diabetics and hypertensive patients requiring low sugar diets. This is also similar to the work of Oladunjoye et al.[10]

Nutritive values of flakes

As expected, the basal diet had the lowest values which are mostly negative. FCE varied from 4.2±0.04 (100:0W: M) to 3.17±0.01 (50:50W: M) relative to 4.2 for case in reference diet. PER ranged from 2.12 (100:0: W: M) to 2.31 (50:50W: M) compared to 2.42 for casein. NPR was 1.6 for casein and varied from 1.00 (100:0 W: M) to 1.50 (50:50 W: M). Apparent digestibility improved from 83.6 (100:0, W: M) to 92:00 % (50:50 W: M) with casein having a value of 87.03 %. The protein content of the flakes increased slightly in the product as a result of the mango pulp added, and this improved the feed efficiency ratio (FCE), protein efficiency ratio (PER), net protein ratio (NPR), and apparent digestibility (AD) of the wheat mango flakes. These improvements can be attributed to textural modifications and higher nutrients retention in the flakes containing mango pulp.[11]

Microbiological examination

The microbial loads of flakes from wheat and mango pulp recorded values of 15, 13, 12, 14, 12, and 11 Cfu/g for 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. The yeast and mould counts ranged from 4 to 23 Cfu/g with 50:50 W: M having the highest count of 23 Cfu/g. Lower total viable counts recorded in wheat mango flakes can be attributed to both the good manufacturing practices and the effect of drying on the sample. This moisture content in the sample makes less water available for microbiological and biochemical activities. Robertson[12] in a study on Food Packaging principles reported that low moisture content affects the microbial load as fewer microbes would be detected. Robertson[12] concluded that dehydrated products have low microbiological load.

Conclusion

The investigation into the possible use of a combination of wheat flour and mango fruit pulp for the preparation of flakes has revealed the possibility of good supplementation of mango pulp in terms of protein quality and mineral quality. Wheat-mango flakes have significantly increased protein and ash contents in the blend ratio of wheat: mango 50:50. Fat and fiber contents were similarly increased. Values obtained from the rat feeding trials indicated the flakes are a good source of protein, as PER and NPR were within the acceptable threshold. Microbiological analysis showed acceptable values for TVC and fungal count.

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None.

Conflicts of interest

The author declares no conflicts of interest.

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