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Research Article

Millet Flour Potential in Enriching Wheat Flour for Biscuit Production

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Abstract

This study investigated the potential of millet flour in enriching wheat flour for biscuits production. Millet grain was processed into flour and used to substitute wheat flour at different proportions of (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100). The functional properties of the flour blends were determined. The composite flour was thereafter processed into biscuit and the proximate composition and sensory properties of the biscuits were determined. The water absorption capacity ranged from 1.23 ml/g - 1.75 ml/g, swelling index ranged from 0.26 ml/sec - 1.92 ml/sec, foam capacity ranged from (5.25 ml/sec - 33.00 ml/sec), bulk density ranged from (0.36 - 0.73 g/ml), oil absorption capacity ranged from (0.74 ml/g - 1.28 ml/g), emulsion capacity ranged from (1.57 ml/g - 2.35 ml/g), gelation temperature ranged from (63.00°C - 75.00°C), viscosity ranged from 6.83 - 8.35 RUV. The proximate composition of the biscuit samples with values ranging from 11.35 - 12.93%, 0.21 - 1.33%, 18.41 - 23.30%, 5.20 - 6.75%, 1.93 - 2.19%, 56.63 - 58.79% for protein, fiber, fat, moisture, ash and carbohydrate respectively were obtained. There were significant differences ($P \leq 0.05$) in sensory attributes of the biscuit samples parameters measured. The biscuit of acceptable quality comparable to the 100% wheat flour biscuit was obtained from wheat-millet composite flour with up to 40% millet substitution. The use of millet in biscuit making would greatly enhance the utilization of the crop and reduce dependency on wheat importation thereby reducing the cost of production.

Keywords: *Biscuits; Composite; Functional; Millet; Proximate*

Introduction

Biscuits is an unleavened crisp, sweet pastry made from wheat flour, shortening (hydrogenated fat) and sugar, and is usually made light by the addition of baking powder [1]. It constitutes major component of human snacks in most parts of the world [1]. Generally, the name biscuit is used in European countries and cookies in the USA [2]. Biscuit and biscuit-like products have been made and eaten by man for centuries [2]. Flour used in biscuit making is made from wheat or composite flour [3]. Biscuit can be made from hard dough e.g. crackers, hard sweet dough e.g. rich tea biscuit or soft dough e.g. shortbread and short cake [3]. It is produced by mixing various ingredients like flour, fat, sweeteners and water to form dough [3]. In many countries biscuits are prepared with fortified or composite flour to increase their nutritive value [4].

Biscuits are ideal for nutrient availability, palatability, compactness and convenience. They differ from other baked foods like bread and cakes because they have low moisture content making them comparatively free from microbial spoilage and increasing the shelf life of the product (Hanan and AL- Sayed, 2013). They are rich source of fat, protein and carbohydrate; hence they provide energy and also a good source of minerals [5]. They can be served with soft drinks or tea and taken between meals like any other snack. Recently, the consumption of wheat increased considerably in Nigeria [6] and other African Countries [7]. This increase in wheat consumption is due to the increase in population and urbanization in these Countries which caused the change in preference for convenient foods particularly snacks (Siebel, 2006).

Millets are a group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. Millets are important crops in the semiarid tropics of Asia, and Africa (especially in India, Nigeria, and Niger), with 97% of millet production in developing countries [8]. The crop is favored due to its productivity and short growing season under dry, high-temperature conditions. Millets have been important food staple in human history, particularly in Asia and Africa. They have been in cultivation in East Asia for the last 10,000 years [8]. They are nutritious compared to the major cereals such as rice and wheat [9]. They contain low phytic acid and are rich in dietary fiber, iron, calcium and B vitamins [9].

Conventional flours are known to play important functional roles in food systems. However, the rising cost has resulted in the search for the alternative replacement to fully or partially substitute the conventional flours with non-conventional in foods [10]. The use of composite flours in bread making has been reported by many researchers. The research workers were able to obtain acceptable bread samples with up to 15% supplementation of wheat with plantain. A substitution of up to 15% of composite flour in the production of baked products will go a long way in reducing cost and enhance utilization. Composite flour simply refers to the mixture of different concentration of non-wheat flour from cereals, legumes, roots and tubers with wheat flour or can be a mixture of flours other than wheat flour [11]. This was also agreed by Shittu., *et al*. [6] that composite flour is either a mixture of binary flours or ternary flours from some other crops with or without wheat flour.

In Nigeria, biscuit consumption is continually growing and there has been an increasing reliance on imported wheat [12]. Biscuit produced from wheat contains lesser amount of proteins than required and lacks certain amino acids as Lysine and Tryptophan [13]. This can cause malnutrition, food insecurity and deficiency of micronutrients; also the consumption of gluten which is common in wheat biscuits can cause celiac disease. Therefore, the objectives of this study are to determine the functional properties of wheat-millet composite flour; determine the proximate properties of wheat and millet flours; and evaluate the proximate and sensory properties of biscuits made from wheat-millet composite flour. Due to high cost of wheat importation, it is therefore of economic importance if wheat importation is reduced by substitution with other locally available materials such as cassava, maize, potato, millet and other carbohydrate and rich protein flours. It is expected that the success of this present study will serve as a basis for creation of other varieties of biscuits. People affected by gluten related disorders, such as celiac disease, non-celiac gluten sensitivity and wheat allergy sufferers, who need a gluten-free diet, can replace gluten-containing cereals in their diets with millet.

Materials and Methods

Source of material

Millet used in the research work was collected from the Department of Food Science and Technology, Federal University of Technology Owerri. The wheat flour, milk, sugar, egg, salt, margarine and baking powder were purchased from Ekeonunwa Market in Owerri Metropolis, Imo State.

Methods

Sample preparation

Millet was processed into flour according to the method of Jideani [13]. Two kilograms 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 washed and dried at 50°C for 24h in an oven. The grains were then reduced to powder using a hammer mill (driver model: De-Demark super) and sieved through 4.25 μm sieves. The flow diagram for the preparation of millet flour is shown in figure 1.

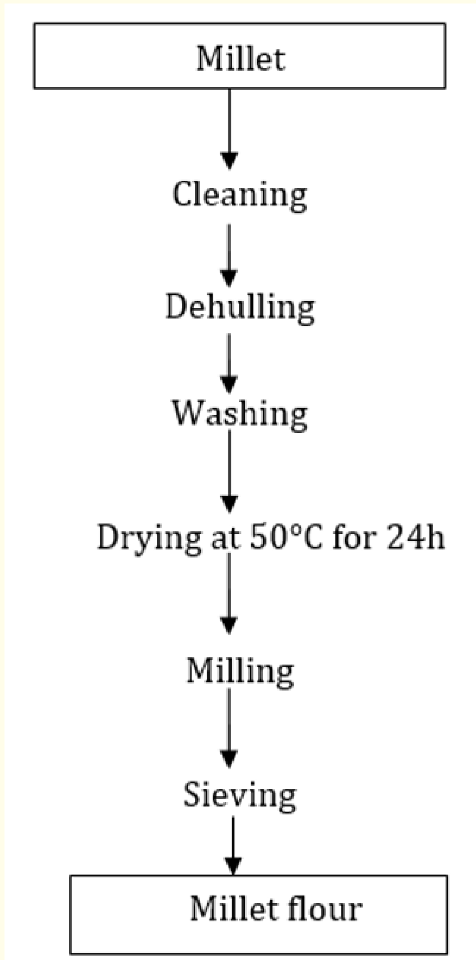

Figure 1: *Flow diagram for the processing of millet into flour [13].*

Formulation of composite flour

Composite flours of wheat and millet were formulated with the ratios as shown in table 1 below. 100% wheat flour and 100% millet flour were used as control.

Biscuit production

The formulated composite flour samples, the 100% wheat flour and millet flour (control) were respectively used in producing biscuits, using standard recipes as shown below in table 2.

Samples	Wheat Flour (%)	Millet Flour (%)
W_1	100	-
WM_1	90	10
WM_2	80	20
WM_3	70	30
WM_4	60	40
WM_5	50	50
WM_6	40	60
WM_7	30	70
WM_8	20	80
WM_9	10	90
M_1	-	100

***Table 1**: Formulation of composite flour.*

Ingredients	Proportions (g)
Flour	200
Sugar	50
Salt	1.5
Fat	80
Baking powder	1.3
Water	15 ml
Egg	1 piece
Milk powder	5
Vanilla powder	5

***Table 2:** Ingredients for biscuit making [14].*

The method of Ihekoronye [14] was used as shown in figure 2. The different flours were sieved using a fine sieve to remove coarse particles and to get a uniform particle size. Using the robbing method, fat, milk and salt were added and robbed for 30s in a plastic bowel already containing the flour and baking powder. In a separate bowl, egg, sugar and water were mixed and added to the flour based mixture and kneaded to form dough. Dough was rolled into a uniform thickness of about 3 - 5 mm with the use of a rolling pin and board. Finally, the dough was cut-out using a hand-cutter, baked, at 200°C for 15 minutes and allowed to cool.

Analyses

Proximate analysis of flour and biscuit samples

The proximate composition (crude protein, crude fat, crude fiber, carbohydrate and moisture) of the flour and biscuit samples were determined using the method described by Association of Official Analytical Chemists [15].

Determination of functional properties of the flour samples

The functional properties of wheat and millet flour composites were determined using the following methods.

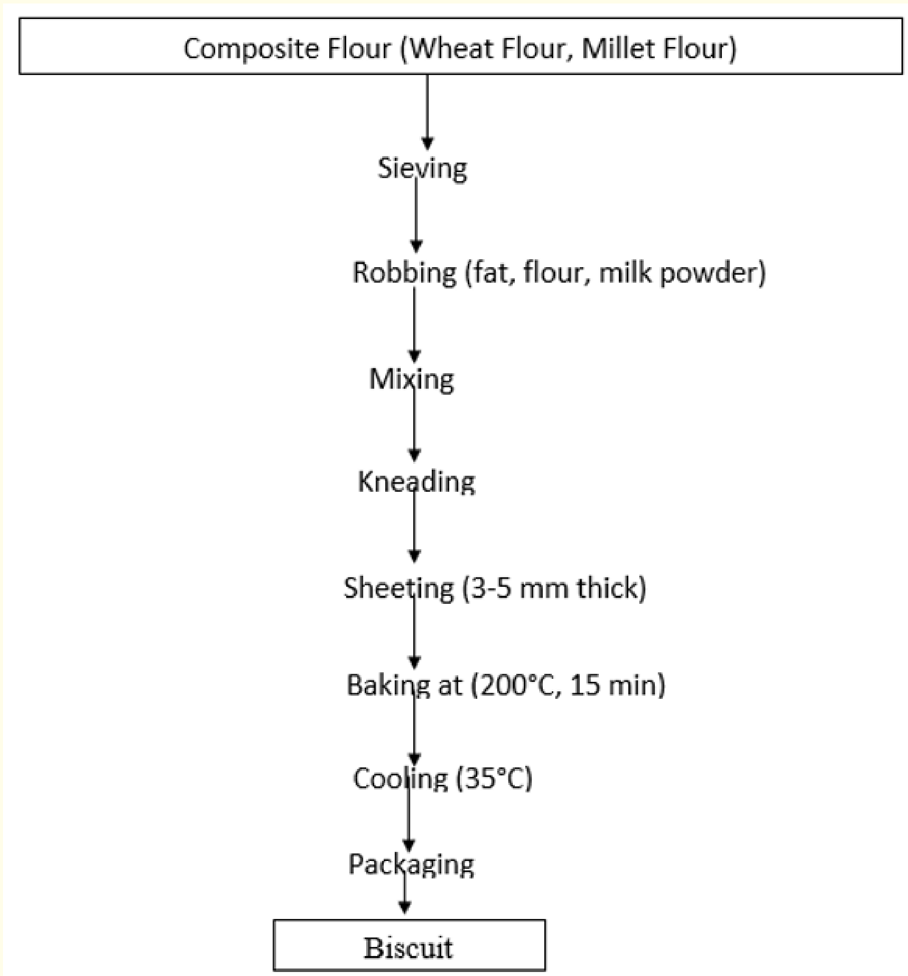

Figure 2: *Process flow for the production of biscuit [14].*

Water/oil absorption capacity

The A.O.A.C [15] method was used. From each sample, one (1) gram was weighed into a conical graduated flask and 10 ml of water or oil was added to the weighed sample. The sample was then transferred to a graduated centrifuge tubes and centrifuged at 500 rpm for 30 minutes. After then, the mixed sample was transferred from the graduated tube into a 10 ml measuring cylinder to know the volume of the free water/oil. The absorption capacity was expressed as gram of oil or water absorbed per gram of sample.

Calculation: water/oil absorption capacity of the sample was calculated as;

$$\text{Water/oil absorption capacity} = \frac{(\text{Volume of oil/water used - volume of free oil/water}) \text{ X } 100}{\text{Weight of sample 1}}$$

Gelatinization temperature

The method of Narayana and Narasinga-Rao (1982) was adopted in the determination of gelling temperature. Ten (10) gram of the flour sample was dispersed in distilled water in a 250 ml beaker and made up to 100ml flour suspension. A thermometer was clamped on a retort stand with its bulk submerged in the suspension with a magnetic stirrer and the system heated. The heating and stirring continued until the suspension began to gel and the corresponding temperature was recorded. The temperature at boiling point was recorded.

Emulsion capacity

The AOAC [15] method was used. From each sample, two (2) gram was blended with 25 ml of distilled water at room temperature for 30s in a warring blender at 1600 rpm. After complete dispersion, 25 ml of vegetable oil was gradually added and the blending continued for another 30s. Then the mixture was transferred into a centrifuge tube and centrifuged at 1600 rpm for 15 minutes. The volume of oil separated from the sample was read directly from the tube after centrifuging.

Calculation: The emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample.

i.e. emulsion capacity = $\frac{x}{y}$ x 100

Where x = height of emulsified layer

y = height of the whole solution in the centrifuge tube

Bulk density

The method of Nwosu [3] was used. Bulk density of flour samples were determined by weighing the sample (50g) into 100 ml graduated cylinder, then tapping the bottom ten times against the palm of the hand and expressing the final volume as g/ml.

Swelling index determination

Three (3) gram of the flour sample was transferred into clean, graduated (50 ml) cylinder and the volume noted. Distilled water (30 ml) was added to the flour samples; the cylinder was swirled and allowed to stand for 60min while change in volume (swelling) was recorded every 15 minutes. The swelling power of the sample was calculated as a multiple of the original volume as done by Ukpabi and Ndimele [16].

Foaming capacity and stability

Foaming capacity and stability of the flour samples were studied according to the methods described by Onwuka [17]. For foam capacity and stability, the flour sample (0.5g) was blended for 30 minutes in distilled water (40 ml) at top speed in a blender. The whipped mixture was transferred into 100 ml graduated cylinder. The blender was rinsed with 10 ml distilled water and then gently added to the graduated cylinder. volume of foam (ml) after mixing was expressed as the foam capacity while volume of foam at 30 minutes and 60 minutes after shaking was used as indicator of foam stability. Duplicate measures were taken for each sample and mean value recorded.

pH

The pH of the flour samples was measured by a 10% (w/v) dispersion of the samples in distilled water. Each suspension was mixed thoroughly and a standard pH meter (Hanna meter model H196107) was used for pH determination. The pH electrode was dipped into the solution and after a few minutes of equilibration, the pH reading of the sample was taken Onwuka [17].

Viscosity

The method of Onwuka [17] was adopted. Ten (10) gram of the flour sample was suspended in distilled water and mechanically stirred for 2h at room temperature using Oswald type viscometer to determine the viscosity.

Sensory evaluation on the biscuit samples

This was done by the method described by Ihekoronye and Ngoddy [18]. The biscuit quality was assessed by a test panel of 20 judges. Each product was evaluated by the panel of judges on a 9-point hedonic scale where '9' represented like extremely and '1' represented dislike extremely. The biscuits were evaluated for quality characteristics such as color, taste, texture, aroma, crispness, mouthfeel and overall acceptability. The scores were subjected to the analysis of variance (Anova) and the treatment means separated using fishers LSD (Least Significant Difference) test.

Results and Discussion

Bulk density

From the result obtained, it was observed that there were significant differences ($p < 0.05$) among the flour samples. The bulk density of the flour samples ranged from 0.36 g/ml - 0.73 g/ml. W_1 had the highest value (0.73 g/ml) while M_1 had the lowest value (0.36 g/ml). W_1 (0.73 g/ml) and WM_1 (0.72 g/ml) were not significantly different ($p > 0.05$) but were significantly different ($p < 0.05$) from other samples. It was observed that as millet flour increased, the bulk density value reduced. Bulk density is generally affected by particle size and the density of flour or flour blend and it is very important in determining the packaging requirement, raw materials handling and application in wet processing in food industry [7]. The low bulk density observed shows that this flour can be used for food formulations with less fear of retrogradation.

Swelling index

The swelling index of the composite flour samples ranged from (0.26 ml/sec^{-1}.92 ml/sec). There were significant differences ($p < 0.05$) among the flour samples. W_1 had the highest value of 1.92 ml/sec while M_1 had the lowest value of 0.26 ml/sec. Swelling capacity can be related to the water absorption index of the starch-based flour during heating. High swelling capacity has been reported as part of the criteria for a good quality biscuit product [19] as observed in sample W_1.

Water absorption capacity

From the result obtained, it was observed that there were significant differences ($P \leq 0.05$) among the flour samples in water absorption capacity; which ranged from 1.23 ml/g^{-1}.75 ml/g. It was observed that water absorption capacity values increased gradually with an increase in the substitution of millet flour. This could be indicative of the fact that addition of millet at higher rate confers high water binding capacity to wheat flour, which in turn improves the reconstitution ability [7]. M_1 had the highest value (1.75 ml/g) and W_1 had the lowest value (1.23 ml/g). High water absorption capacity is attributed to the loose structure of starch polymers while low values indicate the compactness of the structure [7].

Functional properties of the composite flour samples

The result of the functional properties of the flour samples are shown in table 3.

Oil absorption capacity

From the result obtained, there were significant differences ($P \leq 0.05$) among the composite flour samples. The values ranged between (0.74 ml/g) and (1.28 ml/g). Sample M_1 (100% millet flour) had the highest value (1.28 ml/g) and sample W_1 (100% wheat flour) had the lowest value (0.74 ml/g). It was observed that as millet flour is increased, the oil absorption capacity also increased. The possible reason for increase in the oil absorption capacity of the flour sample is the variations in the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours. Similar findings were observed by Kaushal., *et al* [20]. However, the flour in this present study are potentially useful in structural interaction in food especially in flavor retention, palatability improvement and extension of shelf life particularly in bakery or products where fat absorption is desired [21].

Sample	Viscosity (RUV)	Bulk density (g/ml)	Gelatinization temperature (^{0}C)	Water absorption capacity (ml/g)	Oil absorption capacity (ml/g)	Emulsion capacity (ml/g)	Swelling index (ml/sec)	Foam capacity (ml/sec)	Foam stability (ml/sec)	pH
W_1	$8.26^{a} \pm 0.37$	0.73 ± 0.04^{a}	75.00 ± 0.00^{a}	1.23 ± 0.04^{i}	0.74 ± 0.00^{f}	2.35 ± 0.01^{a}	1.92 ± 0.00^{a}	33.00 ± 0.0^{a}	10.27 ± 0.09^{a}	6.16 ± 0.03^{a}
WM_1	$8.35^{a} \pm 0.07$	0.72 ± 0.02^{a}	74.00 ± 1.41^{b}	1.30 ± 0.02^{h}	0.75 ± 0.01^{f}	2.30 ± 0.00	1.80 ± 0.00^{b}	32.16 ± 1.19^{b}	10.25 ± 0.07^{a}	6.16 ± 0.02^{a}
WM_2	$8.15^{b} \pm 0.14$	0.70 ± 0.00^{b}	74.00 ± 0.00^{b}	1.32 ± 0.05^{h}	0.81 ± 0.01^{e}	2.03 ± 0.03^{c}	1.68 ± 0.04^{c}	30.68 ± 0.95^{c}	10.23 ± 0.04^{a}	6.15 ± 0.01^{a}
WM_3	7.98 ± 0.04^{c}	0.66 ± 0.03^{c}	71.00 ± 1.41^{c}	1.40 ± 0.03^{g}	0.90 ± 0.07^{d}	1.97 ± 0.03^{d}	1.49 ± 0.01^{d}	27.97 ± 0.04^{d}	9.61 ± 0.08^{b}	6.11 ± 0.02^{b}
WM_4	7.73 ± 0.11^{d}	0.64 ± 0.02^{d}	70.00 ± 0.00^{d}	1.48 ± 0.00^{f}	0.92 ± 0.09^{d}	1.83 ± 0.04^{e}	1.25 ± 0.07^{e}	24.08 ± 0.64^{e}	9.13 ± 0.11^{c}	6.09 ± 0.01^{c}
WM_5	7.59 ± 0.15^{e}	0.58 ± 0.01^{e}	68.00 ± 1.41^{e}	1.54 ± 0.02^{e}	0.97 ± 0.03^{c}	1.79 ± 0.01^{f}	0.97 ± 0.03^{f}	20.60 ± 0.64^{f}	8.98 ± 0.04^{d}	6.09 ± 0.01^{c}
WM_6	7.38 ± 0.18^{f}	0.54 ± 0.02^{f}	67.50 ± 0.71^{f}	1.61 ± 0.02^{a}	1.21 ± 0.01^{b}	1.77 ± 0.21^{f}	0.32 ± 0.03^{g}	19.86 ± 1.45^{g}	6.50 ± 0.71^{e}	6.07 ± 0.03^{d}
WM_7	6.98 ± 0.42^{g}	0.49 ± 0.01^{g}	66.50 ± 2.12^{g}	1.65 ± 0.00^{c}	1.22 ± 0.02^{b}	1.67 ± 0.02^{g}	0.33 ± 0.04^{h}	9.78 ± 0.17^{h}	5.63 ± 0.53^{f}	6.07 ± 0.03^{d}
WM_8	6.93 ± 0.04^{gh}	0.43 ± 0.02^{h}	65.00 ± 0.00^{h}	1.69 ± 0.01^{b}	1.25 ± 0.00^{ab}	1.65 ± 0.08^{g}	0.28 ± 0.00^{i}	6.43 ± 0.67^{i}	4.64 ± 0.50^{g}	6.05 ± 0.01^{f}
WM_9	6.85 ± 0.00^{h}	0.38 ± 0.02^{i}	64.50 ± 0.71^{h}	1.73 ± 0.04^{a}	1.26 ± 0.01^{a}	1.58 ± 0.01^{h}	0.27 ± 0.01^{i}	5.53 ± 0.04^{j}	4.30 ± 0.07^{h}	6.08 ± 0.02^{e}
M_1	6.83 ± 0.04^{h}	0.36 ± 0.01^{j}	63.00 ± 1.41^{i}	1.75 ± 0.07^{a}	1.28 ± 0.00^{a}	1.57 ± 0.00^{h}	0.26 ± 0.04^{i}	5.25 ± 0.35^{j}	4.03 ± 0.04^{i}	6.04 ± 0.01^{g}
LSD	0.09	0.01	0.74	0.02	0.03	0.02	0.03	0.54	0.21	0.01

Table 3: *Mean values of functional properties of composite flour samples.*

Means of duplicate determination, means with different superscripts down the column are significantly different ($p \leq 0.05$).

Key: W_1 100% wheat, WM_1 90% wheat + 10% millet, WM_2 80% wheat +20% millet, WM_3 70% wheat + 30% millet, WM_4 60% wheat + 40% millet, WM_5 50% wheat +50% millet, WM_6 40% wheat + 60% millet, WM_7 30% wheat + 70% millet, WM_8 20% wheat + 80% millet, WM_9 10% wheat + 90% millet M_1 100% millet.

Foam capacity

From the result obtained, the value of foam capacity ranged from (5.25 ml/sec) to (33.00 ml/sec). There were significant differences ($P \geq 0.05$) among the flour samples. The highest foam capacity was observed for W_1 (33.00) and the lowest was M_1 (5.25). It was observed that as millet flour increased, foam capacity reduced. Foam is a colloidal of many gas bubbles trapped in a liquid, or solid. Akubor and Chukwu (1999) reported that foams are used to improve the texture, consistency and appearance of foods. Good foam capacity are desirable attributes for flours intended for the production of variety of baked products such as cakes, muffins, cookies, fudges, akara etc. and also act as a functional agent in other food formulations [22].

Foam satiability

From the result obtained, there were significant differences ($P \geq 0.05$) among the flour samples in terms of foam stability. The value for foam stability ranged from (4.03 ml/g) to (10.27 ml/g). The highest foam stability was observed for W_1 (10.27 ml/g) which was decreasing with an increase in millet flour and the lowest foam stability value was for M_1 (4.03 ml/g). Flour with high foaming ability could form large air bubbles surrounded by thinner or less flexible protein film. These air bubbles might be easier to collapse and consequently lower the foam stability [24]. Foam stability is important since the usefulness of whipping agents depends on their ability to maintain the whip as long as possible. And it was observed that M_1 (4.03) had poor foam stability, it might be a poor foaming agents in foods requiring foamability.

Gelatinization temperature

The mean value for gelation temperature of the flour samples ranged from (63.00°C) to (75.00°C). There were significant differences ($P \leq 0.05$) among the flour samples. Highest gelation temperature was found to be W_1 (75.00) which decreased with an increase in millet flour and the lowest was M_1 (63.00). Gelation capacity of flour is influenced by physical competition for water between protein gelation and starch gelatinization [20]. From the results obtained, it showed that the flour samples have good gelling properties and could be useful in food formulation and pasta production.

Viscosity

From the results obtained for viscosity, there were significant differences ($P \leq 0.05$) among the flour samples, with sample WM_1, having the highest value (8.35 RUV) and M_1 having the lowest value (6.83 RUV). Viscosity is an index of the ability of starch-based food to swell freely before their physical break down [24]. There was a decrease in the values of viscosity as proportion of millet increases. High viscosity indicates high starch content and this could explain why WM_1 had the highest mean value while M_1 had the lowest mean value. High viscosity will be more stable under certain conditions as observed in WM_1 than other flour samples [25].

Emulsion capacity

From the result obtained, the value for EC ranged from (1.57 ml/g) to (2.35 ml/g). W_1 had the highest value (2.35) and M_1 had the lowest value (1.57). Emulsion capacity is enhanced by high value as observed in sample W_1. Emulsion stability can be greatly increased when highly cohesive films are formed by the absorption of rigid globular protein molecules that are more resistant to mechanical deformation.

pH

From table 3, it was observed that there were significant differences ($P \geq 0.05$) among the p^H of the flour samples. pH fell within the neutral range. There were no significant differences ($P \geq 0.05$) among samples W_1, WM_1 and WM_2 with values of 6.16, 6.16 and 6.18 respectively, but they were significantly different ($P \leq 0.05$) from other samples (WM_3, WM_4, WM_5, WM_6, WM_7, WM_8, WM_9, and M_1). pH value reduced with increase in millet flour.

Proximate composition of the wheat and millet flour samples

The proximate composition of 100% wheat flour and 100% millet flour are shown in table 4.

Samples	Protein (%)	Fat (%)	Fibre (%)	Moisture (%)	Ash (%)	Carbohydrate (%)
W_f	$11.93^a \pm 0.04$	$1.78^b \pm 0.35$	$0.25^b \pm 0.07$	$0.60^b \pm 0.14$	$11.55^a \pm 0.01$	$73.90^a \pm 0.13$
M_f	$10.85^b \pm 0.00$	$4.40^a \pm 0.01$	$1.40^a \pm 0.00$	$2.17^a \pm 0.01$	$9.40^b \pm 0.01$	$71.80^b \pm 0.01$
LSD	0.07	0.81	0.15	0.30	0.21	0.27

Table 4: *Mean value of proximate composition on 100% wheat flour and 100% millet flour. Means of duplicate determination, means with different superscripts down the column are significantly. different ($p \leq 0.05$), Key: W_f100% wheat flour, M_f100% millet flour.*

Protein content

In terms of protein content, there were significant differences in the flour samples. Mean values ranged from 10.85% - 11.93% with wheat flour having the highest value and millet flour having the lowest value. Wheat flour had mean value of 11.93% and this result can be compared to Belderok., *et al*. [26]; the protein content of wheat grains may vary between 10% - 18% of the total dry matter. The protein content of the millet flour was 10.85% and these result compared favorably with the result obtained from Kalinova and Moudry [27]. Although the protein content of wheat flour is higher than that of millet flour it lacks certain amino acids like lysine, tryptophan which is present in millet flour [13].

Fat content

There was significant difference ($P \leq 0.05$) in terms of fat content among the flour samples tested. Mean values ranged from 1.78% - 4.40%, with millet flour having the highest mean value and wheat flour having the lowest mean value. Fat acts as a flavor retainer and helps improve sensory properties of baked products. The fat content obtained for millet flour was in line with that obtained by Kalinova [28]. The higher fat content of millet flour can be attributed to the fact that millet is rich in germ which is rich in oil [29].

Fiber content

From the result obtained in terms of fibre, it was observed that there was a significant difference ($P \leq 0.05$) among the flour samples. Mean values ranged from (0.25% - 1.40%) with millet flour having the highest mean value and wheat flour having the lowest mean value. The low fiber content in wheat flour can be attributed to the different processing methods that wheat flour undergoes that millet flour used in this research work did not undergo. Fiber aids in lowering blood cholesterol levels and slows down the process of absorption of glucose, thereby helping in keeping blood glucose level in control. It also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body, increases satiety and hence impacts some degree of weight management.

Ash content

In terms of ash content, there was significant difference ($P \leq 0.05$) in the flour samples. Mean values ranged from (0.60% - 2.17%) with millet flour having the highest mean value and wheat flour having the lowest mean value. Ash value of millet flour was considerably higher than that of wheat flour because the bran is very rich in ash [9]. Minerals present in wheat grains are especially concentrated in the bran (aleurone layer), therefore the milling process can also result in significant losses of minerals, especially copper, iron, manganese and zinc as observed in the low mean value of wheat flour used in this research work. The ash content (2.17%) of millet flour in this present study is in accordance with Kalinova [28]. Thus ash content indicates a rough estimation of the mineral content of a product and it nutritionally aids in the metabolism of other organic compounds such as fat and carbohydrate.

Moisture content

In term of moisture content, there was significant difference ($P \leq 0.05$) in the flour samples. Mean values ranged from 9.40% - 11.55% with millet flour having the lowest mean value and wheat flour having the highest mean value. Sanni., *et al*. [24] reported that the lower the moisture content of a product to be stored the better the shelf stability of such product. Hence, low moisture ensures higher shelf stability of dried product as observed in millet flour.

Carbohydrate content

Based on result obtained in terms of carbohydrate, it was observed that there was significant difference ($P \leq 0.05$) among the flour samples. The mean values ranged from (71.80% - 73.90%) with wheat flour having the highest mean value and millet flour having the lowest mean value. According to Messiaen [30] increase in the protein, fat and ash content translates to the reduction in carbohydrate content.

Proximate composition of the biscuit samples

Table 5 shows the result for proximate composition of biscuit produced from wheat-millet composite flour, 100% wheat flour and 100% millet flour. There were significant differences (P ≤ 0.05) in all the attributes measured.

Samples	Protein (%)	Fat (%)	Fibre (%)	Moisture (%)	Ash (%)	Carbohydrate (%)
W_1	$12.93^{a} \pm 0.04$	$18.41^{g} \pm 0.03$	0.21 ± 0.01^{c}	6.75 ± 0.07^{a}	1.93 ± 0.04^{g}	58.79 ± 0.43^{a}
WM_1	$12.85^{ab} \pm 0.07$	$18.55^{g} \pm 0.07$	0.22 ± 0.02^{c}	6.74 ± 0.02^{a}	1.98 ± 0.01^{f}	58.66 ± 0.85^{ab}
WM_2	$12.84^{b} \pm 0.02$	$18.65^{g} \pm 0.01$	0.24 ± 0.00^{c}	6.55 ± 0.50^{a}	1.98 ± 0.00^{f}	58.54 ± 0.05^{ab}
WM_3	$12.74^{c} \pm 0.08$	$18.89^{fg} \pm 0.01$	0.28 ± 0.03^{c}	6.55 ± 0.07^{a}	2.01 ± 0.01^{e}	58.54 ± 0.04^{ab}
WM_4	$12.65^{d} \pm 0.07$	$18.99^{f} \pm 0.01$	0.64 ± 0.53^{b}	6.28 ± 0.11^{b}	2.03 ± 0.01^{e}	58.37 ± 0.27^{bc}
WM_5	$12.59^{d} \pm 0.03$	$19.63^{e} \pm 0.25$	0.76 ± 0.70^{b}	5.80 ± 0.00^{c}	2.06 ± 0.01^{d}	58.18 ± 0.18^{cd}
WM_6	$12.35^{e} \pm 0.21$	$19.65^{e} \pm 0.21$	1.27 ± 0.01^{a}	5.73 ± 0.18^{d}	2.07 ± 0.01^{cd}	58.93 ± 0.00^{d}
WM_7	$12.19^{f} \pm 0.23$	$19.93^{d} \pm 0.04$	1.28 ± 0.01^{a}	5.64 ± 0.34^{d}	2.08 ± 0.00^{cd}	58.89 ± 0.35^{d}
WM_8	$11.91^{g} \pm 0.15$	$21.01^{c} \pm 0.00$	1.29 ± 0.01^{a}	5.55 ± 0.66^{d}	2.09 ± 0.01^{c}	58.18 ± 0.19^{e}
WM_9	$11.50^{h} \pm 0.00$	$22.53^{b} \pm 0.73$	1.30 ± 0.00^{a}	5.27 ± 0.33^{e}	2.15 ± 0.07^{b}	57.26 ± 1.13^{f}
M_1	$11.35^{i} \pm 0.63$	$23.30^{d} \pm 0.99$	1.33 ± 1.07^{a}	5.20 ± 0.42^{e}	2.19 ± 0.01^{a}	56.63 ± 0.69^{g}
LSD	0.08	0.25	0.18	0.21	0.02	0.30

Table 5: *Mean values of proximate composition of biscuit samples.*

Means of duplicate determination, means with different superscripts down the column are significantly different (p ≤ 0.05).

Key: W_1 100% wheat, WM_1 90% wheat + 10% millet, WM_2 80% wheat + 20% millet, WM_3 70% wheat + 30% millet, WM_4 60% wheat + 40% millet, WM_5 50% wheat + 50% millet, WM_6 40% wheat + 60% millet, WM_7 30% wheat and 70% millet, WM_8 20% wheat + 80% millet, WM_9 10% wheat + 90% millet M_1 100% millet.

Protein content

In terms of protein content there was significant difference (P ≤ 0.05) in the biscuit samples. The mean value ranged from (11.35% - 12.93%) with M_1 having the lowest mean value and W_1 having the highest mean value. No significant difference (P ≥ 0.05) was observed between sample W_1 and WM_1 with mean values of 12.93% and 12.85% but sample $W_1$was significantly different (P ≤ 0.05) from WM_2, WM_3, WM_4, WM_5, WM_6, WM_7, WM_8, WM_9 and M_1 having values of 12.84, 12.74, 12.65, 12.59, 12.35, 12.19, 11.91, 11.50 and 11.35 respectively. There was no significant difference (P ≥ 0.05) observed between WM_1 and WM_2, also there was no significant difference (P ≥ 0.05) between sample WM_4 and WM_5 with mean value of 12.65 and 12.59 respectively. There was generally a gradual decrease in the protein values of the biscuit as millet flour incorporation increased. Most cookies can be made from flour which has weak and extensible gluten [29].

Fat content

In terms of fat content, there were significant differences (P ≤ 0.05) among the biscuit samples tested. The value ranged from (18.41% to 23.30%) with M_1 having the highest value and W_1 having the lowest mean value. Fats are integral part of cookies, being the third largest component after flour and sugar [29]. Fasasi [25] reported that low fat content in a dry product will help in increasing the shelf life of the sample by decreasing the chances of rancidity and also contribute to low energy value of the food product while high fat content product will have high energy value and promotes lipid oxidation. It was observed that fat content increases as the incorporation of millet flour increases. M_1 with mean value of (23.30) is significantly different from W_1, WM_1, WM_2, WM_3, WM_4, WM_5, WM_6, WM_7, WM_8 and WM_9 with mean values of 18.41, 18.55, 18.65, 18.89, 18.99, 19.63, 19.65, 19.93, 21.01 and 22.53 respectively. There was no significant difference ($P \geq 0.05$) observed amongst sample W_1, WM_1, WM_2, and WM_3 but these samples differed significantly ($P \leq 0.05$) from other samples. There was also no significant difference ($P \geq 0.05$) between samples WM_5 and WM_6 but they differed significantly ($P \leq 0.05$) from other samples. Cookies are in fact a rich source of fat and carbohydrates hence are energy giving food [5].

Fiber content

Based on the result obtained in terms of fibre, there were significant differences ($P \leq 0.05$) among the biscuit samples tested. Mean values ranged from (0.21% - 1.33%) with W_1 (100% wheat) having the lowest mean value and M_1 (100% millet) having the highest mean value. There was no significant difference ($P \geq 0.05$) among biscuit samples W_1, WM_1, WM_2 and WM_3 with mean values of 0.21, 0.22, 0.24 and 0.28 respectively but these samples were significantly different ($P \leq 0.05$) from another sample. Also, there was no significantly different observed between sample WM_4 and WM_5 with mean value of 0.64 and 0.76 respectively but these samples differed significantly ($P \leq 0.05$) from other sample. Also, there was no significant difference ($P \geq 0.05$) observed between samples WM_6, WM_7, WM_8, WM_9 and M_1 having mean values of 1.27, 1.28, 1.29, 1.30 and 1.33 respectively. It was observed that the fiber content of the different biscuit samples increased with an increase in millet flour. Crude fiber is known to aid the digestive system of humans [18], indicating that the 100% millet biscuit could attract good acceptability by many people as well as a health organization.

Moisture content

In terms of moisture content, it was observed that there was significant difference ($P \leq 0.05$) among the biscuit samples. The moisture content ranged from 5.20% to 6.75% with M_1 (100% millet) having the lowest mean value and W_1 (100% wheat) having the highest mean value. Generally, there was reduction in moisture contents as the rate of millet substitution increased. There were no significant ($P \geq 0.05$) differences among samples W_1, WM_1, WM_2 and WM_3 with mean values of 6.75, 6.74, 6.55 and 6.55 respectively but these samples were significantly different from WM_4, WM_5, WM_6, WM_7, WM_8, WM_9 and M_1 with mean values of 6.28, 5.80, 5.73, 5.64, 5.55, 5.27 and 5.20 respectively. The moisture content of a food is indicative of the dry matter in that food, however low residual moisture content in confectionaries is advantageous in that microbial proliferation is reduced and storage life may be prolonged if stored inside appropriate packaging materials under good environment condition.

Ash content

The values obtained for the ash contents indicate that W_1 (100% wheat) had the lowest value of 1.93% whereas M_1 (100% millet flour) had the highest value of 2.19%. There were significant differences among the biscuit samples tested. The ash contents were observed to increase with the percentage increase in the millet flour level. Millet flour contains comparatively higher amount of ash than wheat and this could be responsible for the higher ash content recorded for M_1 than W_1. M_1 is significantly different ($P \leq 0.05$) from sample W_1, WM_1, WM_2, WM_3, WM_4, WM_5, WM_6, WM_7, WM_8 and WM_9 with mean value of 1.93, 1.98, 1.98, 2.01, 2.03, 2.06, 2.07, 2.08, 2.09 and 2.15 respectively. WM_1 and WM_2 were not significantly different ($P \leq 0.05$) with mean value of 1.98 but these samples were significantly different from other biscuit samples. It can be deduced that incorporation of millet flour in the process of biscuit making could enhance the mineral intake of many people, as ash is an indicative of the amount of minerals contained in any food sample.

Carbohydrate content

There were significant differences ($P \leq 0.05$) in the carbohydrate content of the biscuit sample tested. Mean value ranged from 56.63% to 58.93%. M_1 had the lowest mean value of 56.63%. There was no significant difference ($P \geq 0.05$) among sample W_1, WM_2 and WM_3, but these samples are significantly different from other samples. Also, WM_1, WM_2, WM_3 and WM_4, are not significantly different ($P \geq 0.05$) but differed significantly ($P \leq 0.05$) from other samples. According to Messianen [30] increase in the protein, fat and ash content translates to the reduction in the carbohydrate.

Sensory properties of the biscuit samples

Table 6 showed the result of the sensory evaluation of biscuits produced from wheat-millet composite flour. There were significant differences ($P \leq 0.05$) in all the attributes measured.

Samples	Aroma	Appearance	Crispiness	Texture	Taste	Mouthfeel	Overall acceptance
W_1	$5.90^{a} \pm 1.71$	$6.70^{a} \pm 1.08$	$5.70^{b} \pm 1.63$	$5.55^{b} \pm 1.73$	$5.75^{abc} \pm 1.59$	$5.65^{abc} \pm 1.76$	$6.00^{ab} \pm 1.75$
WM_1	$5.85^{a} \pm 1.50$	$5.95^{abc} \pm 1.61$	$6.05^{ab} \pm 1.43$	$5.40^{b} \pm 1.63$	$5.95^{abc} \pm 1.64$	$5.90^{ab} \pm 1.68$	$5.90^{abc} \pm 1.68$
WM_2	$5.45^{ab} \pm 1.28$	$5.90^{abc} \pm 1.33$	$5.80^{b} \pm 1.24$	$5.75^{ab} \pm 1.11$	$5.55^{abc} \pm 1.50$	$5.50^{abc} \pm 1.19$	$5.70^{bc} \pm 1.22$
WM_3	$5.20^{abc} \pm 1.36$	$5.00^{cd} \pm 1.86$	$5.70^{b} \pm 1.49$	$5.25^{b} \pm 1.71$	$5.15^{bcd} \pm 1.42$	$5.00^{bc} \pm 1.52$	$5.40^{bc} \pm 1.50$
WM_4	$6.00^{a} \pm 1.26$	$6.80^{a} \pm 1.06$	$6.80^{a} \pm 1.15$	$6.60^{a} \pm 1.10$	$6.45^{a} \pm 1.54$	$6.25^{a} \pm 1.33$	$6.85^{a} \pm 1.46$
WM_5	$4.75^{bc} \pm 1.97$	$4.70^{de} \pm 1.75$	$6.10^{ab} \pm 1.21$	$5.30^{b} \pm 1.30$	$5.00^{cd} \pm 1.89$	$4.70^{c} \pm 2.03$	$5.35^{bc} \pm 1.66$
WM_6	$4.30^{cd} \pm 1.63$	$3.75^{ef} \pm 1.59$	$5.60^{b} \pm 1.39$	$5.00^{c} \pm 1.56$	$4.45^{de} \pm 1.85$	$4.70^{c} \pm 1.92$	$4.95^{c} \pm 1.61$
WM_7	$5.85^{a} \pm 1.39$	$5.70^{bc} \pm 1.92$	$5.95^{b} \pm 1.19$	$5.60^{b} \pm 1.67$	$6.30^{a} \pm 1.17$	$5.85^{ab} \pm 1.73$	$5.95^{ab} \pm 1.76$
WM_8	$5.85^{a} \pm 1.46$	$6.10^{ab} \pm 1.33$	$6.15^{ab} \pm 1.50$	$6.00^{ab} \pm 1.26$	$6.10^{ab} \pm 1.16$	$6.15^{a} \pm 1.63$	$6.30^{ab} \pm 1.13$
WM_9	$5.55^{ab} \pm 2.10$	$5.30^{bcd} \pm 1.81$	$5.30^{b} \pm 2.23$	$5.20^{b} \pm 1.58$	$5.65^{abc} \pm 1.95$	$5.65^{abc} \pm 1.93$	$5.60^{bc} \pm 1.64$
M_1	$3.65^{d} \pm 1.35$	$3.10^{f} \pm 1.33$	$3.25^{c} \pm 1.48$	$3.60^{d} \pm 1.73$	$3.70^{e} \pm 1.72$	$3.45^{d} \pm 1.50$	$3.75^{d} \pm 1.74$
LSD	0.97	0.96	0.92	0.94	1.00	1.04	0.98

Table 6: *Mean values of sensory scores of the biscuit samples.*

Means of duplicate determination, means with different superscripts down the column are significantly different ($p \leq 0.05$).

Key: W_1 100% wheat, WM_1 90% wheat + 10% millet, WM_2 80% wheat + 20% millet, WM_3 70% wheat + 30% millet, WM_4 60% wheat + 40% millet, WM_5 50% wheat + 50% millet, WM_6 40% wheat + 60% millet, WM_7 30% wheat and 70% millet, WM_8 20% wheat + 80% millet, WM_9 10% wheat + 90% millet, M_1 100% millet.

Aroma

From the result obtained in terms of aroma, it was observed that there were significant differences ($P \leq 0.05$) among the biscuit samples. Sample WM_4 had the highest mean score of 6.00 followed by sample W_1 with mean score of 5.90, samples WM_1, WM_7, and WM_8 had the same mean score of 5.85 and the lowest mean score was sample M_1 with 3.65. According to Ubbor and Akobundu [31] aroma is an attribute that influences the acceptance of baked goods.

Appearance

There were significant differences ($P \leq 0.05$) in term of appearance among the biscuit samples tested. Mean values ranged from 3.10 to 6.80 with sample WM_4 having the highest mean value while sample M_1 had the least mean value. No significant difference ($P \geq 0.05$) was observed between samples W_1, WM_1, WM_2, WM_4 and WM_8 with mean values of 6.70, 5.95, 5.90, 6.80 and 6.10 respectively. Appearance is an important attribute of any food because of its influence on acceptability.

Crispness

In terms of crispiness, there were significant ($P \leq 0.05$) differences in all the tested biscuit samples. Mean value ranged from 3.25 to 6.80 with sample WM_4 having the highest value while sample M_1, had the least value. No significant difference ($P \geq 0.05$) was observed amongst sample W_1, WM_2, WM_3, WM_6, WM_7 and WM_9 with values of 5.70, 5.80, 5.70, 5.60, 5.95 and 5.30 respectively. Crispness is perceived when food is chewed between molars and is usually expressed in terms of hardness [32]. Flour for biscuits should be more extensible but less springy as reported by Kent [33] such that when masticated such biscuit will be crispy.

Texture

Based on texture, there were significant differences ($P \leq 0.05$) in all the biscuit samples. Mean value ranged from 3.60 to 6.60. Sample WM_4 had the highest mean score 6.60 and M_1 had the least score of 3.60. From the result it can be deduced that up to 40 of substitution of millet flour for the production of biscuit can be accepted by the consumers in terms of texture.

Taste

In terms of taste, there were significant differences ($P \leq 0.05$) in all the biscuit samples produced. WM_4 had the highest mean score of 6.45 and M_1 had the lowest mean value of 3.70. WM_4 had the best acceptance in terms of taste whereas M_1 had the least acceptance which could be as a result of its sandy texture.

Mouthfeel

Based on mouth feel, there were no significant difference ($P \geq 0.05$) among sample W_1, WM_1, WM_2, WM_4, WM_7, WM_8 and WM_9. But WM_4 is significantly different ($P \leq 0.05$) from WM_3, WM_5, WM_6 and M_1. WM_4 had the highest mean value of 6.25 and M_1 had the lowest mean value of 3.45.

Overall acceptability

In terms of overall acceptability, significant difference ($P \leq 0.05$) was observed among the various biscuit samples. Mean scores ranged from 3.75 to 6.85 with sample WM_4 having the highest mean score while sample M_1 had the least mean score. There were no significant differences ($P \geq 0.05$) among samples W_1, WM_4, WM_7, and WM_8 and also no significant differences ($P \geq 0.05$) among these samples WM_1, WM_2, WM_3, WM_5, WM_6 and WM_9 but these samples were significantly different ($P \leq 0.05$) from sample WM_4. The result confirmed that the quality of biscuits (Aroma, appearance, crispness, mouthfeel, taste and texture) indeed influenced the overall acceptability of the biscuit.

Conclusion

This study revealed that millet flour is a good source of fat, fiber and ash as compared with wheat flour; this shows that acceptable biscuits can be produced from wheat-millet flour. Functional properties of wheat flour and their blends with millet flour were the criteria of good quality biscuit. Biscuits made from 100% wheat and 40% millet substitution had the highest overall acceptability based on the panelists, but biscuit made from 100% millet was not acceptable due to its poor appearance, taste, sandy texture and aroma. It was concluded that millet flour substitution in wheat flour up to 40% will still meet the quality requirement of 100% wheat flour in biscuit production in terms of nutrients, functionality and sensory attributes. The use of millet in biscuit making would greatly enhance the utilization of the crop in many millet cultivating developing countries where the crop has not been optimally utilized. Furthermore, substituting millet in wheat flour will greatly reduce cost in terms of production by 40% as millet is far cheaper and locally available than wheat.

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