



Physico-chemical and Functional Properties of Whole Maize Flour Blended with Wheat and Gram Flour

Prerna Kathuria, Gagandeep Kaur, Varsha Kanojia

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ABSTRACT

Background: About one third of the maize production is imbibed in the form of flat breads or *chapati* which is consumed basically in the northern states of India. Maize flat breads are generally prepared with hands, owing to lower gluten content and lower binding properties it is difficult to prepare. In the present study the effect of blending composition of wheat and gram in maize flour on physico-chemical and functional properties were investigated.

Methods: The maize flour of PMH-1 variety was blended with wheat and gram flour in different combinations of (20, 30 and 40%). The composite flours were evaluated for different physico-chemical properties like moisture content, protein content, crude fat, crude fibre, ash content, carbohydrates, titrable acidity, color value, titrable acidity, swelling power, oil holding and water holding capacity.

Result: It was observed from the study that the protein content ($2.83 \pm 0.02\%$), fat content ($6.13 \pm 0.02\%$) and fibre content ($2.82 \pm 0.02\%$) was higher for gram blended flour than wheat blended flour. The swelling power of the flour blended with wheat was found out to be higher ($30.74 \pm 0.01\%$), than blended with gram flour ($25.30 \pm 0.01\%$), whereas the oil holding and water holding capacity of wheat blended and maize blended flours was similar.

Key words: Blending ratio, Maize flour, Proximate composition, Water holding capacity.

INTRODUCTION

Maize (*Zea mays* L.) is an important staple food in many countries of the world. The expanse and production of maize in the world have been increasing continuously. India is the fifth largest producer of maize in the world contributing 3% of the global production. It can be processed into different breakfast items, food and feed ingredients and beverages for its consumption throughout the world (Chakraverty, 1988; Rajoo, 1998). Many people throughout the world, particularly living in Asia or people of Asiatic origin, make their own dough-based products on a daily basis. Flat breads or *chapati* is the staple diet of majority of people living in the Indian subcontinent (Sandhu *et al.*, 2007; Nazir and Nayik, 2016). It is made by mixing the flour and water to develop dough, after relaxing dough balls are sheeted to a uniform thickness of around 2 mm and baked for a short time. It is usually consumed fresh (Gujral and Pathak, 2002). There is an increase in consumer demand for nutritious and healthy baked flatbreads with good sensory properties that has led to considerable efforts for the development of such foods (Pardhi *et al.*, 2016). One such novel effort is the use of blended flours for making flatbreads (Bhol and Bosco, 2014). Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured (Kinsela, 1976). The food applications of these flours significantly depend on their properties like moisture content, protein content, crude fat content, ash content, crude fibre content, carbohydrate content, titrable acidity, colour value, swelling power, water holding and oil holding

Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana-141 027, Punjab, India.

Corresponding Author: Gagandeep Kaur, Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana-141 027, Punjab, India. Email: gagandeep@pau.edu

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capacity of flour. These functional properties also influence the flatbread properties during processing and storage. Any change in these properties may significantly influence the nutritional and consumption importance of flatbreads. Previously, some work has been reported on the physico-chemical properties of maize flour and its blends with soy bean, Nile tilapia and groundnut seed flour (Akubor and Onimawo, 2003; Fasasi *et al.*, 2007; Akupapamam and Darbe, 1994). Keeping in view the above aspects the present study was planned to find the effect of blending composition on physico-chemical and functional properties of composite flours.

MATERIALS AND METHODS

Sample preparation

Whole maize kernels (cv. PMH-1) were procured from Maize Section, Punjab Agriculture University Ludhiana, India. The experiments were conducted during the year 2018-2019. The maize kernels were cleaned by using pedal cum power

operated grain cleaner (Brand: Express, 50 Htz, 1.5 Hp, semi automatic mild steel machine) to remove foreign matter such as dust, dirt, chaff, immature and broken grains. The cleaned and graded whole maize kernels were ground to make flour by using a laboratory burr mill machine (Jas-GM-1320BL, 2 Hp, 1.75 Kw, 25-30 Kg grinding capacity per hour). The ground maize flour was sieved into fine and very fine flour with the help of a rotary sieve shaker (VEW, 1440 rpm, 0.25 Hp, 50 Htz) and blended with wheat and gram flour in different combinations; viz A: Very fine whole maize flour; B: Very fine flour + 20% wheat flour; C: Very fine flour + 30% wheat flour; D: Very fine flour + 40% wheat flour; E: Very fine flour + 20% gram flour; F: Very fine flour + 30% gram flour; G: Very fine flour + 40% gram flour; H: Fine whole maize flour; I: Fine flour + 20% wheat flour; J: Fine flour + 30% wheat flour; K: Fine flour + 40% wheat flour; L: Fine flour + 20% gram flour; M: Fine flour + 30% gram flour; N: Fine flour + 40% gram flour.

Determination of proximate composition of whole and blended maize flour

The moisture content of maize flour samples was measured by standard hot air oven (Model SNW 143) method (AOAC 2000). Proteins were determined by Lowry *et al.* (1951). Crude fat was measured using the SOCS PLUS apparatus by standard AOAC method (AOAC 1980). Ash content was measured in crucibles using the standard AOAC method. Crude fiber was measured by digesting the samples using the standard AOAC (1980) method. Carbohydrates were calculated by subtraction method as under:

$$\text{Carbohydrate (\%)} = \{100 - [\text{moisture (\%)} + \text{ash (\%)} + \text{fat (\%)} + \text{protein (\%)} + \text{fibre (\%)}]\}, \quad \dots\dots(1)$$

Colour characteristics

Colour properties of samples were measured using Colour Reader (Miniscan XE Plus). The colour was described by a value of 'L', 'a' and 'b' where L indicates the intensity of colour *i.e.* lightness which varies from 100 for perfect white to 0 for perfect black and 'a' and 'b' values are chromaticity dimensions which give understandable designations of colour *i.e.* the value of 'a' measured redness when positive, grey when zero and blueness when negative. The change in colour was calculated from 'L', 'a' and 'b' readings (Minolta 1994).

$$(\Delta E) = \sqrt{(\Delta L^2 + \Delta a^2 + \Delta b^2)} \quad \dots\dots\dots(2)$$

Where,

ΔL , Δa and Δb are deviations from L, a and b values of the fresh sample.

Titration acidity

Titration acidity of reconstituted sample was estimated by diluting the aliquot of the sample with water to a fixed volume and then titrated with 0.1 N NaOH using Phenolphthalein as an indicator. Percentage acidity was calculated as the percentage of anhydrous citric acid using method described by (Kadam *et al* 2010).

Functional properties

Swelling power

Swelling power was found out in a centrifuge machine (REMI R8C Laboratory centrifuge) using the method suggested by Hirsch and Kokini, 2002. The swelling power was determined according to the equation below:

$$\text{Swelling power} = \frac{\text{Weight of the swollen sediment}}{\text{Weight of the dry starch}} \quad \dots\dots(3)$$

Water holding capacity (WHC) and oil holding capacity (OHC)

The WHC and OHC of the samples were determined by using the methods suggested by Sosulski *et al* (1976). The flour/blend (2 g) was vortexed with distilled water (10 ml) in a pre weighed centrifuge tube for 30 minutes. After standing at room temperature for 30 minutes, the sample was centrifuged for 25 min at 3000 g. The sediments were weighed after complete removal of the supernatant. For the determination of OHC, the flour/blend (0.5 g) was homogenized with canola oil (5 ml) in a pre-weighed centrifuge tube and preceded further as described for WHC. The WHC and OHC (%) were calculated as:

$$\text{WHC} = \frac{\text{Total water mass}}{\text{Dry matter mass}} \quad \dots\dots\dots(4)$$

$$\text{OHC} = \frac{m(\text{oil}) - m(\text{d})}{m(\text{d})} \quad \dots\dots\dots(5)$$

Where,

m (oil) and m (d) are mass of oil and mass of dry material respectively.

Statistical analysis

Three replications of the experiments were performed and all resulting data are presented as mean \pm standard deviation.

RESULTS AND DISCUSSION

Effect of blending ratio on proximate composition of maize flour

Moisture content

The moisture content of flour is important for two reasons, first, the higher the moisture content, the lower the amount of dry solids and secondly, the organisms present naturally in the flour start to grow at higher moisture contents, producing off odour. The moisture content of whole maize flour and blended maize flour varied from 8.56 \pm 0.01 to 8.66 \pm 0.01% as presented in Fig 1. The average moisture content for whole maize flour was found out to be 8.56 \pm 0.01%, wheat flour was 8.58 \pm 0.02% and gram flour was 8.60 \pm 0.02%. The average moisture content of maize flour blended with wheat was 8.58 \pm 0.02% while for the gram flour it was 8.59 \pm 0.01%. It was higher in case of maize flour blended with gram rather than wheat. The difference in the

moisture content of both is due to the difference in the individual moisture content of wheat and gram flours. Similar trends were reported by Kaushal *et al.* (2012) for the blends of taro, rice and pigeon pea flour.

Protein content

Protein is a macronutrient essential to build muscle mass. It is basically composed of amino acids. It is important to measure protein content as a higher percentage of protein means a harder flour best suited to make chewy, crusty flatbreads. The protein content of whole maize flour and blended maize flour varied from 10.41 ± 0.01 to $12.89 \pm 0.02\%$ as presented in Fig 2. The average protein content of whole maize flour was $10.41 \pm 0.01\%$. The average protein content

of maize flour blended with wheat was $12.43 \pm 0.01\%$ while for the blended with gram flour it was $12.83 \pm 0.02\%$. The protein presence was higher for gram blended flour than blended with wheat. The difference in protein content of both the blended flours is due to the fact that the protein content of gram flour is higher than the wheat flour. Similar trend was reported by Butt *et al* (2004) who studied the protein content for the blends of wheat and rice flour.

Crude fat content

The crude fat content of whole maize flour and blended maize flour varied from $4.36 \pm 0.01\%$ to $6.20 \pm 0.02\%$ (Fig 3). The average crude fat content of whole maize flour was $4.36 \pm 0.01\%$. The average crude fat content of maize flour

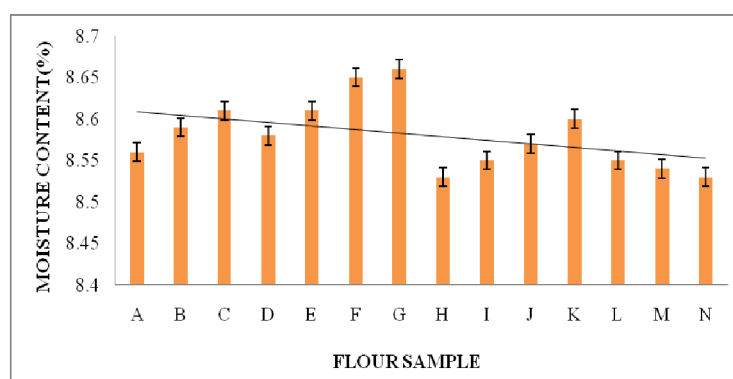


Fig 1: Moisture content of different flour samples.

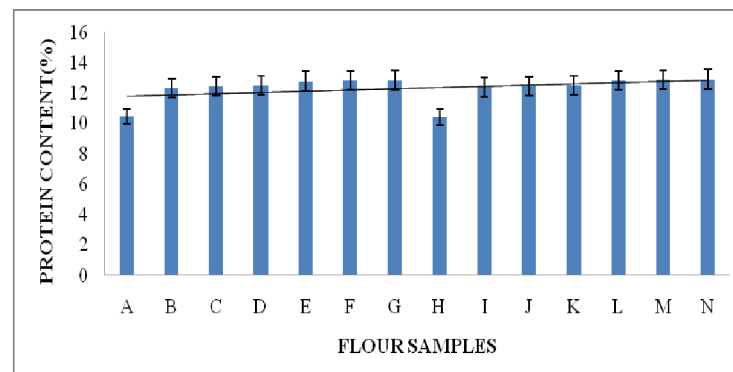


Fig 2: Protein content for different flour samples.

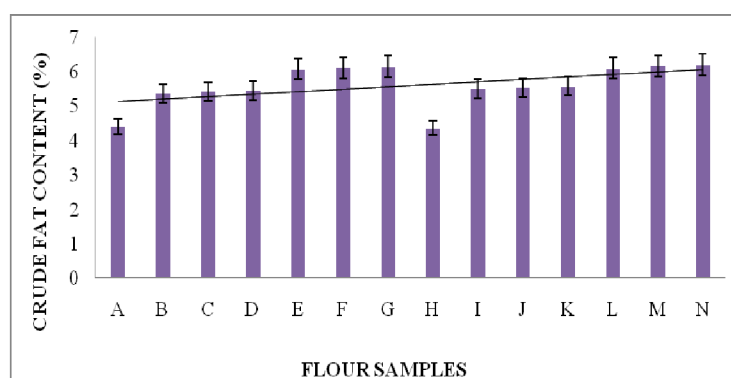


Fig 3: Crude fat content for different flour samples.

blended with wheat was $5.48 \pm 0.01\%$ while for the one blended with gram flour, the average crude fat content was $6.13 \pm 0.02\%$. The crude fat content is higher for maize flour blended with gram than the flour blended with wheat. This may be due to the difference in the individual fat content of both the blended flours. Similar trend was reported by Yaseen *et al* (2007) for finding the crude fat content of corn flour blended with triticale flour.

Ash content

Ash content is the mineral or inorganic material in flour. It is important to measure ash content of flour as it is a good indicator of contamination in refined flour. The ash content of whole maize flour and blended maize flour varied from $2.20 \pm 0.02\%$ to $2.32 \pm 0.02\%$ as presented in Fig 4. The average ash content of whole maize flour was $2.20 \pm 0.02\%$. The average ash content of maize flour blended with wheat flour was $2.22 \pm 0.02\%$ while for the one blended with gram flour was $2.30 \pm 0.02\%$. The ash content of gram blended maize flour is slightly higher than wheat blended flour. This may be due to the difference in the particle size of the two flours used as blend. Similar trend was reported by Tekle (2009) for blending taro flour with wheat.

Crude fibre content

Crude fibre determination is adequate to estimate the dietary fibre in flour. The crude fibre content of whole maize flour

and blended maize flour varied from $2.40 \pm 0.02\%$ to $2.88 \pm 0.02\%$ (Fig 5). The fibre content of whole maize flour was $2.40 \pm 0.02\%$. The average fibre content of maize flour blended with wheat was $2.73 \pm 0.02\%$ while for the one blended with gram flour, the average crude fibre content was $2.82 \pm 0.02\%$. The fibre content of gram blended maize flour is higher than the wheat blended flour. The difference in the fibre content of the two flours used as blend is the reason for the higher fibre content of gram flour than the wheat flour. Similar trend was reported by Tekle (2009) for blending taro flour with wheat.

Carbohydrates content

Carbohydrates are chemically defined as neutral compounds of carbon, hydrogen and oxygen. The carbohydrate content of whole maize flour and blended maize flour varied from 66.04 ± 0.01 to $70.13 \pm 0.01\%$ as presented in Fig 6. The average carbohydrate content of whole maize flour was $70.13 \pm 0.01\%$. The average carbohydrate content of maize flour blended with wheat was $68.72 \pm 0.01\%$ while for the one blended with gram flour, the average crude fibre content was $66.25 \pm 0.01\%$. The carbohydrate content of wheat blended maize flour was higher than the gram flour blended. While measuring the chemical composition of different blending ratios of corn and triticale flour, similar trend was reported by Hussein and Hegazy (2007) on researching the carbohydrate content of the flour.

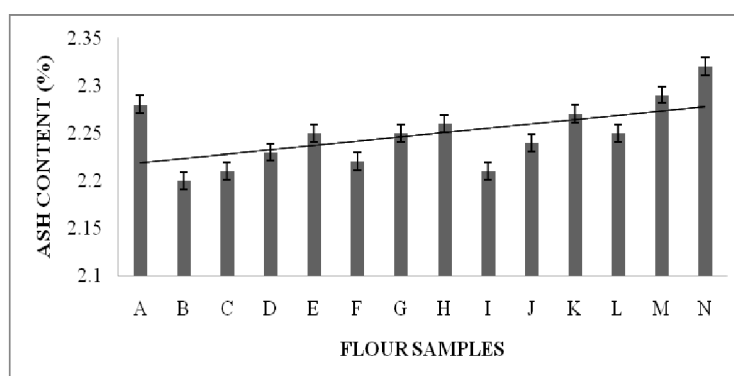


Fig 4: Ash content of different flour samples.

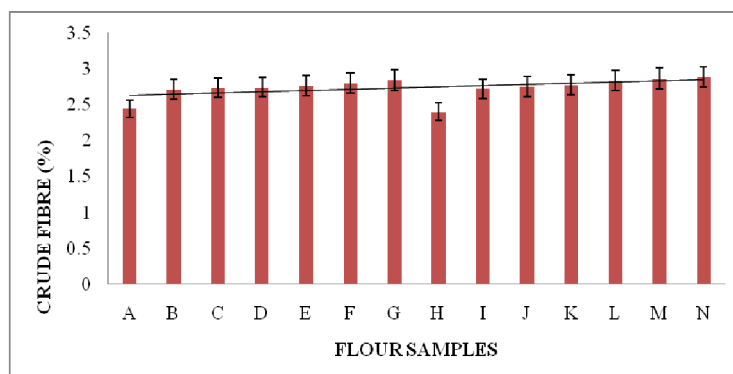


Fig 5: Crude fibre for different flour samples.

Functional properties of flour

Titration acidity

Total titrable acid is a measure of amount of acid present in the flour. Its determination is important to measure the perceivable acidity of the flour. The titrable acidity of whole maize flour and blended maize flour varied from $0.076 \pm 0.001\%$ to $0.085 \pm 0.001\%$ as presented in Fig 7. The average titrable acidity of whole maize flour was $0.076 \pm 0.001\%$. The average titrable acid content of maize flour blended with wheat was $0.083 \pm 0.001\%$ while for the one blended with gram flour, it was $0.078 \pm 0.001\%$. The titrable acidity of wheat blended flour was higher than the

gram blended flour. Hruskova and Machova (2002) studied the acid content of the degermed and whole maize flour and the results showed a trend similar to this.

Colour value

Flour colour determination is important because it affects the crumb colour of the finished product *i.e.* flatbreads. The L of whole maize flour and blended maize flour varied from 65.41 ± 0.02 to 75.52 ± 0.02 as presented in Fig 8. The average colour value of whole maize flour was 70.05 ± 0.02 . The average colour change of the flour blended with wheat was found out to be 75.40 ± 0.02 while for the one blended with gram flour, it was 65.42 ± 0.02 . The colour value for flour

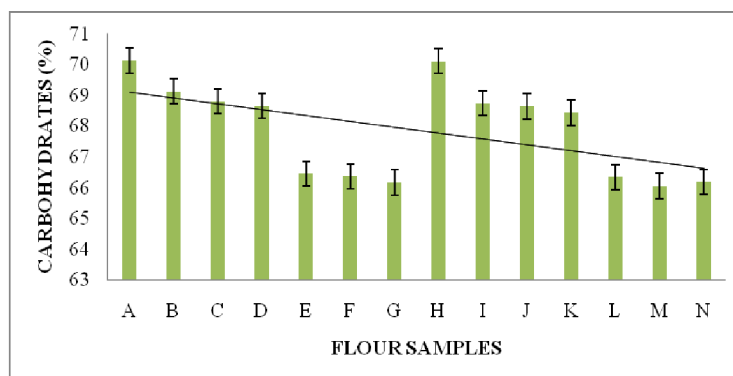


Fig 6: Carbohydrate content for different flour blends.

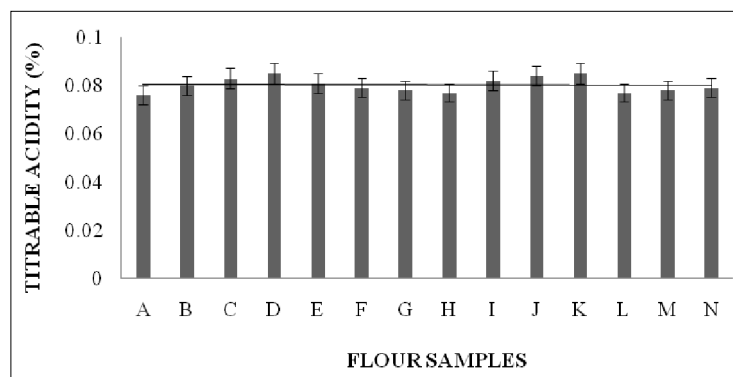


Fig 7: Titrable acidity of different flour samples.

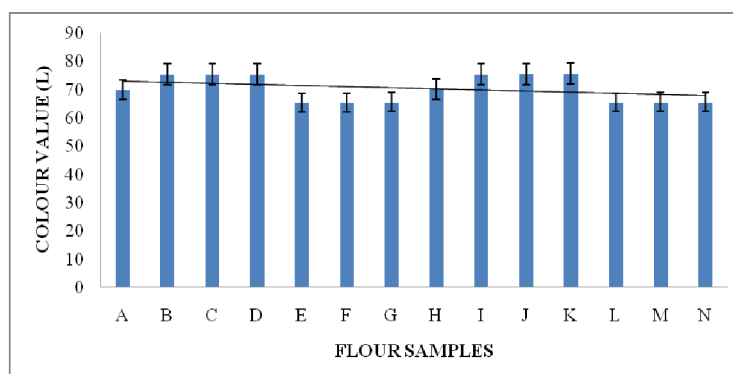


Fig 8: Colour value of different flour samples.

blended with gram flour was less than the flour blended with wheat. This is due to the colour difference of both wheat and gram. Gram flour when mixed with maize flour provides a darker colour, thus decreasing the L value. Wheat flour when mixed with maize flour makes it light in colour, thus increasing the L value. Jamin and Flores (1998) studied the colour difference for different varieties of corn flour and the results showed a trend similar to this.

Swelling power

Swelling power is defined as the wet weight of flour over its dry weight. The determination of swelling power of flour is important for a crunchy and chewable processing of flatbread. The swelling power of whole maize flour and blended maize flour varied from $22.31 \pm 0.01\%$ to $31.06 \pm 0.01\%$ as presented in Fig 9. The average swelling capacity of whole maize flour was $22.31 \pm 0.01\%$. The average swelling power of the flour blended with wheat was found out to be $30.74 \pm 0.01\%$ while for the one blended with gram flour, it was $25.30 \pm 0.01\%$. The swelling power of maize flour blended with wheat was higher than the one blended with gram flour. The main reason for the difference in swelling power is the difference in the amylose content of wheat and gram flours. A similar trend was reported by Moorthy (2002) for the swelling capacity calculation of cassava flour.

Water holding capacity

Water holding capacity (WHC) is the ability of proteins to

prevent water from being released or expelled from their three-dimensional structure. WHC plays an important role in developing food texture. The water holding capacity of whole maize flour and blended maize flour varied from $70.32 \pm 0.01\%$ to $74.16 \pm 0.01\%$ as presented in Fig 10. The average moisture holding capacity of whole maize flour was $70.34 \pm 0.01\%$. The average water retaining power of the flour blended with wheat was found out to be $74.09 \pm 0.01\%$ while for the one blended with gram flour, it was $72.42 \pm 0.01\%$. Water absorption capacity of wheat blended maize flour is higher than the gram blended maize flour. The main reason for the difference in the moisture retaining capacity of the blended flours is the molecular structure which inhibits water absorption. A similar observation was reported by Butt and Batool (2010) while measuring the water absorption capacity (WAC) of rice, green gram and potato flour blended to wheat flour.

Oil holding capacity

Oil holding capacity is the amount of oil that can be absorbed per gram of the sample. It is important to determine OHC for the flavour retention of flatbreads and to improve their palatability. The oil holding capacity of whole maize flour and blended maize flour varied from $122.12 \pm 0.02\%$ to $125.19 \pm 0.02\%$ as presented in Fig 11. The average oil holding capacity of whole maize flour was $122.3 \pm 0.01\%$. The average oil holding power of the flour blended with wheat was found out to be $125.15 \pm 0.02\%$ while for the one blended

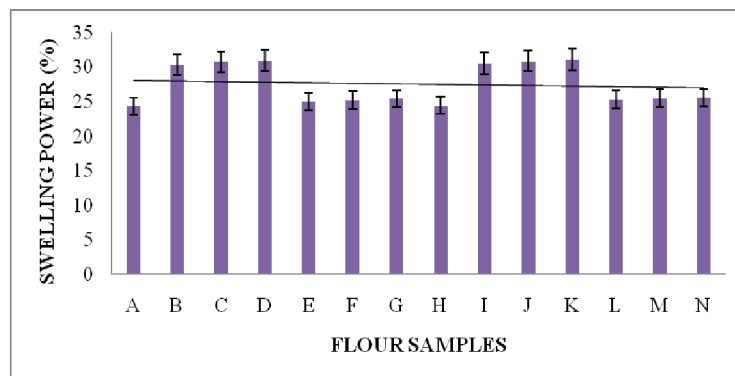


Fig 9: Swelling power of different flour samples.

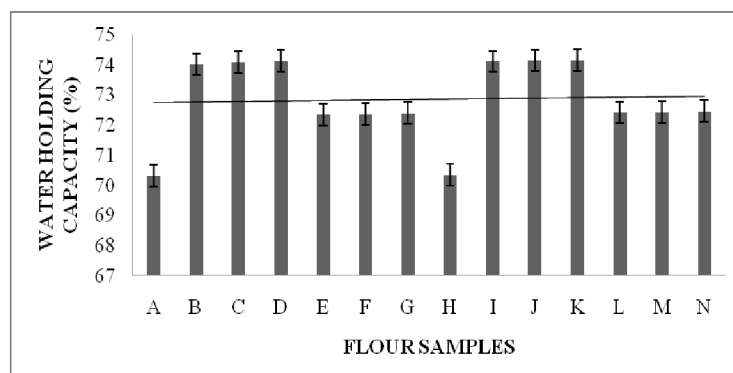


Fig 10: Water holding capacity of different flour samples.

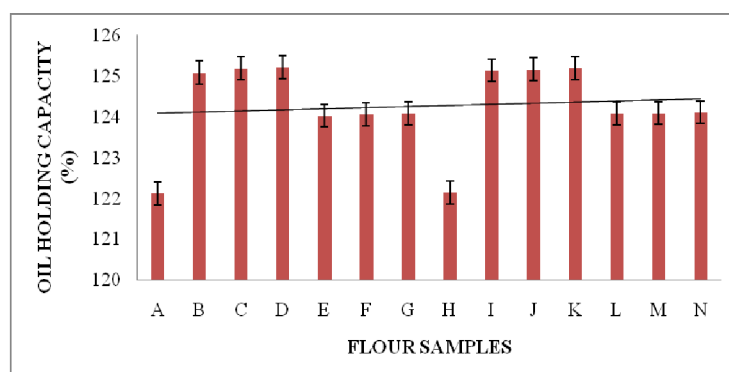


Fig 11: Oil holding capacity of different flour samples.

with gram flour, it was $124.13 \pm 0.01\%$. Oil holding capacity of wheat blended maize flour is higher than the gram blended maize flour. The main reason for the difference in the oil retaining capacity is the presence of high fat content. Similar findings were observed by Kaushal *et al* (2012) and Aremu *et al* (2007) while measuring the oil absorption capacity (OAC) of rice, green gram and potato flour blended to wheat flour.

CONCLUSION

The functional properties of maize flour can be enhanced through the addition of gram and wheat flour. The gram blended flour samples showed a higher protein content of $12.83 \pm 0.02\%$ than the wheat blended maize flour samples $12.43 \pm 0.01\%$. There is also an increase in the water holding capacity of the blended maize flour samples, thus providing better gelling ability than the whole maize flour. The swelling power increase of the blended maize flour samples will account for the improved consistency in food. Thus, with the blending in whole maize flour may serve as the good binder and provide consistency in the food preparation.

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