Evaluation of Physical and Functional properties of composite flour from Finger Millet, Rice and Guar Gum

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Abstract

The objective of this study was to investigate the physical and functional qualities of composite flour made from finger millet (*Eluesine coracana*), rice flour (*Oryza sativa*), and guar gum (*Cyamopsis tetragonoloba*). The moisture content, ash content, fat content, protein content, swelling capacity, water absorption capacity, bulk density, foaming capacity, and oil absorption capacity were determined as physico-chemical and functional parameters. 0%, 5%, 10%, 15%, and 20% of guar gum were combined with equal amounts of flour from finger millet and rice flour. Analyses of composite flour's proximate, physicochemical, and functional properties were conducted. Moisture content, ash content, amount of fat, and protein isolate were 11.2-11.9%, 1.3-2.1%, 1.5-2.5%, and 6.8-23.5%, respectively. The composite flour's moisture level was below 12%, which makes it suitable for storage. The swelling capacity, water absorption capacity, bulk density, foaming capacity, and oil absorption capacity were, respectively, 6.93 to 7.49 g/g, 106 to 364%, 0.815-0.815 gm/ml, 4.0 to 18.6%, and 113 to 119%. This work advocates the promotion and use of ragi and rice flour in pasta and bread production in India, a country known for its exclusive reliance on wheat flour.

Keywords: Finger Millet, Rice, Ragi, Guar Gum, Physical properties, Functional properties

Introduction

Millets have significantly contributed to the reduction of malnutrition around the world. These items are rich in Calcium, Iron, and Carbohydrates. Diverse millets and cereal flours vary in biochemical makeup, molecular structure, and conformation of dietary components, as well as functional qualities (Alleoni and A.C.C, 2006). The structural arrangement of carbohydrates and other polymers in flour is dependent on its bulk density (Adejuyitan et al. 2009).

Without dehulling, finger millet [FM], often known as ragi, is consumed. In some regions of South Africa and India, finger millet grains are a staple meal. Although gluten-free grains with a low glycemic index have nutraceutical and nutritional benefits, they are underutilised and neglected. Finger millet is a member of the Poaceae family and originates in Ethiopia before making its way to India (Shiihii et al.2011).

The second most popular cereal grains in the world are rice (*Oryza sativa*). It is a dietary staple in many parts of the world. Rice provides and over one fifth of the calories consumed by humans globally. Rice is composed of roughly 7.37% protein, 2.2% fat, 64.3% accessible carbohydrates, 0.8% fibre, and 1.4% ash.

Guar Gum (*Cyamopsis tetragonoloba*) is used to modify the rheological qualities of foods containing starch. Guar gum is composed of a chain of (1 to 4)-linked -D-mannopyranosyl units with a single branching -D-galactopyranosyl unit attached via (1 to 6) linkages, on aggregate, to every other polymer backbone unit (Hoefler, 2004). The wide branching of Guar gum is responsible for its better hydration properties as well as its enhanced hydrogen bonding activity, which can also occur between and among polysaccharides, proteins, and starches and may facilitate the creation of complexes (Bahnassey and Breene, 1994). Due to its long, soluble, stiff chain and enormous hydrodynamic volume, guar gum can produce high viscosity with elastoplastic rheology at low concentrations (Whistler and BeMiller, 1997).

Physical and chemical properties are indeed the functional properties that involve a complex interplay between the content, structure, and molecular configuration of food components and the nature of the environment with which they are associated and quantified (Kinchella, 1976). Functional properties of flour assist forecast how protein, fat, fibre, and carbohydrates will function in a certain system and illustrate whether or not this protein may be utilised to replace or boost regular protein (Kaur and Singh, 2006).

The purpose of this study was to generate composite flour made from finger millet, rice, and guar gum and to analyse the functional and physical features of the composite flour that can be used for a variety of applications.

2. Materials and Methods

2.1 Raw materials

Finger millet brand name (*Manna*), Rice brand name (*Manna*) & Guar gum brand name (*Nature vit*) flour were procured from the local market made from Southern Health Food (p) Ltd. and Nature Vitamin. Finger millet, Rice and Guar gum flour were sieved at 100 µm. All flour samples were packed and sealed in poly bags at ambient room temperature for further

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analysis. The research work was performed in Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj, U.P, India.

2.2 Composite flour proportion

Different ratios of finger millet flour, rice flour, and guar gum flour were used to make blends, as shown in Table 1. Five mixtures were produced in consideration of the extruder's smooth flowability based on preliminary tests. In addition to physical qualities and nutritional value, product appearance was also assessed.

Table 1 Standardization of Formulation

Sr. No	**Sample**	**Rice and Ragi (Flour %)**	**Guar Gum Flour (%)**
1.	T0	50:50	0
2.	T1	47.5:47.5	5
3.	T2	45:45	10
4.	T3	42.5:42.5	15
5.	T4	40:40	20

2.3 Moisture Content

The moisture content (%) was determined as per AOAC method using hot air oven. Test sample was taken in Petri dishes at a temperature of 100°C-105°C, kept inside the oven for 4 hours. Petri dish was transferred into dessicator for cooling. Final weight of Petri dishes was noted.

2.4 Ash Content

The approach was used to determine the ash content (AOAC, 2005). The sample of ash was weighed in crucible dishes at a quantity ranging from 3 to 5 g. After that, the samples were heated in a Furnace at a temperature at 550 degrees Celsius for five hours. After being allowed to cool, the samples were then weighed, and the percentage of ash was determined.

2.5 Fat Content

Fat content was determined by the sample's fat loss weight (AOAC, 2002). Semi-continuous solvent extraction is the Soxhlet method. In this procedure, the samples were totally soaked for 5 to 10 minutes in a solvent before being returned to the distillation flask. After the solvent was completely extracted, it was evaporated, dried, and weighed. At 70°C, the

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extraction procedure was continued for almost four hours. After the solvent was completely extracted, it was evaporated, dried, and weighed.

2.6 Protein Content

The protein content was evaluated using the AOAC technique from 2005. In this procedure, food material was thoroughly digested with a strong acid, and nitrogen was released during this process, which was calculated using the titration technique. Using a conversion factor based on the nitrogen concentration of the food, the protein content was determined (Maehre et.al. 2018).

2.7 Swelling Capacity

The approach outlined in was used to determine swelling capacity (Chandra and Samsher 2013). A 100-ml graduated cylinder was filled to the 10-ml mark with a sample of flour. 50 cc of distilled water were added to make up the whole volume. The measuring cylinder's top was tightly covered, and mixing was achieved by rotating the cylinder. After 2 minutes of suspension, the sample was inverted and allowed to stand for an additional 8 minutes before its volume was measured. The swelling capacity was computed using Equation (1):

$$SC(\%) = \frac{Wrw}{Ws} \times 100 \ldots\ldots\ldots\ldots (1)$$

Where, Wrw is weight of sample along with retained water while Ws is weight of the sample.

2.8 Water Absorption Capacity (WAC)

The capacity to absorb water of flour was measured in accordance with (Sosulski, and Slinkard 1976). One gramme of sample was combined with ten millilitres of distilled water and left to stand at room temperature for thirty minutes. The material was then centrifuged for 30 min at 3000 revolutions per minute. The resultant liquid was decanted and drained for 30 minutes to eliminate excess moisture. The centrifugation tubes were weighed once more, and WHC was computed using Equation (2):

$$WHC(\%) = \frac{(W2-W1)}{W0} \times 100 \ldots\ldots\ldots\ldots (2)$$

Where, w_2 is the weight of the tube and sediments, w_1 is the weight of tube and w_0 is weight of sample.

2.9 Bulk Density (BD)

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The bulk density was measured in accordance with (Jones, et al., 2000). A known weight of sample flour was placed in a pre-weight (w1) measuring cylinder, and both the cylinder's weight (w2) and the flour's volume (v1) were recorded. The bulk density was determined as the ratio of sample weight to measuring cylinder volume using Equation (3):

$$BD(g/ml) = \frac{(W2-W1)}{v1} \ldots\ldots\ldots\ldots (3)$$

2.10 Foaming Capacity (FC)

Foaming capacity was determined by the subsequent: (Narayana and Narsinga 1982). 1 g of flour was added to 50 ml of distilled water at 30 2 degrees Celsius in a graduated cylinder. Five minutes were spent mixing and shaking a suspension to produce foam. Using Eq. (4), the volume of foam 30 seconds after whipping was represented as foam capacity:

$$FC(\%) = \frac{Volume\ of\ foam\ AW - Volume\ of\ foam\ BW}{Volume\ of\ foam\ BW} \times 100 \ldots\ldots\ldots\ldots\ldots (4)$$

Where, AW is after whipping and BW is before whipping.

2.11 Oil Absorption Capacity (OAC)

Estimated oil absorption capability was proposed by (Sosulski, et al., 1976). One gramme of sample was combined with ten millilitres of vegetable oil and allowed to stand at room temperature. The sample was centrifuged at 2500 rpm for 30 minutes. The oil absorption was measured as a proportion of oil bound per g of material.

$$OHC(\%) = \frac{(W2-W1)}{W0} \times 100 \ldots\ldots\ldots\ldots (5)$$

Where, w_2 is the weight of the tube and sediments, w_1 is the weight of tube and sample and w_0 is weight of sample.

2.12 Statistical Analysis

The experiment was conducted three times. The significant differences were determined using one-way ANOVA. Analysis of variance was performed to identify statistically significant (p 0.05) changes in the physical and functional attributes of composite flour samples.

3. Results and Discussion

3.1 Proximate analysis

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The approximate composition of the composite flour preparation raw materials, finger millet, rice, and guar gum flour, is presented in Table 2. Samples of finger millet flour, rice flour, and guar gum flour had respective moisture levels of 11.2%, 11.3%, and 11.9%. The ash concentration of finger millet, rice, and guar gum flour samples is 2.1 percent, 1.37 percent, and 1.4 percent, respectively. Guar gum flour contains the most fat at 2.5%, followed by finger millet flour at 2.4% and rice at 1.5%. The highest protein concentration was found in guar gum flour at 23.8%, followed by finger millet flour at 8.1% and rice at 6.8%.

Table 2 Proximate compositions of raw materials

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)
Finger Millet	11.2	2.1	2.4	8.1
Rice	11.3	1.3	1.5	6.8
Guar gum	11.9	1.4	2.5	23.8

The values are expressed as the mean of three replicate samples ± standard deviation

3.2 Physical and Functional properties of composite flour

Fig. 2 shows the result of moisture content of the composite flour that ranged from 10.7% to 11.1% compared to reported value of 11 % to 15 % depending upon storage conditions and hygroscopic nature of flour. Recommend moisture content level for safe storage is 14 % and the level of moisture content in this research is below 14 %. The moisture content should be below 14 % to prevent microbial growth and chemical changes during storage (Shahzadi *et al.*, 2005). Ash content of composite flour ranged from 1.11 % to 2.22 % and maximum ash content was observed in T4 composite flour and minimum ash content in T0 composite flour as shown in Table 3. In T4 guar gum flour level was higher than in T0. It can be concluded that ash content increases as the level of guar gum flour is increased. Similar results were obtained by (Butt *et al.*, 2007) for ash content at different level of guar gum incorporated composite flour.

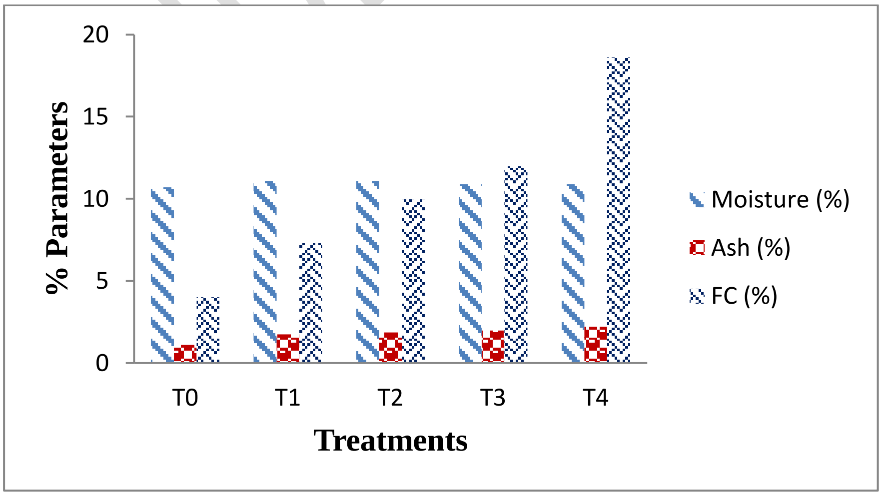

Fig. 2 Functional properties of composite flour (T0, T1, T2, T3 & T4)

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Swelling capacity (SC) in the composite flour ranged from 6.93 g/g to 7.49 for g/g for T4 and T0 shown in Fig. 3. In composite flour T0 is without guar gum flour and T4 composite flour have 20 % guar gum flour. Swelling capacity decreased as the level of guar gum flour increased. Similar observation was made in a research study by (Gong *et al.*, 2021). Swelling capacity is often related to their protein and starch content (Woolfe 1992) High protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restrict the swelling capacity (Aprinita *et al.*, 2009).

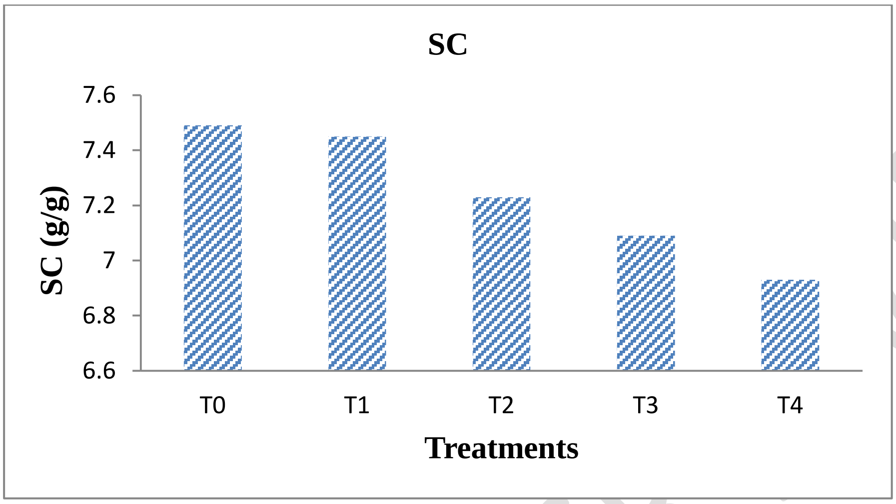

Fig. 3 Swelling properties of composite flour

Water absorption capacity is an important parameter during processing and has implication for viscosity. It is also important for bulking and consistency of product. As shown in Fig.5 water absorption capacity for composite flour ranged from 106 % to 364 % for T0 to T4. Lowest WAC was recorded for T0 composite flour (106%) and highest WAC for T4 composite flour (364%). Therefore, it is found that increase in concentration of guar gum linearly increased water absorption capacity of flour. These results were expected due structural modification in flour due to incorporation of guar gum which allows more water absorption due to hydrogen bonding (Ognean *et al.*, 2016). High water absorption capacities of flour help to maintain the freshness of food products. This similar observation was made in research study by (Akinola *et al.*, 2017) and (Tharise *et al.*, 2014). As shown in Table 3, results of analysis also showed that bulk density ranged from 0.815 g/ml to 0.869 g/ml respectively; with T0 showing the highest bulk density and T4 is showing the lowest bulk density. It has been observed that high bulk density is a desirable characteristic for the packaging of food materials of high nutrient content (Hassan *et al.,* 2013). The results agree with finding of (Akinola *et al.*, 2017) & (Wolu 2017).

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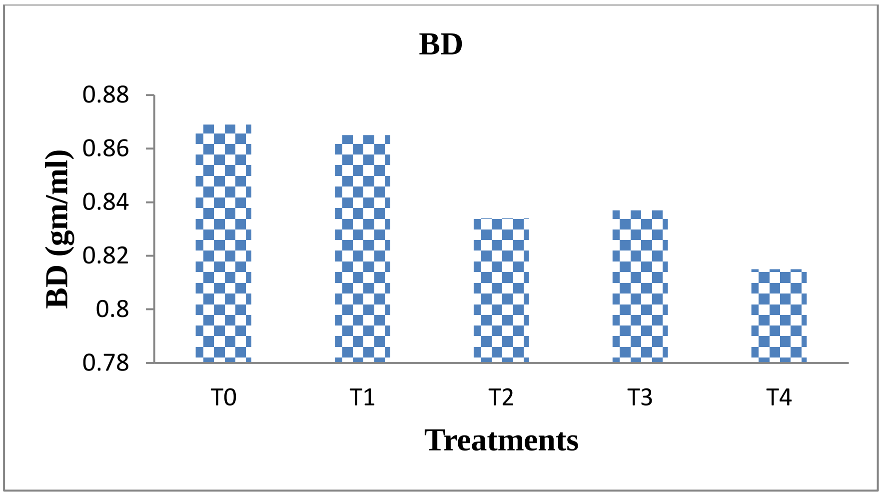

Fig. 4 Bulk density of composite flour

Foaming capacity (FC) ranged from 4.0% to 18.6% with T0 sample having the least value 4.0% as shown in Table 3. Product formability is related to the rate of decrease of surface tension of air/ water interface cause by absorption of protein molecules. Foam capacity shows the level of adsorbed air on the air liquid interface during whipping or bubbling, and by ability to its form a cohesive viscoelastic film by way of intermolecular interaction (Zhou *et al.*, 2011). This finding agrees with the observation of (Chidinma and Okafor 2015) & (Elmoneim *et al.*, 2007).

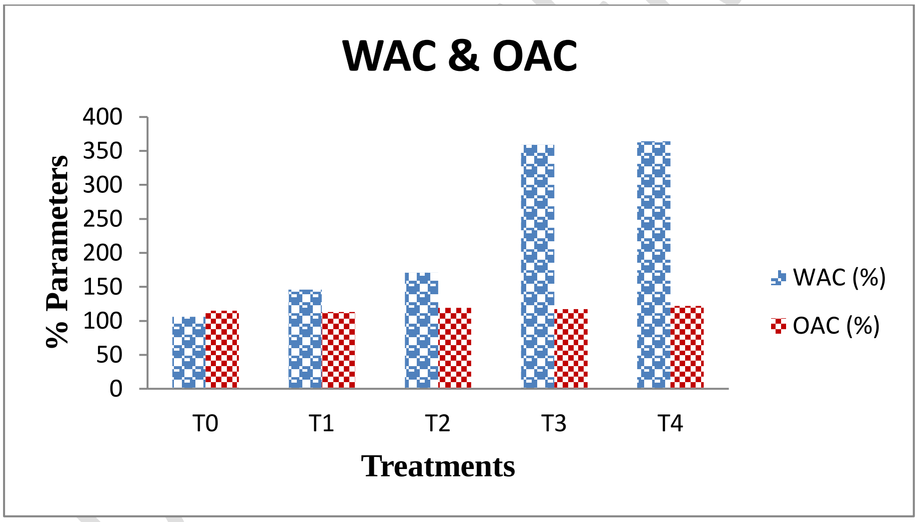

Fig. 5 Water absorption and Oil absorption capacity of composite flour

Table 3 shows the oil absorption capacity [OAC] of composite flour in various treatments. Oil absorption capacity is importance since oil act as a flavour retainer and increases the mouth feel of foods, improvement of palatability and extension of shelf life (Aremu *et al.*, 2007). Oil absorption capacity of composite flour ranged from 115% for T0 to 122% for T4. The highest oil absorption capacity for composite flour was found in T4 and lowest oil

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absorption capacity for composite flour was found in T0. This finding agrees with the observation of (Tharise *et al.*, 2014) & (Zhou *et al.*, 2011).

Table 3 Physical and Functional properties of composite flour

Sample	**Moisture (%)**	**Ash (%)**	**SC (g/g)**	**WAC (%)**	**BD (g/ml)**	**FC (%)**	**OAC (%)**
T0	10.7	1.11	7.49	106	0.869	4.0	115
T1	11.1	1.75	7.45	146	0.865	7.3	113
T2	11.1	1.87	7.23	171	0.834	10.0	119
T3	10.9	1.98	7.09	359	0.837	12.0	117
T4	10.9	2.22	6.93	364	0.815	18.6	122

The values are expressed as the mean of three replicate samples ± standard deviation. Values with similar superscripts in a column do not differ significantly ($p \leq 0.05$).

4. Conclusion

Functional properties of composite flour were determined by the proportions of Ragi, Rice & Guar gum flour. Blends of Finger millet flour, Rice flour & Guar gum flour had a dramatic influence on all functional properties. The higher level of guar gum flour increased the water absorption capacity, foaming capacity and oil absorption capacity and decreased the swelling capacity and bulk density. Composite flour may be used by food processors for the development of the different bakery, confectionary, breakfast, cereal products etc for all people including those in urban areas suffering from different types of health ailments.

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