Correlation between Rice and Maize Flour based on Physicochemical, Functional and Pasting Characteristics

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Abstract—*Rice and maize are the most important crops in the world because of their food utilization. The present study was conducted to correlate the characteristics of rice and maize flour. Proximate composition, functional and pasting properties of flours was related to each other using Pearson correlation. Maize flour had significant ($P \leq 0.05$) higher ash, fat, protein and fiber content than rice flour, whereas total carbohydrate of rice was significantly ($P \leq 0.05$) higher than maize flour. Non-significant difference was observed between both the flours for their functional properties. Except pasting temperature, maize flour had significant ($P \leq 0.05$) higher pasting properties including peak, trough, breakdown, final and setback viscosities. It can be concluded that both the flours possess nutritional profile and had some functional properties and good pasting properties. All these properties showed that both the flours are favourable for human consumption and have useful application in food systems.*

Keywords: *Rice, Maize, Correlation, Proximate, Functional, Pasting properties*

1. INTRODUCTION

Cereals belong to the family Poaceae. Their importance to humans is because they are staple food crops in most areas of the world [1]. About 50% of the daily calories are obtained through cereal grains ingested by people globally. The most important cultivated cereals include wheat, rice, maize, barley, oats and rye. In India, among the cereals rice and maize are grown in most areas. These are main source of carbohydrate to the indian people. India ranks second for the production of rice in the world with a production of 157.8 million MT [2]. On the other hand, India also has the privilege of being the 9th largest producer of maize in the world, with a production of 22.26 million MT [2].

In view of the increasing utilization of these flours in composite flours for the formulation in various new food products, their functional properties including oil absorption, water absorption, foaming capacity and foaming stability etc. are assuming a great importance. Functionality has been defined as any property of a food ingredient, except that of its nutritional values, that has a great impact on its utilization [3]. The applications of rice and maize flours as functional ingredients in some foods like that of extruded snacks, cakes, breads, pasta, biscuits, doughnuts and tortillas have been reported by large number of authors [4, 5]. The aim of this study was to correlate between rice and maize flour on the basis of chemical composition, functional properties and pasting properties and its utilization for the development of various products.

2. MATERIALS AND METHODS

2.1. Materials

Local varieties of rice (paddy) and the corn (maize) were bought from the market of Sangrur, Punjab, India. Seeds were cleaned from the dirt, foreign material etc and stored at room temperature until further use. The milled rice was ground to flour in a hammer mill, passed through a 60-mesh (British standard) sieve. Reagents used in this study were of analytical grade.

2.2. Proximate composition

Protein (920.87), fat (920.85), crude fiber (978.10), ash (923.03), and moisture (925.10) contents were determined according to standard methods of AOAC [6].

2.3. Functional properties

Water and oil absorption capacity was determined with slight modification to the method of Wani et al. [7] as modified by Wani and Kumar [8]. Foaming properties were determined according to the method of Okaka and Potter [9].

2.4. Bulk density

Bulk density was measured as a ratio of mass to volume. A graduated cylinder, previously tarred, was gently filled upto 10 ml mark with flour sample. This was then packed by gently tapping the cylinder on the bench top until there was no further diminution of the sample level and noted the volume.

The weight of the filled cylinder was taken and the bulk density was calculated as the weight of sample per unit volume (g/ml).

2.5. Pasting properties

Pasting properties were studied by using Rapid Visco Analyzer (Perten, UK). Viscosity profiles of flours were recorded using flour suspensions (3.5 g/25 g). The sample was heated from 50 to 95 °C at 6 °C per min after equilibrium time of 1 min at 50 °C and a holding time of 5 min at 95 °C. The cooling was carried out from 95 to 50 °C at 6 °C per min with a holding for 2 min at 50 °C. Parameters recorded were pasting temperature, peak viscosity, trough viscosity (minimum viscosity at 95 °C), final viscosity (viscosity at 50 °C), breakdown viscosity (peak viscosity -trough viscosity) and setback viscosity (final viscosity - trough viscosity).

2.6. Statistical analysis

The data reported in all of the tables are the averages of triplicate observations. Statistical analysis of the results was done using the commercial statistical package (Trial Version, SPSS 281 Inc., Chicago USA). Duncan's test was applied to determine the differences between means. Pearson's correlation coefficients of properties of flour were carried out to establish relationship between variables.

3. RESULTS AND DISCUSSION

3.1. Proximate composition

The proximate composition of rice and maize flour are presented in Table 1. As shown from the table, maize flour had significant (P≤0.05) higher value of ash (0.88±1.43±0.0), fat (4.32 ±0.13), protein (8.86±0.87) and fiber (2.00±0.06) as compared to rice flour, whereas rice flour had significant (P≤0.05) higher percentage of total carbohydrate (88.82±1.3) as compared to maize flour. The proximate composition of rice flour was in accordance with the result obtained by Prasad et al. [10] for rice flour (Pusa 1121), and proximate composition of maize flour was in accordance with the results of Edema et al. [11].

Table 1: Proximate composition of flour

Parameters	Rice	Maize
Moisture (%)	$11.67{\pm}0.62^a$	$11.57{\pm}0.98^a$
Ash (%)	$0.88{\pm}0.01^b$	$1.43{\pm}0.0^a$
Fat (%)	$1.99{\pm}0.07^b$	$4.32{\pm}0.13^a$
Protein (%)	$7.38{\pm}0.12^b$	$8.86{\pm}0.87^a$
Fiber (%)	$0.91{\pm}0.02^b$	$2.00{\pm}0.06^a$
Total carbohydrate (%)	$77.17{\pm}1.3^a$	$71.82{\pm}1.54^b$

Values are means ± SD of 3 replications. Means figures in a row followed by different superscripts indicate that they are significantly (P≤0.05) different with each other determined by Duncan's tests.

3.2. Functional properties

The functional properties play important role in the production of different types of products. Functional properties of rice and maize flour are shown is Table 2.

The water absorption capacity (WAC) of flour has an important role in the food product development, as it influences other functional and sensory properties. The WAC for rice flour was found to be 1.94g/g, the result was in accordance with the result obtained by Chandra and Samsher [12] for rice flour and the WAC of maize flour were found to be 1.81g/g, which was in accordance with results of Edema et al. [11] for maize flour (1.94g/g). The WAC is directly correlated to their cooking properties and affects their food processing properties. Kaur and Singh [13] reported that it is the hydrophilic components, like polysaccharides which have high WAC. The protein quality of flour also affects their WAC. WAC of both the rice and maize flour was high, which could be attributed to the presence of greater amount of hydrophilic constituents like soluble fiber and lower amount of fat content [14].

The oil absorption capacity (OAC) of flour is important as it improves the mouth feel and keeps the flavor. The OAC of rice flour was found to be 1.50g/g, similar results for rice flour were found by Chandra and Samsher [12] (1.24g/g) and that of maize flour was 1.41g/g as shown in Table 2, similar results were observed by Adedeji et al. [15] and Shad et al. [16] for maize flour. A non-significant difference of OAC was observed among the flours. Hydrophobic proteins play the main role in oil absorption. The OACs of different flours are influenced by particle sizes, starch and protein contents, protein types [17], and non-polar amino acid side chain ratios on the protein molecule surface [18].

Foaming capacity is assumed to be dependent on the configuration of protein molecules. It has been found that flexible proteins have good foaming capacity and highly ordered globular molecule gives low foam ability [19]. Foaming capacity and stability generally depend on the interfacial film formed by proteins, which maintains the air bubbles in suspension and slows down the rate of coalescence. The foaming capacity and foaming stability of both the flours show a non significant difference. The foaming capacity and stability of rice flour was 3% and 0% where as foaming capacity and stability of maize flour was 7% and 0%, the result of foaming capacity was in accordance to the result obtained by Shad et al. [16] for maize flour. This lowered value of foaming capacity and negligible foaming stability of both the flours indicate that both of these flours possess little amount of proteins especially flexible proteins and may have highly ordered globular molecules.

Akubor and Obiegbuna [20] reported that bulk density of a sample could be used in determining its packaging requirements as this relates to the load the sample can carry if allowed to rest directly on one another. Non significant differences were observed among the bulk densities of the both the flours from different legumes as shown in Table 2. The bulk density for rice flours were found to be 0.83 g/ml, similar results were reported by Juliano et al. [21] for milled rice (0.78g/ml) and Islam et al. [22] for brown rice. The bulk density of maize flour was 0.71 g/ml, same findings (0.70g/ml) were reported by Adedeji et al. [15].

Table 2: Functional properties of rice and maize flour

Parameters	Rice	Maize
Water absorption index	1.94±0.09 [a]	1.81±0.4 [a]
Oil absorption index	1.50 ±0.03[a]	1.4±0.03 [a]
Bulk density	0.83±0.01 [a]	0.71±0.0 [a]
Foaming capacity	3%±0[b]	7%±1 [a]
Foaming stability	0% ±0[a]	0% ±0[a]

Values are means ± SD of 3 replications. Means figures in a row followed by different superscripts indicate that they are significantly (P≤0.05) different with each other determined by Duncan's tests.

3.2. Pasting properties

The pasting properties of maize flour including peak viscosity (2833 cp), trough (2063 cp), breakdown (800 cp), final viscosity (4055 cp) and setback (2052 cp) were significantly (P≤0.05) higher than rice flour, whereas pasting temperature of maize flour was significantly (P≤0.05) lower than rice flour as shown in Table 3. Although both having good pasting properties.

Significantly (P≤0.05) higher peak viscosity of maize flour than rice flour could be attributed to its higher starch content. Highest value of trough viscosity was observed for maize flour and the lowest value for rice flour. Trough viscosity is influenced by the rate of granule swelling amylose exudation, and amylose-lipid complex formation [23]. Breakdown viscosity which is a measure of the ease with which the swollen starch granules can be disintegrated, the highest breakdown viscosity was observed for maize flour. Setback viscosity, which is a measure of retrogradation tendency of flours gels on cooling varied significantly (P≤0.05). Retrogradation is the result of hydrogen bonding between starch molecules that have both hydroxyl and hydrogen acceptor sites [24]. The amylose fraction of starch is believed to be responsible for retrogradation, since amylose molecules are free to orient themselves together than are the amylopectin molecules. Retrogradation rate is affected by amylose and amylopectin concentrations, molecular size, temperature and pH. Significantly (P≤0.05) higher protein content of maize flour than rice flour could induce increased protein-starch interaction and consequently tends to increase in pasting temperature.

Table 3: Pasting properties of rice and maize flour

Parameters	Rice	Maize
Pasting temperature °C	79.8±1.9 [a]	71.88±2.1 [a]
Peak viscosity (cp)	881±3.1[b]	2833±7 [a]
Trough viscosity (cp)	690±4.3 [b]	2063±4 [a]
Breakdown (cp)	192±2.1 [b]	800±3 [a]
Final viscosity(cp)	1950±5 [b]	4055±8 [a]
Setback (cp)	1360±6 [b]	2052±6 [a]

Values are means ± SD of 3 replications. Means figures in a row followed by different superscripts indicate that they are significantly (P≤0.05) different with each other determined by Duncan's tests.

3.3. Pearson's correlation coefficient between rice and maize flour

Pearson's correlation coefficient between rice and maize flour for various properties is shown in Table 4. Ash content had a significant (P≤0.05) positive correlation with fat, fiber and bulk density, whereas significant (P≤0.05) negative correlation with total carbohydrate. Fat content was positively (P≤0.05) correlated with protein, fiber, bulk density, peak viscosity, trough viscosity, breakdown, final viscosity and setback, however significant (P≤0.05) negative correlated with total carbohydrate and pasting temperature. Protein displayed significant (P≤0.05) positive effect with oil absorption capacity, bulk density, peak viscosity, trough viscosity, breakdown, final viscosity and setback, whereas negative (P≤0.05) correlation with total carbohydrate, water absorption capacity and pasting temperature. Fiber had significant (P≤0.05) positive correlation with bulk density, peak viscosity, trough viscosity, breakdown, final viscosity and setback. Total carbohydrate showed significant (P≤0.05) positive correlation with pasting temperature and with peak viscosity, trough viscosity, breakdown, final viscosity and setback. Bulk density was positively (P≤0.05) correlated with pasting temperature and negatively correlated with peak viscosity, trough viscosity, breakdown, final viscosity and setback. Pasting temperature was negatively (P≤0.05) correlated with all the pasting properties. However all the pasting properties were positively (P≤0.05) correlated with each other.

Table 4: Pearson's correlation coefficient between proximate, functional and pasting properties

Parameters	Ash	Fat	Protein	Fiber	TC	WAC	OAC	BD	PT	PV	TV	BDW	FV	SB
Ash	1													
Fat	0.91*	1												
Protein	0.8	0.9*	1											
Fiber	0.92*	0.92*	0.69	1										
TC	-0.93*	-0.99*	-0.92*	-0.92*	1									
WAC	-0.36	-0.56	-0.84*	-0.22	0.58	1								
OAC	0.51	0.78	0.84*	0.5	-0.75	-0.83	1							
BD	0.9*	0.97*	0.82*	0.97*	-0.97*	-0.43	0.64	1						
PT	-0.88	-0.99*	-0.91*	-0.91*	0.99*	0.6	-0.77	-0.98*	1					
PV	0.89	1*	0.9*	0.92*	0.99*	-0.57	0.76	0.98*	-1*	1				
TV	0.88	1*	0.89*	0.93*	0.99*	-0.55	0.77	0.98*	-1*	1*	1			
BDW	0.87	0.99*	0.87*	0.93*	0.98*	-0.54	0.78	0.98*	-0.99*	1*	1*	1		
FV	0.89	0.99*	0.9*	0.93*	0.99*	-0.57	0.77	0.98*	-1*	1*	1*	1*	1	
Setback	0.92	0.97*	0.83*	0.92*	0.96*	-0.46	0.75	0.91*	-0.93*	0.95*	0.95*	0.96*	0.95*	1

* Correlation is significant at $P \leq 0.05$ level

Where TC is Total carbohydrate, WAC is water absorption capacity, OAC is Oil absorption capacity, BD is bulk density, PT is pasting temperature, PV is peak viscosity, TV is trough viscosity, BDW is breakdown, FV is final viscosity.

4. CONCLUSIONS"

Significant difference for proximate and pasting characteristics was observed between rice and maize flour indicating that these would require some variation in the processing. Significant positive correlation of fiber, protein and fat was observed with pasting properties. Protein showed positive correlation with oil absorption capacity and bulk density. Both the flour showed higher setback indicating that they cannot be used in products requiring refrigerated storage. Water and Oil absorption capacity of flours were very good making them potentially useful in flavour retention, improvement of palatability and extension of shelf life. One can say that rice and maize flours could be used is development of gluten-free products, which have shown a tremendous marketing potential in recent years.

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