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Mineral composition physicochemical properties, FTIR spectra and scanning electron microscopy of rice flour

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Abstract

The physicochemical properties of rice flour affect the physical and chemical attributes of food during processing. Therefore, it is necessary to understand the physicochemical properties of rice flour. Rice flour had moisture content 10.85 per cent, water activity 0.83, total ash 0.39 per cent, crude protein 6.25 per cent and soluble protein 1.75 per cent. Whereas, crude fibre and crude fat were 0.74 per cent and 0.58 per cent, respectively. Rice flour was light creamish (L* 51.25, a* 2.98 and b* 14.50) with potassium 105.00 mg/100g, magnesium 20.15 mg/100g and calcium 14.25 mg/100g). The FTIR spectra of rice flour was basically indistinguishable in the wave-number range of 4000–400 cm^{-1}. Higher intense region 3734.31 cm^{-1} indicated the presence of no of O-H stretching (water) in the structure. The water content of the rice flour was 10.85 per cent. Peak at 2019.54 cm^{-1}, 1546.96 cm^{-1} and 785.05 cm^{-1} showed the presence of an amine functional group as indicative of protein content. The SEM was conducted at magnification of 1000 x and 1200x. The image of rice flour had some medium to large ellipsoidal, irregular, cubical and polygonal shape and also the cluster bodies represent the presence of starch molecules in the sample. The external chalky and opaque appearance in the rice flour, resulting from air spaces between the starch granules. Whereas, cracked and flaky plate like structure surface represents the presence of protein and indicate the presence of less protein content in the rice flour.

Keywords: Rice flour• FTIR• SEM• Amide• Protein• Minerals

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Introduction

Rice is an important cereal grain and is one of leading food crops in the world. Rice is a member of the family Poaceae (Gramineae). Rice is a staple food in many Asian countries. South Asia alone produces about 30 % of global rice production. Rice flour and rice starch have a unique characteristics. The physicochemical properties of rice affect the physical and chemical attributes of food during processing (Falade *et al*. 2014). The functional properties of rice grains such as pasting profiles, texture, water holding capacity and cooking characteristics are important factors which determine the end use and marketing of rice grains flour. It has also many beneficial properties as it is easy to digest, has mild taste and hypoallergenic properties and also provides 45 per cent of calories and 40 per cent total protein requirement of an average population (Wang *et al*. 2018)

Materials and Methods

Procurement of raw materials

Rice flour was procured from the Solan market (HP) and brought to the laboratory of Department of Food Science and Technology for the further studies.

Physicochemical properties analysis

The chemical composition in terms of moisture, ash, fat, crude fibre and protein was determined as described by AOAC, (2000). The protein content of rice flour was calculated based on nitrogen content (N%X6.25). Whereas, Colour of samples was measured in a Lovibond Colour Tintometer Model PFX-I series spectrocolourimeter in which RYBN colour units were obtained along with CIE readings i.e. L^* a^* and b^* values.

Minerals estimation

The dry ashing method was used for mineral estimation. The ground sample was placed into a crucible overnight in an electric muffle furnace; the temperature was maintained between 410 to 440 ^{0}C. Ashing was done to destroy all of the organic materials present in the sample. The ash was removed from the crucible and allowed to cool in desiccators. Two gram of ash was digested with a mixture of HCl and nitric acid in the ratio 1:3. The digested sample was dissolved in 50 ml of distilled water and used for the assay of trace elements such as iron, calcium, zinc, copper, cobalt, manganese and magnesium through atomic absorption spectrophotometer (Rajasekaran *et al.* 2005).

Fourier Transforms Infrared (FTIR) Spectroscopy analysis

For the qualitative analysis of different samples subjected to FTIR analysis (Shimadzu 8400S FTIR spectrometer, equipped with KBr beam splitter) using approximately 5 mg of each sample along with 5 mg KBr. FTIR spectrophotometer was operated at a spectral range of 4000–400 cm^{-1} with a maximum resolution of -0.85 cm^{-1}. The spectra so obtained for the respective samples were interpreted as per the guidelines given by Stuart (2004).

Microstructure (SEM)

The morphology of sample was evaluated using a EmCraft (Korea): Table-top scanning electron microscope (SEM Cube-1000). Samples were dehydrated by putting them into critical point drying equipment or freeze dried. The mucilage powder was fixed in an aluminum plate (specimen holder), using an electrically conductive tap and a coating of gold at 10 mbar for 90 s was applied. Each sample was transferred to microscope for observation. The procedure was applied to gain information about the arrangements of particle that correlated with structure of samples. The microscope was operated at 5 kV and different levels of magnification: 1000X and 1200X.

Statistical analysis

All the analytical parameters were recorded in triplicates and the mean value of each parameter was described. The data of quantitative estimation of biochemical characteristics were assessed by RBD using two factors analysis of variance (AOVA) with the help of OPSTAT software (Cochran and Cox 1967).

Results and Discussion

Physicochemical composition

Moisture content of the flour is an indicator for shelf life of flour as it encourages microbial prolifiration that lead to spoilage. However, the quality factor for flour should have maximum moisture content of 15 per cent (Codex STAN 152) and perusal of data in Table 1 for moisture content as well as water activity of rice flour was 10.85 per cent and 0.83. Ash content indicated the presence of nutritionally important mineral elements presented in rice flour was 0.39 per cent. Whereas crude protein, soluble protein, crude fibre, crude fat, carbohydrate and energy value were 6.25 per cent, 1.75 per cent, 0.74 per cent, 0.58 per cent, 81.19 per cent and 354.98 Kcal/100g respectively. The results were in conformity with finding of Tharise *et al*. (2014) reported rice flour constitutes moisture (12.85%), ash (0.39%), protein (5.14%), fat (0.58%) and fibre (0.74%). Similarly, Ahmed *et al*. (2016) reported that rice flour contained 4.47 per cent moisture, 0.52 per cent ash, 8.93 per cent protein and 1.41 per cent fat.

Table 1. Physicochemical composition of rice flour

Parameters	**Observations (Mean ± SE)**
Moisture (%)	10.85 ± 0.03
Water activity	0.83 ± 0.02
Total ash (%)	0.39 ± 0.01
Crude protein (%)	6.25 ± 0.03
Soluble protein (%)	1.75 ± 0.02
Crude fibre (%)	0.74 ± 0.02
Crude fat (%)	0.58 ± 0.01
Carbohydrate (%)	81.19 ± 0.85
Energy value (Kcal/100g)	354.98 ± 1.25

Colour value of rice flour

Colour is an important quality attribute in the food industries, and it influences consumer's choice and preferences. Flour CIE L*, a*and b* values are the most important color components for assessing the visual quality of the milled product. The colour values L*, a * and b * of rice flour are shown in (Fig 1). The rice flour was creamish in colour accorded lightness (L *) value 51.25, redness (a*) value 2.98 and yellowness (b*) value 14.50 (Table 2). Our results were confirmatory with the earlier findings of Mohapatra and Bal (2014) reported rice flour lightness (L *) values ranged 41.01-69.05, redness (a*) 2.99-3.28 and yellowness (b*) 14.01-16.99.

Table 2. Colour properties (Lab) of the rice flour

Properties	value
L * (Lightness)	51.25
a * (Redness-greeness)	2.98
b * (Yellowness- blueness)	14.50

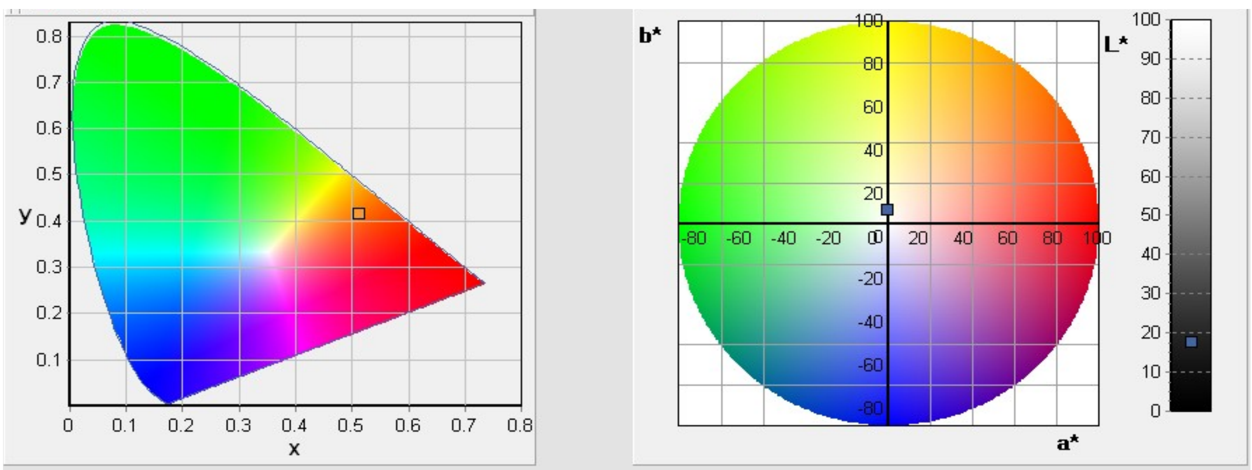

Figure 1. CIE readings of rice flour

Mineral content of rice flour

Minerals are essential component required in the normal diet as it can promote health to an optimum level. Minerals are naturally found in various foodstuffs, and are at higher levels in those, which are grown directly from the soil (e.g. fruits, vegetables, cereals, grains, etc). Results on the mineral content of rice sample evaluated in the present study are presented in Table 3. The rice flour had higher potassium 105.00 mg/100g, sodium 10.25 mg/100g, calcium 14.25 mg/100g and magnesium 20.15 mg/100g content. Whereas iron, zinc, copper and manganese contents were 1.75 mg/100 g, 2.64 mg/100g, 0.58 mg/100g and 0.81 mg/100 g, respectively. Our results are in confirmatory with the results of Thomas *et al*. (2015) reported 84.02 mg/100g potassium, 6.11 mg/100g sodium, 11.85 mg/100g calcium, 0.54 mg/100g iron, 13.49 mg/100g magnesium, 0.16 mg/100g zinc, 0.54 mg/100g copper and 0.81 mg/100g manganese in rice flour.

Table 3. Mineral content of rice flour

Parameters	Observation (Mean±SE)
Potassium (mg/100g)	105.00 ± 1.15
Sodium (mg/100g)	10.25 ± 0.82
Calcium (mg/100g)	14.25 ± 0.90
Iron (mg/100g)	1.75 ± 0.25
Magnesium (mg/100g)	20.15 ± 1.25
Zinc (mg/100g)	2.64 ± 0.32
Copper (mg/100g)	0.58 ± 0.12
Manganese (mg/100g)	0.81 ± 0.10

FTIR spectra of rice flour

FTIR spectroscopy is one of the most important analytical techniques available today to virtually study physicochemical and conformational properties of any sample (Stuart, 2004). The FTIR spectra of rice flour showed (Fig 2) at higher intense region 3734.31 cm^{-1} indicated the presence of number of O-H stretching (water) in the structure. The water content of the rice flour was 10.85 per cent. Whereas similar intense peak was at 1740.78 cm^{-1} indicated the presence of C=O stretching had hydrogen bonding and conjugation within the molecules.

Table 4. FTIR frequencies and their peak assignments for the spectra of rice flour

Peak	Area	Compounds
443.64	23.80	P-S stretching
569.02	3.04	P-Cl stretching
665.46	6.23	C-H (alkyl bromide)
785.05	0.24	NH_2 wagging
1020.38	8.75	C-C stretch of starch
1396.51	3.27	S=O sulphate
1456.30	2.76	Methyl scissory
1516.10	14.98	Aromatic nitro compound NO_2 asymmetrical stretching
1546.96	8.24	First overturn N-H stretching (amide III)
1741.78	19.24	Aliphatic aldehyde C=O stretching (Aldehyde and ketone)
2019.54	10.58	Combination N-H stretching, Combination O-H stretching
2922.25	27.39	O-H stretching (Carboxylic acid)
3734.31	19.01	O-H stretching (Water)

According to the infrared spectral absorption (Table 4) the N-H bonds at peak 2019.54 cm^{-1}, 1546.96 cm^{-1} and 785.05 cm^{-1} showed the presence of amine functional group as indicative of protein content. Starch content is one of the major constituent of the flours. Spectra of starches band originate mainly from the vibrational modes of amylase and amylopectin because these are the main components of starch and peaks were observed in the regions below 800 cm^{-1}, 800 to 1500 cm^{-1} (finger print region). Raharja *et al*. (2018) had studied the FTIR spectra of rice flour and observed that rice flour had five spectrum peaks that can represent functional groups in the sample. The spectrum showed the presence of O-H groups in the wavelength range 3385.64-3393.27 cm^{-1}, C-H at 2929.29-2930.50 cm^{-1}, N-H at the range of 2150.71-2154.20 cm^{-1}, C=O in the range of 1650.01-1655.52 cm^{-1}, and C-N at the range 1155.48-1155.22 cm^{-1}, respectively. Sevenou *et al*. (2002) had also reported that bands at 1047 and 1022 cm^{-1} respectively described the indices of crystalline and amorphous of starch in the sample. Whereas, the absorption peaks at wave numbers of 1400 and 1800 cm^{-1} were the characteristic of amide bands and the band 3400 cm^{-1} characterized the deformation vibrations of H_2O molecules in the sample.

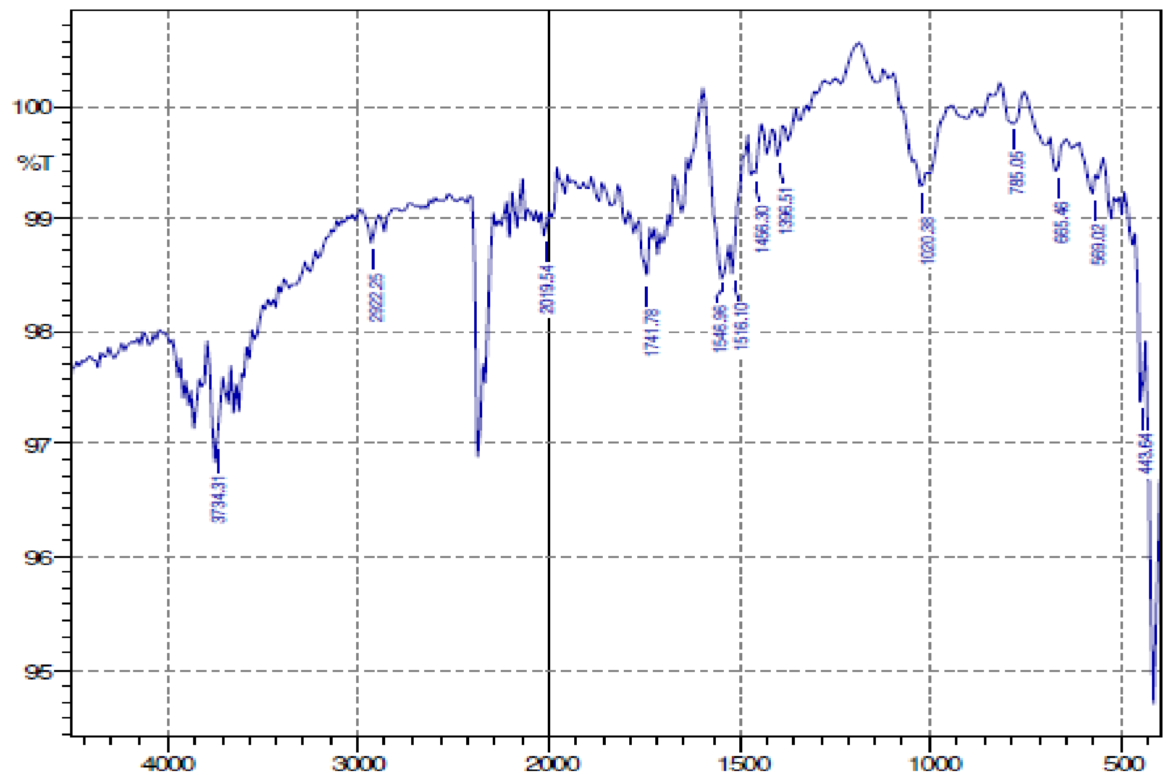

Figure 2. FTIR spectra of rice flour

Scanning Electron Microscopy (SEM) of rice flour

The microstructure examination is conducted to study the magnification under scanning electron microscopy (SEM) which determines the microstructure, chemical composition and physical (size and shape) characterizations. The SEM was conducted at magnification of 1000 x and 1200x. The image (Fig 3) for rice flour reveals that, the rice flour had some medium to large ellipsoidal, irregular, cubical and polygonal shape and also the cluster bodies represent the presence of starch molecules in the sample. The external chalky and opaque appearance in the rice flour, resulting from air spaces between the starch granules. Whereas, cracked and flaky plate like structure surface represented the presence of protein and indicated the presence of less protein content in the rice flour. Our results are confirmatory with the earlier reporting of Kang *et al*. (2015) and Majzoobi *et al*. (2016) studied the scanning electron microscopy (SEM) of rice starch granules and rice flour, respectively.

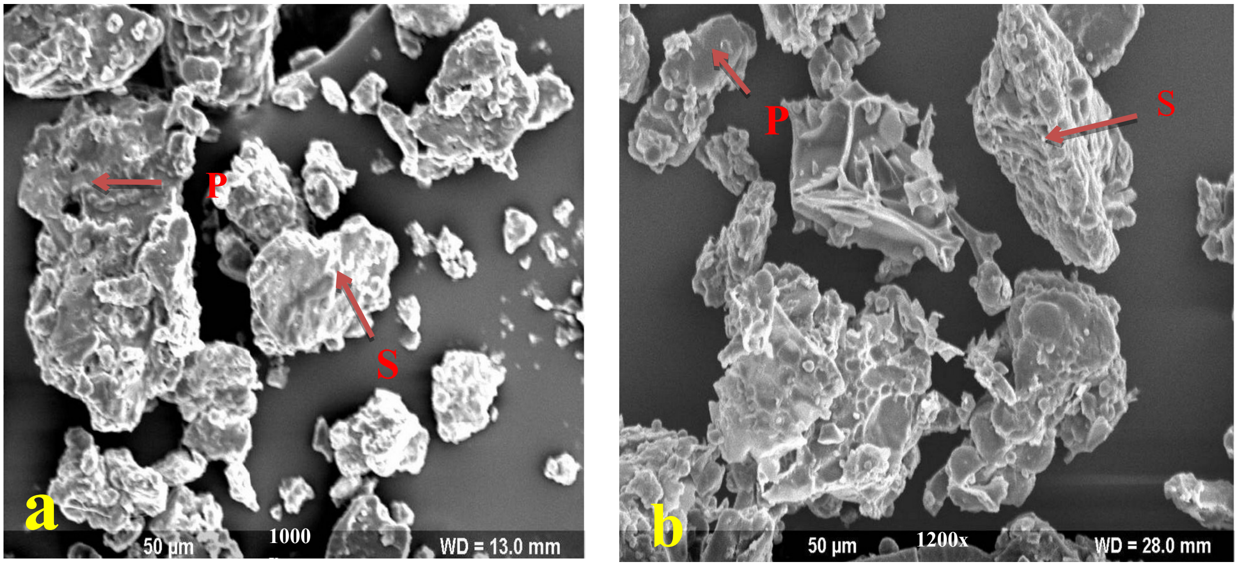

Figure 2. Scanning electron microscopy (SEM) of rice flour
2a) magnification 1000x, 2b) magnification 1200 x: P- Protein, S- Starch

Conclusion

The research indicated that the rice flour had the good physicochemical properties, higher mineral content and good FTIR spectra. Similarly, it also showed good scanning electron microscopy which indicate the presence of protein and starch content in the rice flour. It has also many beneficial properties as it is easy to digest, has mild taste and hypoallergenic properties and also provides 45 per cent of calories, so can be easily used as raw ingredient for making different food products.

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