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EFFECT OF MUNG BEAN AND RICE ON PHYSICO-CHEMICAL, SENSORY AND MICROSTRUCTURAL PROPERTIES OF CEREAL BARS

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ABSTRACT

Cereal bars were formulated using dry raw materials (mung bean and rice). The bars were mixed with dry ingredients at different percentages. The physico-chemical, sensory and microstructural properties of cereal bars after mixing were investigated. The consumer acceptability of the cereal bars were carried out using 9-hedonic scale. All the qualities evaluated significantly ($p \leq 0.05$) affect the acceptability and preference of the samples.

1. Introduction

In the present era, consumers are getting more aware about health foods with balanced nutrition. This has diverted the attention of food researchers towards the development of high quality food products with health benefits. Cereals are known to possess a vital role in day-to-day life and are being utilized in preparation of cereal bars, instants and energy bars as they serve the necessary ingredients to functional foods (Silva et al., 2014). Cereal bars, the most convenient foods often used as alternatives to meet the demand of low-calorie or protein enriched products for athletes (Norajit et al., 2011). These bars are easy to manufacture and generally obtained by compacting cereal flakes viz. rice, maize, oats, barley, along with glucose syrup/sugar, natural/artificial sweetener, and dried fruits (Appelt et al., 2015). The energy bars are multi-component and can be very complex in its formulation. The ingredients must be combined in a specific manner to ensure that they complement each other and results into good taste, texture and physical properties (Murphy, 1995). Many fruits have been used extensively in preparation of cereal bars which results in increased vitamin and mineral content (Silva et al., 2014).

Al-Shahib et al., (2003) reported that date flesh contains significant amount of carbohydrates, proteins, lipids, vitamins and minerals. Bioactive compounds from date polysaccharides can be used as a functional constituent in drug formulations (Chaira et al., 2009). Polyphenolic compounds from dates with antioxidant properties have been studied for its protective effect against lipid oxidation (Moure et al., 2000); controls cardio vascular disease and possess antimutagenic property (Vayalil, et al., 2002). Among cereals, corn has highest antioxidant potential followed by wheat, oat, and rice (Adom and Liu, 2002). On the other hand, barley contains essential bioactive component such as β-glucan which is known to possess positive health benefits as lowering blood cholesterol (Behall et al., 2004; et al.,

1989) and glycemic index (Braaten et al., 1991). Barley is a good source of tocopherols and tocotrienols known to reduce serum cholesterol through their antioxidant action (Qureshi et al., 1986). Hence, this study was undertaken to investigate the effect of mung bean and rice on the physio-chemical, sensory and microstructural properties of cereal bar.

2. Materials and methods

2.1. Raw Materials

The raw materials viz. rice flakes, mung beans, barley, glucose syrup, brown sugar, honey, dry fruit (dates), black cumin, and cocoa butter were procured from a local market of Srinagar, J & K, India.

2.2. Preparation of mung bean flour

Mung beans were thoroughly cleaned, washed and dried at 50^{o}C for 5 hours. The mung beans flour (MBF) was obtained using grinder followed by sieving (60 mesh sieve). The MBF was then packed in high density polyethylene bags for further use.

2.3. Preparation of rice based cereal bars

The dry fruits (dates) were diced and mixed with black cumin powder in mixer followed by addition of rice flakes, barley and MBF along with binding agents (honey and glucose syrup). The contents were heated in an oven at 100^{0} C for 15 minutes. After heating, the mixture was allowed to cool. The cooled mixture was then subjected to cutting of rectangular shape bars (11cm x 3cm x 1.5 cm).

2.4. Proximate analysis of cereal bars

Proximate analysis of cereal bars was done by AOAC methods (2001).

2.5. Color measurement

Color of cereal bars was measured by a spectrophotometer (COLOR TECH PCM Model: 3001476) equipped with a D65 illuminant using the CIE l*, a* and b* color scale. The samples were placed in the petri dish covered with black container to avoid the external lighting. The measurements were made in triplicate at two random locations on the surface.

2.6. Free Fatty Acids and Water activity (a_w)

Free fatty acids and peroxide values were determined by AOCS (1990) and AOCS (1973) respectively. The water activity of the samples was measured using a water activity meter (Pre Aqua water activity Analyzer Lab) under controlled temperature conditions.

2.7. Sensory properties of cereal bars

Hedonic sensory evaluation of different cereal bars was carried out by semi-trained panelists consisting of 7 members drawn from scholars and staff members of Department of Food Technology, Islamic University of Science and Technology Awantipora Kashmir. The analysis was done on the basis of color, taste, texture, appearance on a nine-point hedonic scale (Meilgaard et al., 2006). Attributes were scored on a scale varying from “9 = like extremely” to “1 = dislike extremely”. Differently coded samples were presented to panel members one at a time and they were asked to rate their hedonic response on the scale. At the end of this phase, marking of individual products were calculated and the best acceptable product was determined.

2.8. Scanning electron microscopy (SEM)

Scanning electron microscopy (SEM) uses a focused electron probe to extract structural and chemical information point-by-point from a region of interest in the sample. The high spatial resolution of an SEM makes it a powerful tool to characterize a wide range of specimens at the nanometer to micrometer length scales. The cereal bars for SEM were dried overnight till a vacuum oven at 65°C to reduce moisture content. They were cut using a razor blade. Two specimens were taken from each sample, with one cut along the longitudinal axis and the other along the cross section. Each specimen was fixed on the aluminum stub with a copper tape, coated with gold-palladium by an SEM sputter coater (Model E5100, Polaron Instruments Inc., Cambridge MA, U.S.A.). A voltage of 2.5 kV and a current of 20 mA were applied for 2 min to deposit a conductive layer of 300 A in thicknesses over the specimen. The specimen was then examined with HITACHI Scanning Electron Microscope (Model S-3000H, Japan) at 5kV. Photographs were taken using Polaroid 55 P/N film.

2.9. Statistical analysis:

Data were analyzed by one way analysis of variance followed by Duncan's multiple range tests. All data were presented as means ± SE. Significant differences were accepted when the P value was less than 0.05.

3. Results & Discussion

3.1. Chemical composition of rice flakes, mung bean flour and barley flour

The chemical composition of rice flakes, mung flour and barley flour is presented in Table 1. The results indicated that rice flakes contained highest amount of carbohydrates (77.7%). The MBF had highest ash (3.79%) protein (24.7%) and crude fiber (7.9%). Similar results were reported by Naivikul et al., (1978). It is also evident from the findings that barley flour contains highest fat (2.45%) and significant amount of crude fiber (5.70%) and ash (2.1%). Similar results were observed by Helm et al., (2004) in chemical characterization of dehulled barley.

Table 1. Proximate composition of rice flakes, mung bean and barley flour

Parameter	Rice Flakes	Mung Powder	Barley Flour
Moisture (%)	15.6 ± 0.02 $^{a, B}$	8.60 ± 0.02 $^{c, C}$	10.5 ± 0.01 $^{b, B}$
Ash (%)	1.0 ± 0.04 $^{c, D}$	3.79 ± 0.04 $^{a, D}$	2.10 ±0.05 $^{b, D}$
Protein (%)	5.9 ± 0.02 $^{c, C}$	24.7 ± 0.02 $^{a, B}$	9.1 ± 0.01 $^{b, B}$
Crude Fat (%)	0.60 ± 0.01 $^{c, D}$	2.13 ± 0.01 $^{b, D}$	2.45 ± 0.01 $^{a, D}$
Crude Fiber (%)	0.60 ± 0.01 $^{c, D}$	7.9 ± 0.01 $^{a, C}$	5.70 ± 0.02 $^{b, C}$
Carbohydrates (%)	77.7 ± 0.04 $^{a, A}$	52.88 ± 0.04 $^{c, A}$	70.15 ± 0.05 $^{b, A}$

Values are expressed as mean ± standard deviation. . Means having different letters within the same column differ significantly at $p < 0.05$.

3.2. Preparation of cereal bars

The selected fruits and cereals were used for preparation of cereal bars are shown in Table 2. The rice based cereal bars were formulated using the rice flakes and MBF (50:0:-T_0, 48:2- T_1, 46:4- T_2, 44:6- T_3, 42:8- T_4,) in specific proportion. The samples were then analyzed for physico-chemical, color and sensory properties.

Table 2. Formulation of cereal bars

Treatments (%)	Rice (%)	Mung (%)	Dates (%)	Barley (%)	Black Cumin (%)	Honey (%)	Glucose Syrup (%)
T_0	50	0	3	3	0.5	25	18.5
T_1	48	2	3	3	0.5	25	18.5
T_2	46	4	3	3	0.5	25	18.5
T_3	44	6	3	3	0.5	25	18.5
T_4	42	8	3	3	0.5	25	18.5

Values are expressed on dry weight basis.

3.3. Effect of Mung flour on proximate composition of Rice based cereal bars

The effect of mung flour on proximate composition of rice based cereal bars is shown in Table 3. It was observed that moisture content increased significantly from 8.98 (T_0) to 14.7% (T_4) with increasing level of mung powder. This increase in moisture may be due to fiber present in mung beans powder. These results are in close agreement with the findings of Agbaje et al., (2014) in apricot-date bars and Ahmad et al., (2005) in papaya fruit bars. The cereal bar containing highest enrichment level possess high ash content (3.08%) while as control sample showed lowest ash content (1.70%). This might be due to the mineral content present in mung powder and barley. Similar results were reported in cereals by Cecchi et al., (2003). It was observed that total carbohydrate content of cereal bars showed a decreasing trend (62.07 – 22.45 %), with increasing level of mung powder. The control sample was observed with highest carbohydrate while as cereal bars with highest incorporation level were found with lowest carbohydrates. The reason for decrease in carbohydrate content in cereal bars might be due to low carbohydrate content of mung powder. Carvalho et al., (2011) depicted the similar results for cereal bars made from almonds of chichai, sapucaia and gurgueia nuts. The total protein content of cereal bars showed an increasing trend from 10.37 to 30.47% with increasing level of mung powder.

Table 3. Effect of Mung bean flour on proximate composition of Rice based cereal bars

Parameter	**T_0 (0%)**	**T_1 (2%)**	**T_2 (4%)**	**T_3 (6%)**	**T_4 (8%)**
Moisture	8.98 ± 0.02 $^{d, D}$	9.9 ± 0.21 $^{d, D}$	11.6 ± 0.10 $^{d, C}$	13.2 ± 0.20 $^{d, B}$	14.7 ±0.18 $^{d, A}$
Ash	1.7 ± 0.04 $^{f, D}$	1.90 ± 0.07 $^{f, C}$	2.1 ± 0.08 $^{f, B}$	2.21 ± 0.11 $^{f, B}$	3.08 ± 0.14 $^{f, A}$
Protein	10.37 ±0.11 $^{c, E}$	12.13 ±0.10 $^{c, D}$	22.4 ± 0.12 $^{b, C}$	26.31 ± 0.16 $^{b, B}$	30.47 ± 0.24 $^{a, A}$
Fat	12.39±0.08 $^{b, D}$	13.05 ± 0.05 $^{b, C}$	14.79 ± 0.14 $^{c, B}$	15.10 ±0.09 $^{c, A}$	15.78 ± 0.18 $^{c, A}$
Fiber	3.86 ± 0.05 $^{e, E}$	5.07 ± 0.04 $^{e, D}$	6.85 ± 0.03 $^{e, C}$	8.59 ± 0.02 $^{e, B}$	12.08 ± 0.01 $^{e, A}$
Carbohydrate	62.07 ± 0.06 $^{a, A}$	57.35 ± 0.05 $^{a, B}$	42.27 ± 0.02 $^{a, C}$	34.35 ± 0.03 $^{a, D}$	22.45 ± 0.02 $^{b, E}$

Values are expressed as mean ± standard deviation. . Means having different letters within the same column differ significantly at $p < 0.05$.

The lowest protein content was observed in control sample (10.37%) while as the protein content increased with the addition of Mung powder (30.47%) in T_4. The increase in protein content might be due to the appreciable amount of protein present in mung powder. Similar variations in protein content was reported by Lobato et al., (2012) in snack bars with high soy protein and isoflavone content. The fat content of cereal bars ranged from 12.39 to 15.78% significantly. The lowest fat content was observed in control sample (12.39%) and the highest fat content was observed in T_4 sample.

3.4. Physicochemical analysis of Rice based Cereal bars

The different parameters like water activity, fatty acids, peroxide value and browning index of the rice based cereal bars are shown in Table 4.

3.4.1. Water activity

The water activity of cereal bars varied from each other. The results indicated variation in water activity within different treatments. The lowest water activity was recorded in T_4 sample with 8% incorporation level of mung powder. While as highest water activity was found in control sample. This reduction in water activity in cereal bars might be due to lower moisture in mung powder. Estevez et al., (1995), reported similar results for water activity in cereal nut bars.

3.4.2. Fatty acids

It is evident from the table that the total fatty acid content of cereal bars showed an increasing trend with increase in concentration of mung powder. The highest fatty acid value of 1.11% was observed in samples containing 8% incorporation level of mung powder and lowest value of 1.05% was found in control sample. The increase in fatty acid value might be due to the amount of fatty acid content present in mung powder. Similar results were reported by Padmashree et al., (2012).

3.4.3. Peroxide value

It was evident from the table that the peroxide value in cereal bars decreases with increasing level of mung powder. The highest peroxide value (5.92 meq O_2/kg oil) was noticed in control sample while as the lowest value (5.60 meq O_2/kg oil) was found in cereal bars having highest level of incorporation. This might be destruction of antioxidants by the steaming of the rice flakes. Similar results have been reported by Shaheen et al., (1995). The results are also in accordance with Padmashree et al., (2013).

3.4.4. Browning index

Browning index of cereal bars showed an increasing trend with highest browning index (0.14 OD) found in T_4 sample and lowest browning index (0.07 OD) was found in control sample. The results are in agreement with the findings of Padmashree et al., (2013) for protein rich composite cereal bars.

3.4.5 Color values of cereal bars

Color analysis of the cereal bars shown in Table 5, depicted that the lightness, redness and yellowness values decreases as the concentration of mung, barley and rice flakes increases. Control sample got the highest value for lightness (l*), redness (a*) and yellowness (b*) respectively which indicated that there is little effect of caramelization and Millard browning in cereal bars. The results are in close agreement with the findings of Murillo et al. (2011).

3.5. Effect of Mung powder on sensory perception of rice based cereal bars

Five parameters viz., appearance, color, taste, texture and overall acceptability were used to analyze the best developed optimized product. The results shown in Table 6 represent the lowest and highest color score for T_4 (5.62) and T_0 (6.64) respectively. This color darkening of cereal bars might be due to sugar caramelization and the Millard reaction between sugars and amino acids. The results are in consonance to the findings of Barros et al., (2011) for cereal bars made from almonds of chichai, sapucaia and gurgueia. The mean value score for taste decreased from 6.92 to 5.61. Lower score for taste in cereal bars is due to the increasing level of Mung powder in as it gives bitter taste and legumes have after taste and beamy flavor. The results are in closer with the findings of Santos et al., (2011) for cereal bars made with jackfruit. The mean sensory score for texture decreased from 6.61 to 5.80. The highest mean score value for texture was found in control sample (6.61) while as lowest mean score for texture was found in 8% incorporation level of mung powder T_4 (5.80). This might be due to fiber in mung powder and may be due to high water absorption capacity of mung powder resulting in dehydration which may increase the cereal bar hardness because of increased 8% level of mung powder. Similar findings were presented by Agbaje et al., (2014) for cereal bars made from glutinous rice flakes and sunnah foods. In appearance of cereal bars, control sample got the highest score (6.66), while as the lowest mean score for appearance was found in T_4 sample (6.64). The decrease in appearance scores might be due to the pigment and lipid oxidation resulting in non-enzymatic browning.

The results were closer to the results of Shaheen et al., (2013) and others for date based fiber enriched bars. The mean values for overall acceptability score of cereal bars indicated that T_2 has maximum 6.52 score. Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, texture, flavor and taste of the cookies. The data in Table-6 outlines that the majority of panelists accept the cookies made of T_2 level which has score of as 6.52 on 9 point scale. The overall acceptability for various treatments is in accordance with the findings of Al-Hooti et al., (1997) who reported overall acceptability score from 6.9 to 7.3. Agbaje et al. (2014) also reported similar results regarding the overall acceptability for cereal bars made from glutinous rice flakes.

Table 4. Fatty acids, Peroxide value, Browning index and Water activity of Rice based Cereal bars

Parameter	**T_0 (0%)**	**T_1 (2%)**	**T_2 (4%)**	**T_3 (6%)**	**T_4 (8%)**
Water Activity (%)	0.590±0.012 $^{a, C}$	0.58±0.012 $^{b, C}$	0.581 ± 0.012 $^{b, C}$	0.577±0.012 $^{c, C}$	0.573± 0.012 $^{c, C}$
Fatty acids (%)	1.05 ± 0.04 $^{e, B}$	1.06 ± 0.07 $^{d, B}$	1.07 ± 0.01 $^{c, B}$	1.09± 0.04 $^{b, B}$	1.11 ± 0.04 $^{a, B}$
PeroxideValue (meqO_2/kg oil)	5.92 ± 1 .04 $^{a, A}$	5.66 ± 1.03 $^{b, A}$	5.64 ± 1.03 $^{b, A}$	5.61 ± 1.01 $^{b, A}$	5.60 ± 1.01 $^{b, A}$
Browning index (OD)	0.07 ± 0.03 $^{e, D}$	0.08 ± 0.04 $^{d, D}$	0.10 ± 0.06 $^{c, D}$	0.12 ± 0.08 $^{b, D}$	0.14 ± 0.10 $^{a, D}$

Values are expressed as mean ± standard deviation. . Means having different letters within the same column differ significantly at $p < 0.05$.

Table 5. Color values of cereal bars

Treatments	**L*(lightness)**	**a*(Redness)**	**b*(yellowish)**
T_0	49.92 ± 3.45 $^{b, A}$	10.96 ± 1.86 $^{c, A}$	50.69 ± 2.40 $^{a, A}$
T_1	48.82 ± 3.02 $^{b, B}$	9.86 ± 1.66 $^{c, B}$	49.59 ± 2.14 $^{a, B}$
T_2	47.72 ± 2.83 $^{b, C}$	8.76 ± 1.46 $^{c, C}$	48.49 ± 1.88 a, C
T_3	46.51 ± 2.57 $^{b. D}$	7.66 ± 1.26 $^{c, D}$	47.39 ± 1.62 $^{a, D}$
T_4	45.52 ± 2.13 $^{b, E}$	6.56 ± 1.06 $^{c, E}$	46.29 ± 1.36 $^{a, E}$

Values are expressed as mean ± standard deviation. . Means having different letters within the same column differ significantly at $p < 0.05$.

Table 6. Effect of Mung powder on sensory perception of cereal bars

Treatments	**Appearance**	**Taste**	**Colour**	**Texture**	**Overall Acceptability**
T_0	6.66±1.03 $^{b, A}$	6.92 ± 1.04 $^{a, A}$	6.64 ± 1.03 $^{b, A}$	6.61 ± 1.01 $^{b, A}$	6.39
T_1	6.59 ± 1.02 $^{b, B}$	6.85 ± 1.03 $^{a, B}$	6.58 ± 1.02 $^{b, B}$	6.33 ± 1.04 $^{b, B}$	6.43
T_2	6.33 ± 0.97 $^{c, C}$	6.70 ± 1.02 $^{a, C}$	6.40 ± 1.01 $^{b, C}$	6.24 ± 1.03 $^{d, C}$	6.52
T_3	5.98 ± 1.03 $^{c, D}$	6.08 ± 1.02 $^{b, D}$	6.08 ± 1.02 $^{b, D}$	6.09 ± 1.01 $^{a, D}$	6.19
T_4	5.54 ± 1.04 $^{c, E}$	5.61 ± 1.03 $^{b, E}$	5.62 ± 1.01 $^{b, E}$	5.80 ± 1.04 $^{a, E}$	5.97

Values are expressed as mean ± standard deviation. . Means having different letters within the same column differ significantly at $p < 0.05$.

3.6. Scanning electron microscopy (SEM) of rice based cereal bars

The micrographs of cereal bars are shown in Fig 1, 2 & 3. Samples stored under PP showed a spongy (Comb Like) appearance while the samples stored under PFP showed less sponginess. The formation of a gel like network in treated sampled stored under PFP is indicative of the agglomeration of the protein network. A more compact and dense structure is formed upon PFP which is evident from micrographs. The micrograph (Fig. 1A) of the control sample also had spongy appearance while the treatment sample packaged under PFP conditions had more compact appearance than all other formulations.

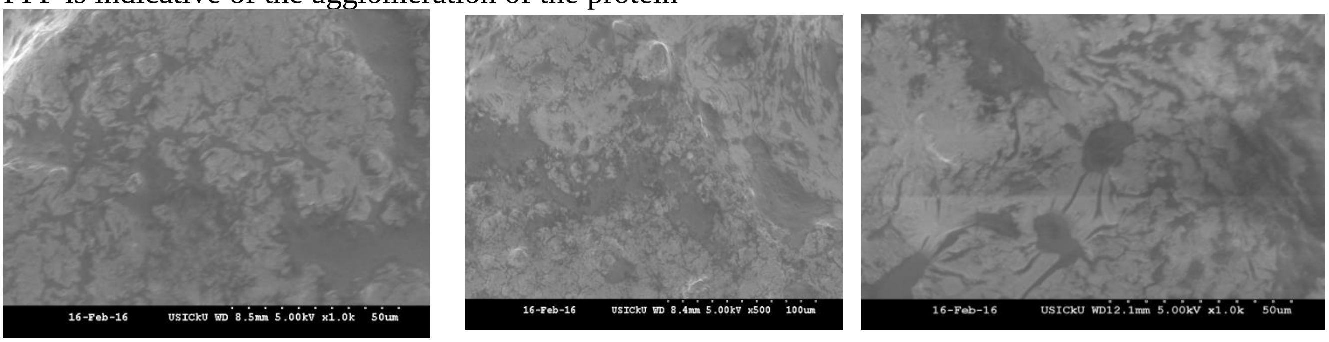

Figure 1. (A) (B) (C)

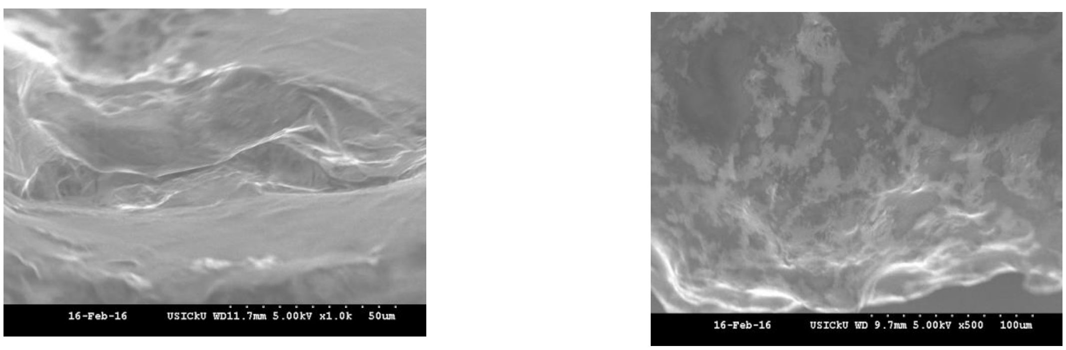

Figure 2. (A) (B)

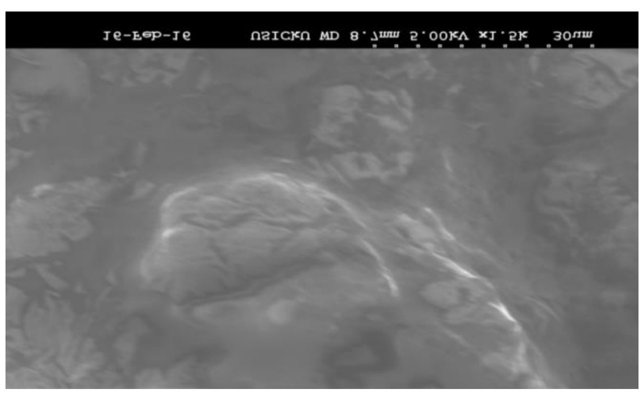

Figure 3.

Cereal-based foods are derived from grains that have a well-organized microstructure (Autio & Salmenkallio-Marttila, 2001). The microstructure determines the appearance and texture of protein fractions and the stability of the final product. Therefore it was important to study the effect of mung beans on the microstructure of cereal bars.

Micrographs of cereal bars had shown an extensive protein starch network holding starch granules intact. Also, it has been observed that there is excessive starch gelatinization in some areas which may be due to coarse flour of rice and mung bean powder. There has been seen less granular structure with starchy endosperm completely fused and had formed cavities with irregular boundaries. Such structural modifications had been visualized by Braadbaart et al., (2005) in wheat. It was also seen that the protein matrix in starch granules with very small air sacs which could be due to moisture retention by fiber in mung beans. However, in some areas prominent peaks had been observed embedded with air resulting in bulging of certain areas.

4. Conclusions

Incorporation of high levels of mung bean and rice in cereal bars is feasible. The supplemented products were accepted to consumers, however incorporation of high levels of supplements results in change in physico-chemical, sensory, and other characteristics.

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