Research Article

Ingredients Interaction Effect on Development and Characterization of Rice Flour and *Moringa Oleifera* Leaf Powder Based Instant Soup Mix

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Abstract

The ingredients interaction having the role in deciding various characteristics of instant soup mix with significant influence. Rice flour (Pusa 1121 brokens), moringa leaf powder and blended oil were considered as major suitable nutritive ingredient for development of instant soup mix. Characterization of optimized instant soup mix was carried out on the basis of microstructure, physical, chemical, rheological, optical, advanced analytical characteristics, cost analysis and reconstitution behaviour. The optimized formulation of major ingredients (rice flour, 5.537g; moringa leaf powder, 0.890g; blended oil, 0.526g) results in the soup mix have energy value of 390.55 kcal/100 g with appreciable amount of protein (7.79±0.46%) and fat (9.11±0.28%) with acceptable quality, cost effectiveness and improved nutrition. The rheological properties of soup mix analyzed using a controlled stress rheometer revealed the significant changes with supplementation of moringa oleifera leaf powder and soup sample exhibits non-Newtonian, shear thinning and pseudo-plastic behavior.

Keywords: Soup mix, rheology, characterization, rice, *moringa oleifera*

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Introduction

Convenience is a multifaceted concept and often listed as the most important factors that determine the food of choice apart from the cost, health, sensory acceptability and related concerns [1]. It also decides to a greater extent when, where, what and how to eat foods. As a consequence, the demand of ready to eat or ready to cook minimally processed products has noticeably increased during the recent years with transcended effects on the problem of protein-energy malnutrition in under developed and developing countries.

The attentions are being given towards exploring underutilized food sources. Price as well as the utilization problems has been often faced by the entrepreneurs in disposing off their produce in terms of various byproducts. Broken rice is a valuable byproduct of rice milling industry may thus be better source of nutritive starch as the quality of rice protein which surpasses that of wheat and also better than corn starch [2]. Thus, broken rice flour could be considered as suitable nutritive ingredient for various food formulations.

High consumption of fruit and vegetables, as in the Mediterranean diet, contributes to an increased intake of key nutrients, such as vitamins, minerals, antioxidant compounds and dietary fibre, with subsequent beneficial effects on health [3]. The utilization of vegetable as protein source also continued to attract attention globally because of the presence of affordable nutrients particularly to feed low-income populations mainly to combat the protein energy malnutrition problems [4]. The pre and processing treatments especially dehydration have been reported to influence the quality of products [5]. Dietary sources of essential elements are important for correct physiological functions of the human body and balanced nutrients are also considered as the nutraceutical foods or part of foods that provide health benefits beyond supplying the basic nutrients [6].

Instant soups are a wide group of dried foods, which play an important role in the nutrition of people as they satisfy the present and future consumer requirements. Soup is primarily a liquid heterogeneous food category food, predominantly served hot, which is prepared using vegetables or meat with stock, juice or water with some thickening agent before the main meal as it stimulates appetite and provides quick nourishment [7]. In current scenario food industries are more emphasizing on the preparation of nutraceuticals foods by utilizing various plants their parts and extracts for betterment of human health. Among the beneficial plants *Moringa oleifera* is one of them having numerous health benefits and it also utilize in the different food products [8]. The commercial production of soups depends on their physicochemical and rheological behavior during and after preparation. It is, therefore, important to understand the ingredient interactions in both dry as well as in the reconstituted soup form [9] and [10]. The mixture of starch, vegetable and fat sources with the other essential constituents play the vital role in providing the structure and body of prepared soup [11]. The extent of starch used in soup is mainly responsible for the sensory mouth feel by altering the viscosity during reconstitution and subsequent thermal treatment in its preparation. The addition of leaf powder and blended fat not only improves the nutritional quality of soup but may also enhance the cost effectiveness with the sensory acceptability. Due to its complex rheological nature its viscosity also depends on temperature and ingredient's composition with composite viscoelastic behavior [12]. The rheological properties of solid food materials are vital indicators for storage stability of foods and usefulness for various applications and exhibit effects such as shear thinning, shear thickening, thixotropic, anti-thixotropic, yield stress as well as viscoelasticity [13].

Several methods of component elucidation in terms of physical, chemical, morphological, rheological, optical and sensory changes of pure starch systems are available. A very few studies were conducted on characterization of soup whereas no reports on rice based instant soup mix are cited yet hence associated features of rice flour, vegetable powder and oil component in the form of soup mix are explored as part of the characterization part for both the dry as well as the reconstituted soup form under the present work. The techniques, such as Fourier transform infra-red spectroscopy (FTIR), scanning electron microscopy (SEM) and X-ray diffraction were also explored.

Material and Methods

Pusa 1121, basmati paddy variety was procured from CCS Haryana Agricultural University, Hisar (Haryana) and milled to polished rice with 6% degree of milling as described in previous study [14]. The obtained rice broken during milling was used to prepare the rice flour using dry grinding method. The broken rice flour was used as one of the soup ingredient replacing corn starch entirely from the commercial process of soup preparation [2, 15]. *Moringa oleifera* leaves were dehydrated, powdered, fractionated and characterized fine fraction was used as major ingredient of vegetable source [10, 16]. The oil blend used instant soup mix was formulated with linear programming method using sunflower, rice bran, palm and linseed oil to the desired fatty acids ratio as 1:1:1 [17]. Rice flour, moringa leaf powder and oil blend were used as process independent variables for optimization of ingredients level. The other ingredients such as quick cooking dehydrated peas [18] and diced carrot further vegetable source used in constant quantities with the other ingredients.

Sample Preparation

The optimized level of soup ingredients (rice flour, 5.537 %; moringa leaf powder, 0.890 %; blended oil, 0.526 %) obtained response surface methodology (RSM) were used to prepare the dry mix. The required ingredients were dry mixed as per mix total weight basis. The optimized soup mix prepared sample was stored in a low-density polyethylene (LDPE) sealed pouches at refrigerated temperature (4±2 °C) for at least five days before any experimentation proceeded further.

Reconstitution and Soup Preparation

Soup mix was prepared from the developed and optimized standard recipe (**Table 1**). 12 gm of dry soup mix was allowed to reconstitute in the small quantity of distilled water (88 ml). The prepared slurry was cooked in a steam kettle (100±5°C) maximum to 5 minutes with the constant stirring. The prepared soup was then subjected further for the characterization on the basis of sensory characteristics and rheological behavior. The prepared soup was tested for the subjected parameters within 10 minutes time.

Particle size analysis

The particle size analysis for the soup mix was done using laser diffraction particle size analyzer (Malvern Instrument Ltd., Malvern, England). Small quantity (0.2 g) of the soup mix was placed in a cuvette cell containing the dispersion liquid and positioned in the laser path with constant stirring [19]. Size distribution was quantified as the relative volume of particles in size bands presented as size distribution curves and the mean particle size in micro meter were provided by the instrument's software (Wing SALD II-2300, US, V3.1).

Morphological analysis

Scanning electron micrographs of optimized soup mix with the used dry ingredients were acquired in the range of 500 to 3500 magnifications using scanning electron microscope (Jeol JSM-6100, Japan). The sample for acquiring the micrographs was prepared and mounted on double sided tape on the used aluminum stubs. Further the adhered samples were coated with gold–palladium (60:40) at an accelerated voltage of 15 kV in accordance with the method described by [20].

Table 1 Ingredients percentage in soup mix and after reconstitution

Ingredients (%)	Soup mix	Reconstituted Soup
Rice flour	45.94	5.537
Moringa powder	7.38	0.89
Blended Oil	4.36	0.526
Carrot	15.35	1.85
Peas	7.88	0.95
Salt	5.39	0.65
Sugar	5.39	0.65
Spices and condiments	8.30	1.00

Gravimetric and frictional properties

The bulk density (BD) of the soup mix sample was evaluated using the method suggested by [21]. The static coefficient of friction (COF) was determined for four frictional surfaces namely glass (COFG), galvanized iron sheet (COFGI), plywood surfaces with horizontal movement (COFPAR) and vertical movement (COFPER). The angle of repose (AOR) was determined using the relationship (Singh and Prasad, 2013a):

$$\text{Angle of repose (AOR)} = tan^{-1}\frac{(2h)}{d}$$

Where, *h* and *d* are the height and diameter of the heap in mm.

Chemical Characterization

The recommended methods of the Association of Official Analytical Chemists [22] were adopted for the determination of moisture, crude protein, crude fat and ash content. The amount of carbohydrate was assessed using difference method.

The energy value was calculated by multiplying the mean values of the crude protein, fat and carbohydrate by their physiological energy change coefficients as 4, 9 and 4, respectively, taking the sum of the products and expressing the result in kilocalories [23].

The chlorophyll content estimation was carried out as per the method described by [24] and [25] total chlorophyll content was expressed in mg/g.

Total antioxidant capacity (TAC) of the samples was measured on the basis of the scavenging activity of the stable 1, 1- diphenyl- 2-picrylhydrazyl (DPPH) free radical as per the method adopted by [26] and expressed as Trolox equivalent mg/g. Total phenol content (TPC) was estimated as per the method reported by [27].

Pasting properties

Pasting properties of rice flour were studied by using rapid Visco analyzer (RVA, Newport Scientific Pty Ltd, Australia). 28 g aqueous dispersion with the sample (~3g) was equilibrated at 50 °C for one minute. Viscosity profiles of flour from different samples were recorded and the temperature–time conditions included a heating step from 50 to 95 °C, a holding phase at 95 °C, a cooling step from 95 to 50 °C. From the Rapid Visco Analyzer (RVA) profiles, pasting temperature, peak time, peak viscosity, trough, final viscosity, breakdown (peak viscosity minus trough viscosity) and setback (final viscosity minus trough viscosity) were calculated.

Rheological characterization

For rheological analysis each formulation of soup mix was dry blended prior to slurring in distilled water to a total volume of 100 ml. Small deformation dynamic oscillatory measurement technique with the use of Dynamic Rheometer (Model MCR301, Anton Paar GmbH, Austria) having the parallel stainless steel plates of 4 cm diameter for placing the sample with software based peltier temperature control was used. The measurements were made at

45±0.1°C. The viscoelastic properties of the samples were quantified by measuring the following dynamic rheological parameters: storage or elastic modulus (G´), loss or viscous modulus (G´´) as a function of frequency.

Optical Characteristics

The optical characteristics of the soup mix was evaluated using the Hunter Colorimeter (Gretag Macbeth, Model i5, USA) in terms of L, a and b, where, L corresponds to the luminance or brightness and a, b to the chromaticity, 'a' value particularly represents the red - green component from positive to negative values; 'b' value represents the yellow - blue component in similar ways [14].

X-ray diffraction (XRD) pattern

The X-ray diffraction technique was applied to obtain the X-ray diffraction (XRD) pattern using an X-ray diffractometer (Rigaku Denki Co. Ltd., Japan) with the following operating conditions: 40 kV, 30 mA using Cu-Kα X-rays of wavelength (λ) 1.54056 Å and data was taken for the 2θ range of 10–40° with a resolution of 0.05°step size.

Fourier transform infrared (FTIR) spectroscopy

Transmission infrared spectra of the films were recorded at room temperature using a FTIR spectrometer (Perkin–Elmer, Buckinghamshire) from 16 scans in the range 700–4000 cm^{-1}. A background was collected before each sample was analyzed then subtracted from the sample spectra prior to further analysis. After every scan, a new reference air background spectrum was taken.

Sensory analysis

The sensory evaluation of the dry instant soup mix and prepared soup sample was carried out through sensory attributes considered as sensory color, mouthfeel, flavor and overall acceptability by semi trained panel on 9 point hedonic rating scale [28].

Statistical analysis

The data reported were average of triplicate observations and expressed as mean ± standard deviation. In order to determine any statistically significant effects prevailed, Duncan multiple range test and critical difference (CD) at $P \leq 0.05$ was analyzed using SPSS 16.0 and Microsoft excel software package (Microsoft Corporation, USA).

Results and Discussion

Particle size analysis

The particle size and particle size distribution of the instant dry soup mix is presented in **Figure 1**. The results revealed that the soup mix was composed of the particles having the average size as 110.28 µm. The rice flour granule used in soup mix was found more variable and comparatively lesser in size as compared with the average soup particle. Studies have further support the fact regarding the reduced swelling of starch granule in presence of non-polar component absorption manly due to the decreased mobility of water molecules [29] on its reconstitution with thermal treatment during soup preparation.

Morphological analysis

Microscopy has played an important role in increasing understanding of particle structure of soup mix. The granular structure of soup mix along with the used ingredients showed significant variation in size and shape when viewed under scanning electron microscope (**Figure 2**). The non-uniform and irregular granules shapes of the used ingredients i.e. rice flour and moringa leaf powder was observed as per characteristic associated morphologies. The granules have adhered particles in composite forms for both the ingredients on the application of blended oil as reflected from the appearance of granules for the soup mix (Figure 2). The shape and size of soup mix have also found to be affected on forming the agglomeration and reflected with the narrow size distribution in the particle size analysis, which has found to be in agreement with earlier reports [30].

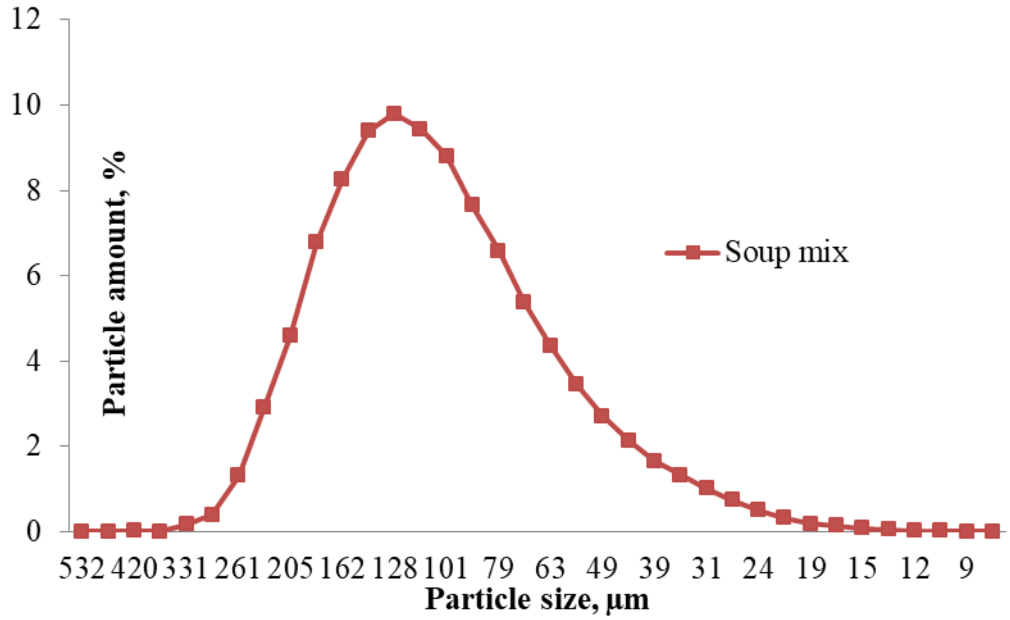

Figure 1 Effect of soup ingredients (rice flour, moringa leaf powder and blended oil) on particle size analysis of instant soup mix

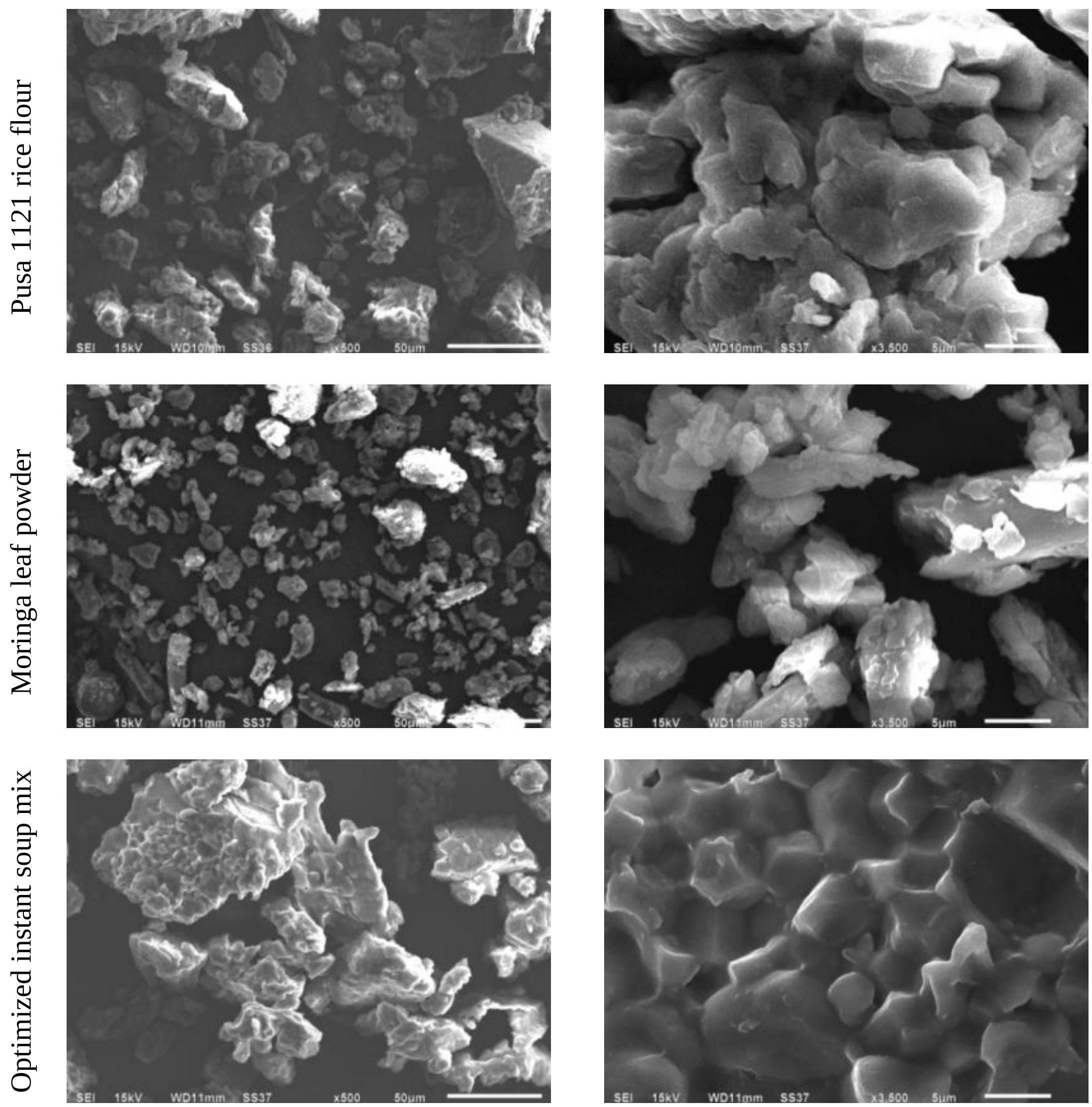

Figure 2 Effect of soup ingredients (rice flour and moringa leaf powder) on morphological characteristics of instant soup mix

Gravimetric and frictional properties

The bulk density (BD) of optimized soup mix was found to be 494.48±2.68 kg/m^3 and in agreement with the work mentioned elsewhere [31]. The experimental value of angle of repose (AOR) was found as 52.87±0.28°, which was found to be similar for emptying angle of repose for rice [32]. The coefficient of friction (COF) was minimum for glass surface (COFG) and maximum for plywood surface vertically aligned and found as 0.44 to 0.73, respectively. The differences in the values may be due to the fact that the roughness of the associated used material surface in determining the coefficient of friction [33].

Chemical Characterization

The result of proximate analysis of the dry soup mix sample is presented in **Table 2** and ingredients used for soup significantly affected in terms of chemical composition of soup. The initial moisture content of optimized instant soup mix was 8.95±0.55 %. It is evident from these results that crude fat and protein content of soup are 9.11 and 7.79%, respectively. The energy value of soup was 390.55 kcal per 100g, this value fall considerable towards daily energy requirement as reported for adults [34]. On comparing the nutritive value of developed soup with the available market sample then found better nutritional properties associated with the developed soup.

DPPH assay is one of the most widely used methods for evaluating antioxidant activity. Antioxidant potential evaluated by scavenging of DPPH radicals (60.54), that soup sample possessed high potential antioxidant activity. Total phenolic content in the sample methanolic extracts was 52.31 mg GAE/g extract (Table 2). Phenolic acids are generally considered as good antioxidants; they express antioxidant activity as chelators and free radical scavengers with special impact over hydroxyl and peroxyl radicals, superoxide anions and peroxynitrites [35]. Appreciable amount of total antioxidant capacity (60.54 Trolox equivalent mg/g) with higher phenolic content further made this important nutritional biomaterial a functional material may be applied for the therapeutic purposes too.

Table 2 Chemical composition of rice based instant soup mix

Particulars	Content
Moisture, %	8.95±0.55^e
Protein, %	7.79±0.46^f
Fat, %	9.11±0.28^e
Fiber,%	3.34±0.19^g
Ash, %	1.46±0.11^h
Carbohydrate, %	69.35±0.14^b
Energy, Kcal	390.55±0.64^a
Chlorophyll, mg/g	7.73±0.08^f
Total antioxidant capacity, Trolox equivalent mg/g	60.54±0.79^c
Total phenol content, mg/100g	52.31±0.44^d

The values are represented in triplicate as Mean ± standard deviation with different superscripts along the column denote significant difference at the $p \leq 0.05$.

Pasting properties

The formulated samples of soups as exhibited the pasting behavior is shown in form of typical viscographs (**Figure 3**). The RVA characteristics of soup mix as analyzed are shown (**Table 3**). The information for the change in the pasting process leading to a peak viscosity of 1488 cPand further reduce to a level of hot and cool paste viscosity as 608 cP and 1448 cP, respectively, which is vital for the soup system to decide the concentration of the ingredients to be used (Table 3). The increase in viscosity during the cooling period is indicative not of only the normal inverse relationship between the viscosity and temperature of suspensions but also of the tendency for various constituents present in the hot paste to associate or retrograde as the temperature of the paste decreases. A decrease in pasting temperature of corn starch paste was found with the addition of guar gum [8]. Our results also suggest the influence the addition of moringa leaf powder and blended oil in decreasing the pasting profile in comparison of rice flour in a pure system (Table 3). This behavior is in contrast to observations by [36], who reported a delay in gelatinization of starch granules as a result of increased viscosity of continuous phase, thereby increasing pasting temperatures and decreasing peak viscosity. It is possible that the composite of ingredients (blended oil) used in the soup formulations may also have influenced the swelling of starch granules and/or absorption of water by the polysaccharide [37] in lowering the pasting temperature.

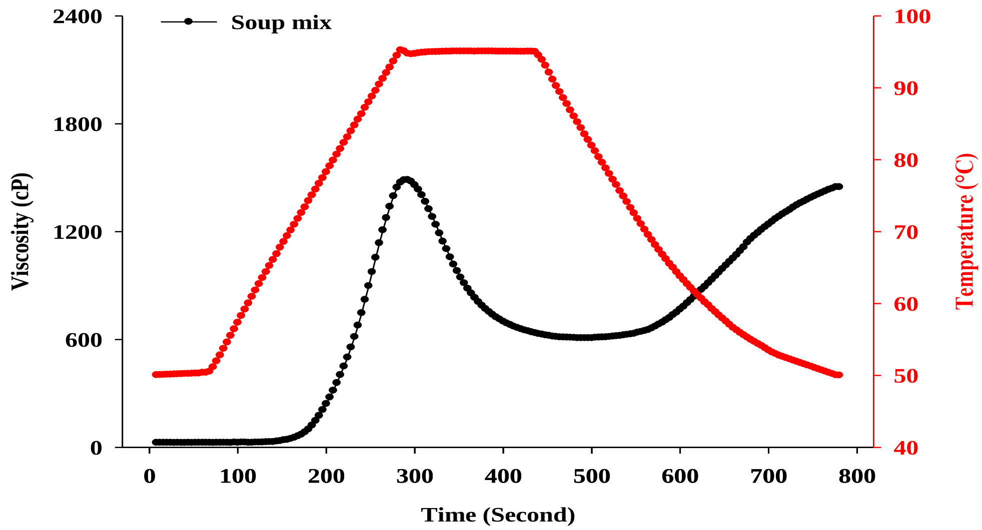

Figure 3 Pasting profile of instant soup mix

Table 3 Pasting characteristics of rice based instant soup mix

Particulars	Soup mix
Peak Visocity, cP	1488
Hot Paste Viscosity, cP	608
Breakdown Visocity, cP	880
Cool Paste Viscosity, cP	1448
Setback Visocity, cP	840
Pasting Temp, °C	74.25

Rheological Characterization

Rheological properties reflect the force required for the deformation to occur or flow to set in. During gelatinization, starch granules swell to several times then their initial volume. Swelling is accompanied by leaching of granule constituents, predominantly amylose, and the formation of a three dimensional network [38]. Storage modulus (G`) and loss modulus (G``) were the parameters characterizing the viscoelastic character of the product. The G` value characterizes the degree of solid-like character of the gel; on the other hand, tan θ is a better predictor of the viscoelastic properties of the cross linked network as it includes the contribution of both the elastic (G`) and the viscous (G``) components. The higher the G` and the lower the tan θ values, the more solid-like is the character of the soup formulation. These changes are responsible for the rheological characteristics exhibited by soup during heating and shearing. During the rheological measurements G` was higher than G`` for all soup (**Figure 4**). Consequently, G` was used to evaluate and compare the firmness/consistency of the soup. Similar responses have been reported for different food systems [39].

Optical Characteristics

The optical properties, L, a and b values of the soup mix was found to be 59.73±0.05, -6.32 ±0.02 and 24.18±0.03, respectively. Higher L value reflects the use of more rice flour in improving the lightness of soup, whereas decreased *a* values show the higher green color of soup mix sample [14]. [40] found the results (a-55.8±0.4 & 51.7±2.0) i.e darker color of bread as compared to white bread (67.14± 0.77) after addition of Moringa oleifera leaf powder (10%).

X-ray Diffraction (XRD)

The effects of ingredients used in instant soup mix on X-ray diffraction (XRD) pattern can be used to study the characteristics of soup complexes formed in an aqueous starch system (**Figure 5**). The crystallinity of starch as measured by X-ray diffraction is significantly independent for the ingredients. indicated the presence of A-type patterned starch with strong peaks at around 15.23, 18.11 and 23.34° 2θ and feeble peaks at 19.77 and 26.52° 2θ [41]. Higher crystallinity found to be associated with the moringa leaf powder and could be due to associated with the presence of minerals with the fibrous components. The broadening of the XRD pattern further indicates the finding of the aggregation of flours in presence of blended oil (Figure 5).

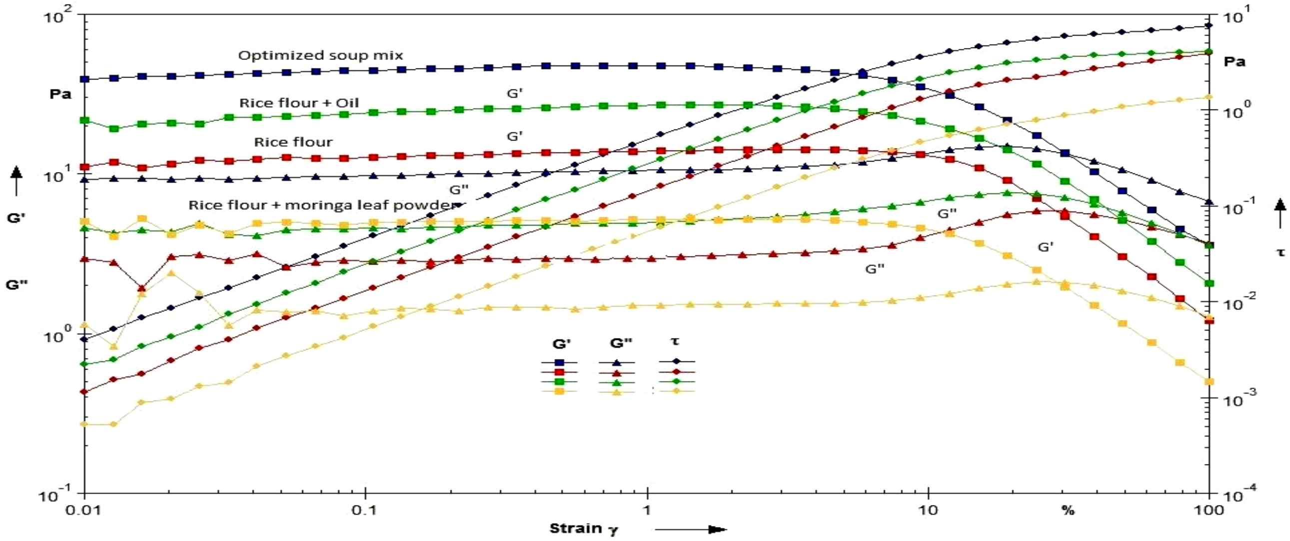

Figure 4 Variations in storage modulus, loss modulus and shear stress as affected by changing the shear rate in amplitude sweep test

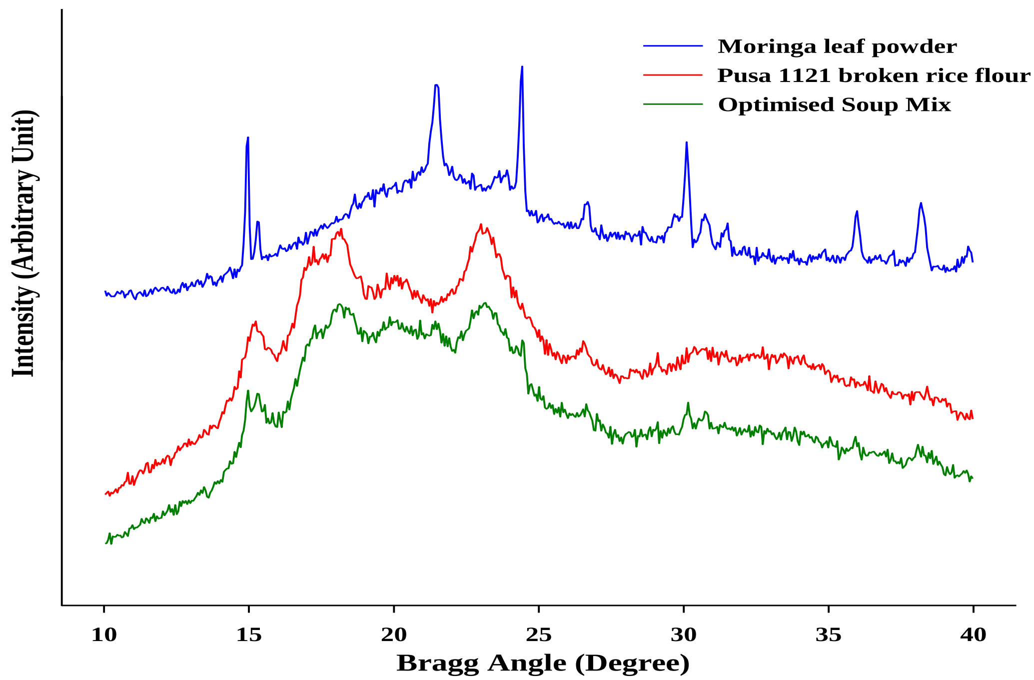

Figure 5 Effect of soup ingredients (rice flour and moringa leaf powder) on x-ray diffraction pattern of instant soup mix

Fourier transform infrared (FTIR) spectroscopy

Fourier transform infrared (FTIR) spectra of optimized instant soup mix as well as ingredient (rice flour and moringa leaf powder) are shown in **Figure 6**. All the peaks present in the IR spectra for the ingredients of soup are evident in the mixed soup sample is indicative for the originality of the preparation and may be considered as the quality assessment parameters to check the adulterations even. FTIR results showed a significant increase in peaks associated with soup components (Figure 6), this increase in total oxygenated carbon bonds may be attributed to degradation of the matrix.

Reconstitution and Sensory analysis

Overall acceptability indicates the acceptability of the product both in the dry and reconstituted soup form (**Figure 7**) as represented in **Table 4**. The mean sensory scores have reflected that all sensory parameters were found above the minimum acceptable range being the scores crossed 7 sensory scores on 9 point hedonic scale. Moringa leaf powder and blended oil shows the positive effect on overall acceptability of soup as described earlier.

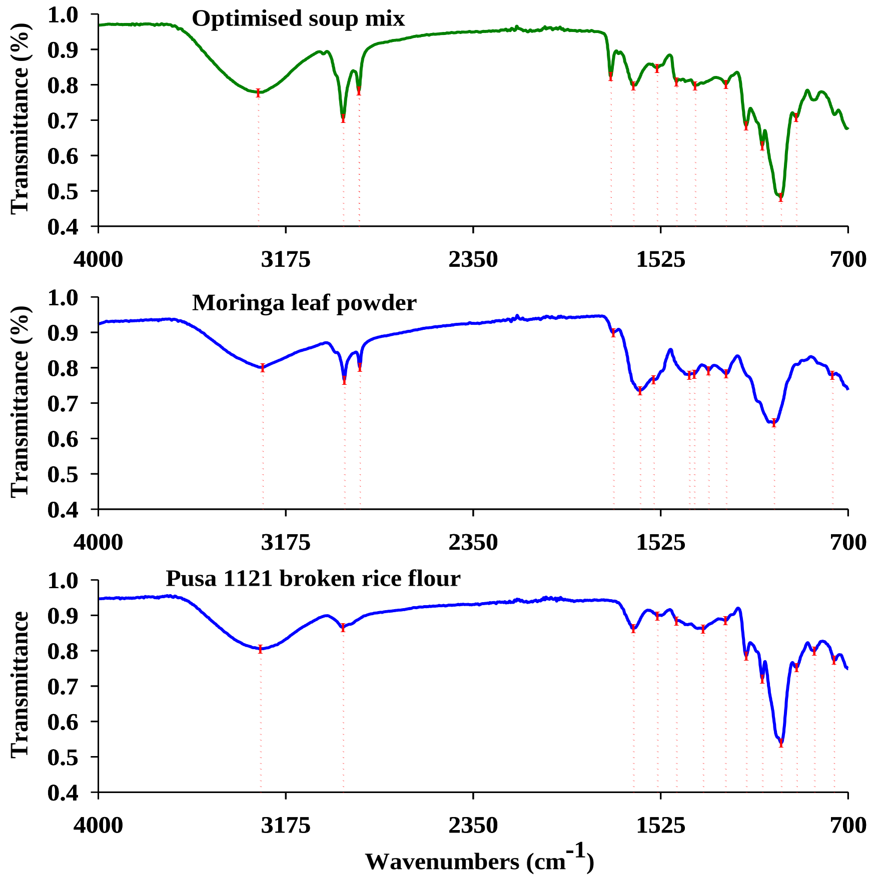

Figure 6 Effect of soup ingredients (rice flour and moringa leaf powder) on fourier transform infra-red spectroscopy profile of instant soup mix

Table 4 Sensory characterization (9 point hedonic scale) of instant soup mix and prepared soup

Particulars	Soup mix	Prepared soup
Sensory color	-	8.39±0.12
Sensory mouthfeel	-	8.11±0.08
Sensory flavor	-	8.18±0.05
Overall acceptability	8.23±0.28	8.29±0.09

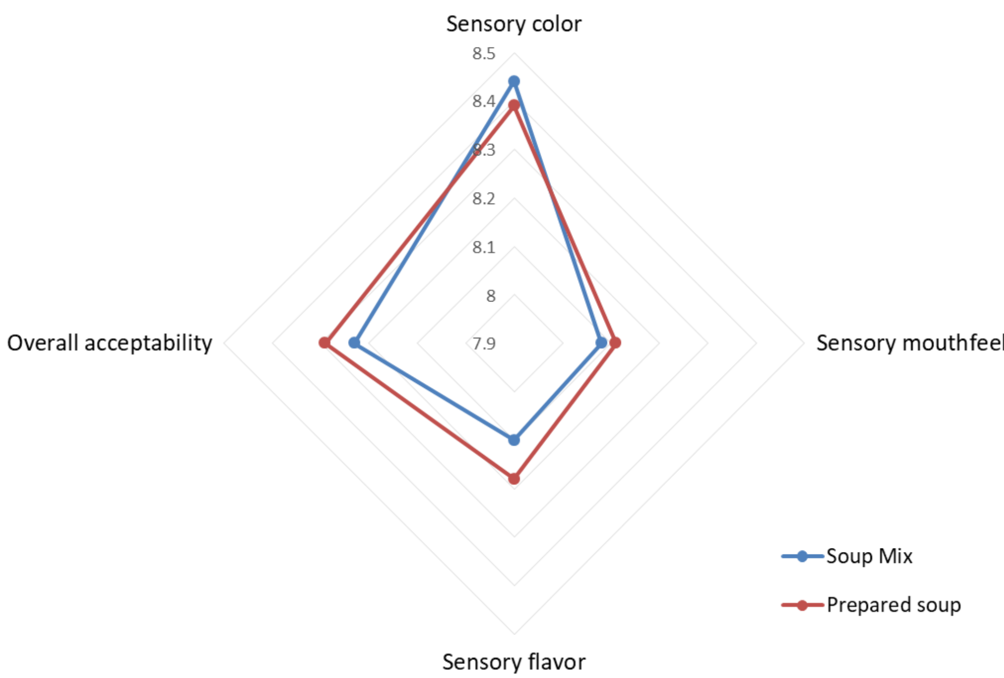

Figure 7 Radar chart for sensory characterization of instant soup mix and prepared soup

Figure 8 Rice based instant soup mix and prepared soup

Conclusion

The use of rice flour in the preparation soup with the addition of moringa leaf powder and blended oil has been found to improve the nutritional and functional components. The optimized formulation results in to a soup mix having appreciable amount of protein, 7.79±0.46%, fat, 9.11±0.28%, total antioxidant capacity, 60.54±0.79 as Trolox equivalent mg/g and phenolic content. 52.31±0.44 mg/100 g with the optical characteristics in terms of L, a and b values as 59.73±0.05, -6.32±0.02 and 24.18±0.03, respectively. Shear stress and shear rates of the rheograms for the soup sample exhibited a non-Newtonian, shear thinning and pseudoplastic behavior. The mean sensory scores were found above 7 sensory scores on 9 point hedonic scale have reflected the overall sensory acceptability of soup.

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