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Formulation and Evaluation of Nutritional, Rheological, Microstructural Parameters and Shelf Life of Instant Buckwheat Soup Mix

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Buckwheat is an underutilized pseudo- cereal which has potential as a functional food ingredient. The investigation study was carried out to formulate a buckwheat based soup mix. The different level of incorporation (0 to 50%) of gelatinised buckwheat flour was used to prepare soup mix at a different concentration. 30% buckwheat flour incorporation was identified as the best based on proximate, functional and sensory parameters. Storage study at ambient condition, showed a declining trend in sensory score, whereas the total plate count was increasing. The developed instant buckwheat soup mix requires less time for preparation without compensating on the health benefits. Non-communicable diseases (NCD) are chronic diseases that are not transmissible from one person to another. The scope of the study indicated that the effect of buckwheat incorporated instant soup mix helps to prevent non-communicable diseases.

Keywords: Buckwheat flour; Functional food; Proximate analysis; Sensory attributes; Soup mix.

Buckwheat is a typical conventional crop in Asia and Europe. The most commonly grown buckwheat species is common buckwheat (*Fagopyrum esculentum* Moench). The two additional species of buckwheat that are *F. emarginatum and F. tataricum* Gaertner have been farmed on a small scale.[1,2] Buckwheat belong to the polygonaceae family not Poaceae, the cereal family. It is classified under pseudocereal in which it displays both variations and associations with cereals.[2] Currently, buckwheat is considered as crop of alternative for organic farming and also considered as a healthy food. Buckwheat comprises numerous compounds that are proven to have the potency in diminishing the risk of certain complications.[2] Buckwheat is a source of numerous vitamins, phenolic compounds (rutin, quercetin), flavonoids, highly nutritive protein, dietary fibre, and minerals. Buckwheat proteins, fagopyritols, resistant starch, D-chiro-inositol showed substantial health impacts on animals. However, more clinical trials studies are required to confirm the influences of buckwheat. The primary antioxidants in buckwheat are quercetin and rutin which are considered to be a remedy for deep vein thrombosis (DVT). The quality and value of nutrition of buckwheat is almost comparable to cereals. The quantity of fibre is similar to starch in buckwheat. Moreover, the polyunsaturated fatty acids (PUFA) which is essential fatty acids

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were shown to be high in buckwheat. Buckwheat is a source for many vitamins which comprises of vitamins B, E and C. It also has minerals that exist in ample quantity. In opposition to cereals, the superior nutritional value of buckwheat protein is found. Buckwheat has comparatively better quantity of lysine which contributes the superior protein quality of it. Contrarily, phytic acid, tannins and protease inhibitors which are available in the buckwheat protein is reported to have a low digestibility. Few of the inhibitors of protease may produce allergic responses in people. The functional and nutritional properties of buckwheat may be improved by malting, which increases the protein digestibility and the nutritional quality and the quantity of bioactive compounds.[2] The consumption of buckwheat has been associated with chronic diseases, such as anticancer, anti-inflammatory, anti-tumor, anti-hypertensive, anti-diabetic and neuro-protection and also used in the alleviation of other common disease. So, buckwheat is safe to consume and may provide various favourable effects on human health.

Recently, due to industrialisation and globalisation, less time is available for people to prepare food. Therefore most of them consume what is accessible or food that needs less preparation time without recognising the health benefits derived out of the food they consume. Convenience is a multifaceted idea and is classified as the most crucial factor that defines food choice apart from cost, health and sensory acceptability.[2] Hence an attempt is made to prepare an instant soup mix from buckwheat which is underutilised and rich in nutrients. Buckwheat flour was developed with different components for the development of instant soup mix. Additionally, it was more assessed for physicochemical, sensory and storage studies.

MATERIALS AND METHODS

Raw materials and chemicals procurement

Corn starch, buckwheat flour, salt and powders of onion, tomato, garlic, milk, pepper, carrot were procured from the regional supermarket (Salem, Tamil Nadu, India). All the analytical and standard chemicals utilised for the experiments were procured from SRL chemicals, Mumbai, India.

Preparation of different composition of instant buckwheat soup mix

At 50 $^oC \pm 2$ ^oCvegetables (onion, tomato, carrot, garlic) were cut and dried for 24 h using tray drier (Prism Pharma Machinery, Gujarat). Buckwheat flour was gelatinised and dried before the formulation of soup mix. Different soup mix combinations were developed by dry blending all the components as mentioned in Table 1. Different combinations were examined forphysico-chemical and sensory quality of soup. 1 part of soup mix was mixed with 10 part of water prior to the cooking. The cooking was carried out for 2-3 min in a gas stove (Butterfly 2 burner gas stove).

Proximate analysis

The protein, moisture, fibre, ash and fat of soup mix were estimated based on the standardised protocols.[3] The difference method was used to calculate the carbohydrate content.

Extraction of bioactive from the different formulation of instant buckwheat soup mix

In 25 ml of 80% (v/v) methanol, 5 g of sample was dissolved and kept for shaking for 8 h in incubator cum shaker (Orbital, Mumbai) at 250 rpm at room temperature. The extracts were prepared and stored at 4^{o}C to determine the quantity of flavonoids, phenolics and antioxidant in the developed product.

Estimation of total phenolic content

Folin Ciocalteu's(FC) method with little modifications was used to determine total phenolic content.[4,5] Concisely, in the test tubes, standard gallic acid at different concentrations, distilled water (5 ml) and 500 µl of FC reagent was placed. Later, it was agitated. 20 % sodium carbonate (w/v)(1500 µl) was added 5 mins after that. Eventually, up to 10 ml volume was made up by adding distilled water. The incubation of tubes was done for 2 h at ambient temperature. Subsequent to the incubation, the blue colour with high intensity was produced. The absorbance was estimated at 750 nmwavelengthwith the assistance of a spectrophotometer. The experiment was done in triplicates. The solvent was used as a reagent blank. The mg of gallic acid equivalent weight (GAE) in 100 g of soup mix (GAE/100 g) was used to represent the total phenolic contents of soup mix.

Quantification of total flavonoid content

The total flavonoid content (TFC) was

estimated by aluminium chloride, acolourimetric assay with slight modifications.[5,6] Summarily, 1ml standard quercetin solution at different concentrations and 1ml of aliquots were positioned into test tubes, and 5 % sodium nitrite solution(w/v) (0.3 mL) and 400µl of distilled water were mixedinto each. 0.3 ml of aluminium chloride (10 %)(w/v) was added after 5 minutes, 2000µl of sodium hydroxide (1M) was also added on at 6th minute was making up to 10 ml with distilled water and it was mixed well. End point was orange yellow colour. At 510 nm, absorbance was estimated by using a spectrophotometer (UV–Vis Spectrophotometer, Thermo Scientific evolution 220, CA, USA). The blank was performed using distilled water. The samples were done in triplicates. By using standard quercetin calibration curve was plotted. The mg of quercetin equivalents/ 100 g of the soup mix was used to depict the total flavonoids of different formulations of buckwheat soup mix.

Quantification of total antioxidant capacity

To estimate total antioxidant capacity, the ABTS radical scavenging assay was carried out. It is acation decolourization assay is used to estimate radical scavenging function of soup mix.[4] The reaction between 2.45 mM potassium persulfate (1:1) and 7 mM ABTS in water generated ABTS·+ cation radical. It was stored in the dark place at ambient temperature for 12-16 h prior to use. Methanol was used to dilute ABTS·+ solution was diluted to obtain an absorbance of 0.700 at 734 nm. The 5 ìl of the test phenolic extract was added to diluted ABTS·+ (3.995 mL). The absorbance was estimated in a spectrophotometer (UV–Vis Spectrophotometer, Thermo Scientific evolution 220, CA, USA) at 30 min after the first mixing at 734 nm.

Functional and rheological properties

Buckwheat soup mixes were analysed for water absorption index (WAI).[7] Colour is measured by a colour meter (Minolta chromameter CR-300, Japan). The viscosity of the buckwheat soup mix was estimated utilising Rheo meter (Anton-PaarMCR-52, Austria). The soup samples were analysed using rheo meter at 25 °C and 60 °C. The relationship between shear rate vs apparent viscosity was studied under steady-state rheology. The samples were exposed to the range of shear from 0.1 to 1000s˜1. Herschel-Bulkley model presents a relationship of the test samples in a rheological aspect between shear rate and viscosity which is done to check the flow behaviour.[8]

Sensory analysis

The buckwheat soup mix was prepared and analysed using a nine point hedonic scale varying from excellent to very poor. Semi-trained panelists were instructed to rate the developed soup samples for appearance, consistency, flavor, taste, aroma and overall acceptability. These semi-trained panels were composed of people who are professional and trained with the characteristics of various kinds of food products.[9]

Morphological analysis

Morphological structure of buckwheat dry mass of developed soup mix was examined by using the scanning electron microscope (SEM). The SEM was used to magnify the samples at different magnifications. The soup mixes were slightly sprinkled on a tape with double adhesive ess which was adhering on an aluminium stub. Gold coating up to a thickness of 300A° with a coater was done on the stubs and then observed under SEM. The photomicrographs at proper magnification were received.[10]

Storage studies

The buckwheat soup mix was packed in aluminium laminated pouches. It was stored for five months under ambient conditions and evaluated for total plate count (TPC) and sensory attributes at 15 days period.[11]

Statistical analysis

The data gathered from the experiments were analyzed with the assistance of SPSS software 16.0 version for windows. The results are shown as mean ± standard deviation (SD). The Analysis of variance (ANOVA) was also conducted. The Tukey's test was performed to find the significant difference between experimental samples for comparisons (p d" 0.05). The averages of three replicates were depicted as results. [12]

RESULTS AND DISCUSSION

Effect of different formulation of buckwheat soup mix on chemicals properties

The buckwheat soup mix was developed by trying different combinations of corn starch and buckwheat flour to attain the acceptable sensory qualities. Gandhi et al. 2017 assessed the shelf life of the extrusion technology based instant vegetable soup mixes. The development of instant vegetable soup mixes was done after the response surface methodology (RSM) to optimize corn and potato starches.[11] The dill leaf powder based soup mix was developed and studied for its antioxidant properties by Rekha et al. 2010.[11] In Table 2, the proximate and chemical composition of different formulations of buckwheat soup mix is shown. From the results, it was noted that improving the amount of buckwheat flour in different combination of formulations reduced the moisture around 0.15%. The change in content of moisture was perceived due to a reduction in the added corn flour that decreased the amount of moisture in the range of 0% to 30% of soup mixes. The maintenance of the amount of moisture in dried food products lesser than 10% limits the microorganisms growth and considered to improve the shelf life of soup.[11] The fat content was ranged between 6.23 and 5.12% in the formulations. There was no impact on carbohydrates whereas, and ash was found to be 6.35% at 50% buckwheat incorporation, which was the highest among all the treatments. This similar trend was observed in protein and fibre content which significantly enhanced with improvement in the quantity of buckwheat flour present in the formulations. The trends of our results were alike to the outcomes of Gandhi (2017). From the results, it is evident that rise in the level of buckwheat in soup mix affect the protein, ash and fibre.[11]

Table 1. Ingredient composition of different instant buckwheat soup mix formulation

Ingredients	0%	10%	30%	50%
Corn starch	35	25	5	-
Milk powder	35	35	35	20
Buckwheat flour	-	10	30	50
Dried chopped vegetables	13	13	13	13
Onion powder	4	4	4	4
Garlic powder	3	3	3	3
Tomato powder	4	4	4	4
Salt	3	3	3	3
Pepper powder	3	3	3	3
Total	100	100	100	100

Values are expressed in g; 0% - Control (without buckwheat flour incorporation); 10% - 10% of buckwheat flour incorporation; 30% - 30% of buckwheat flour incorporation; 50% - 50% of buckwheat flour incorporation

The rise in buckwheat incorporation also increased the total flavonoids, phenolics and antioxidant capacity of the soup mix. The sum of phenolic and flavonoid content was observed as 31.21 mg/100g and 52.89 mg/100g respectively in control. As the buckwheat flour incorporation increases, phenolics and flavonoids content increased up to 60.34 mg/100g and 83.45 mg/100g respectively, at the maximum of 50% buckwheat addition. The similar trend of result of antioxidant capacity was found, which ranged from 42.34 mg/g in control to 74.67 mg/g in 50% soup mix formulation. The research findings of Rekha et

Table 2. Chemical composition of different formulation of instant buckwheat soup mix

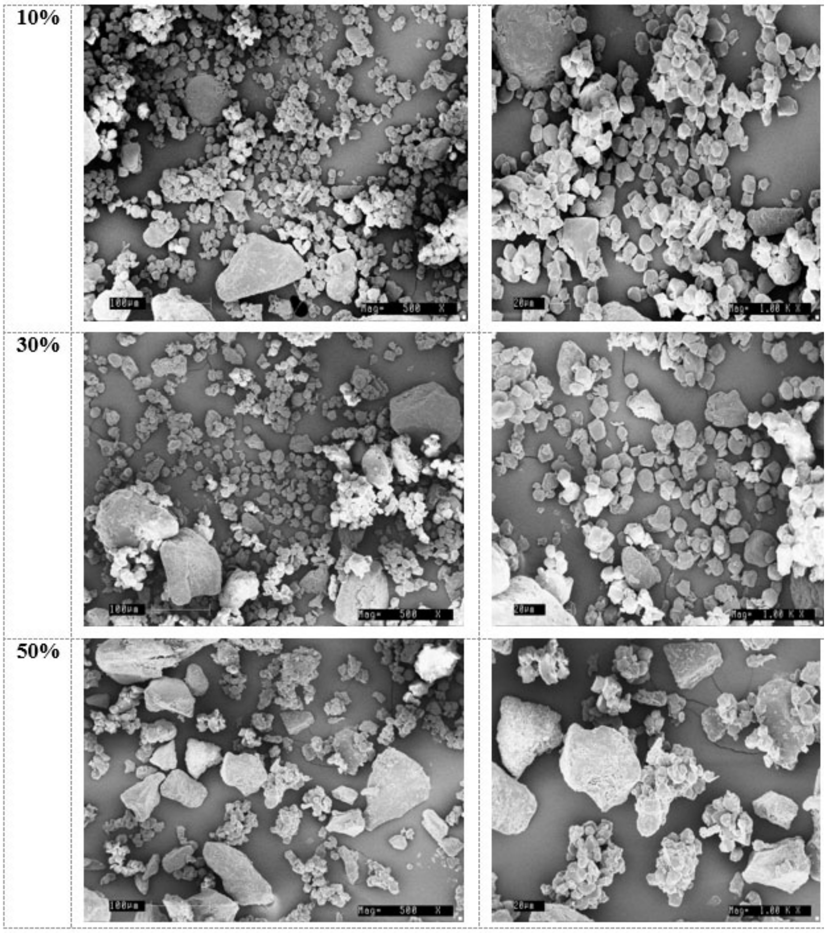
Parameters	0%	10%	30%	50%
Moisture (%)	9.32±0.12^{a}	9.21±0.05^{b}	9.18±0.04^{c}	9.15±0.21^{d}
Protein (%)	8.03±0.37^{a}	7.95±0.58^{b}	7.71±0.32^{c}	7.85±0.41^{d}
Fat (%)	6.23±0.21^{a}	6.03±0.31^{b}	5.61±0.51^{c}	5.12±0.03^{d}
Fibre (%)	4.52±0.53^{d}	5.12±0.62^{c}	5.69±0.53^{b}	6.25±0.24^{a}
Ash (%)	1.21±0.03^{d}	1.25±0.09^{c}	1.32±0.22^{b}	1.51±0.47^{a}
Carbohydrate (%)	70.69±0.25^{a}	70.47±0.33^{a}	70.54±0.32^{a}	70.12±0.14^{a}
Energy (K cal/100 g)	370.97±0.28^{a}	367.96±0.41^{b}	363.49±0.3^{c}	357.96±0.56^{d}
Total phenolic content (mg/100g)	31.21±0.38^{d}	47.26±0.17^{c}	53.34±0.04^{b}	60.34±0.13^{a}
Total antioxidant capacity, Trolox equivalent (mg/g)	42.34±0.23^{d}	59.16±0.45^{c}	67.12±0.13^{b}	74.67±0.23^{a}
Total flavonoids (mg/100 g)	52.89±0.18^{d}	61.14±0.58^{c}	74.36±0.19^{b}	83.45±0.78^{a}

Values are mean ± standard deviation. Values in different superscripts within the column are significantly different from each other (p?0.05); 0% - Control (without buckwheat flour incorporation); 10% - 10% of buckwheat flour incorporation; 30% - 30% of buckwheat flour incorporation; 50% - 50% of buckwheat flour incorporation.

Table 3. Physical and sensory characteristics of different formulations of instant buckwheat soup mix

Physical parameters	0%	10%	30%	50%
L*(D65)	31.01±0.35[a]	2.21±0.03[b]	0.14±0.78[c]	0.02±0.13[d]
a*(D65)	14.08±0.24[a]	4.12±0.25[b]	0.46±0.42[c]	0.24±0.18[d]
b*(D65)	41.07±0.15[a]	3.78±0.17[b]	0.27±0.04[c]	0.06±0.34[d]
Consistency coefficient-k (mPaSn)	0.512±0.03[a]	2.98±0.02[d]	3.127±0.05[c]	3.874±0.12[b]
Flow behavior index-n	0.437±0.15[a]	0.278±0.06[d]	0.301±0.08[c]	0.336±0.09[b]
Water Absorption Index (g/g)	3.12±0.04[d]	3.31±0.16[c]	3.47±0.54[b]	3.53±0.32[a]
Sensory parameters				
Appearance	8.12±0.04[b]	8.52±0.13[a]	8.03±0.03[c]	7.12±0.34[d]
Consistency	8.23±0.21[b]	7.87±0.05[c]	8.31±0.21[a]	7.34±0.58[d]
Taste/Flavor	8.45±0.34[a]	8.34±0.15[c]	8.41±0.07[b]	7.26±0.16[d]
Overall acceptability	8.26±0.20[a]	8.24±0.11[c]	8.25±0.10[b]	7.24±0.36[d]

Values are mean ± standard deviation. Values in different superscripts within the column are significantly different from each other (pd"0.05); 0% - Control (without buckwheat flour incorporation); 10% - 10% of buckwheat flour incorporation; 30% - 30% of buckwheat flour incorporation; 50% - 50% of buckwheat flour incorporation.



0% - Control (without buckwheat flour incorporation); 10% - 10% of buckwheat flour incorporation; 30% - 30% of buckwheat flour incorporation; 50% - 50% of buckwheat flour incorporation.

Fig. 1. Morphological structure of instant buckwheat soup mix

al. 2010 were akin with our results, where they developed dill leaf powder (DLP) based soup. As an effect of the inclusion of DLP, the notable increase in total phenolics was identified this led to the antioxidant enhancement properties.[9]

Table 4. Effect of storage of buckwheat soup mix on Total Plate Count (TPC)

Storage period(in days)	TPC ($X10^2$ CFU/g)
0	2.21±0.02^{i}
15	2.24±0.14^{h}
45	2.45±0.41^{g}
60	2.95±0.05^{f}
75	3.31±0.03^{e}
90	3.67±0.31^{d}
105	3.95±0.16^{c}
120	4.05±0.24^{bc}
135	4.14±0.17^{ab}
150	4.32±0.21^{a}

Values are mean ± standard deviation. Values in different superscripts within the column are significantly different from each other (pd"0.05); 0% - Control (without buckwheat flour incorporation); 10% - 10% of buckwheat flour incorporation; 30% - 30% of buckwheat flour incorporation; 50% - 50% of buckwheat flour incorporation.

Effect of different formulation of buckwheat soup mix on physical and sensory parameters

Colour is an essential quality attribute of any food product. Colour measurements, sensory and other physical parameters of different buckwheat soup mix formulations are shown in Table 2. The results designated that L*, a* and b* values of the sample altered significantly. The L* a* and b* data representing lightness, redness and yellowness sequentially decreased on the increase in buckwheat flour that is comparable to the conclusions of Pathare et al. (2013) where they examined the colour attributes of processed foods and fresh foods.[13] The holding of water by the starch after it is swollen in excess water, which contributes to the weight of the gel formed is measured by Water absorption index (WAI). Table 2. shows the WAI of buckwheat soup mixes that varied from 3.12 - 3.53 g/g. The results showed higher values of WAI for instant soup mixes made from gelatinised buckwheat which has more capacity for absorbing water. This improvement in water absorption by soup mixes might be connected to the elevated water absorption capacity and water binding ability of the pregelatinised starch in the buckwheat. The

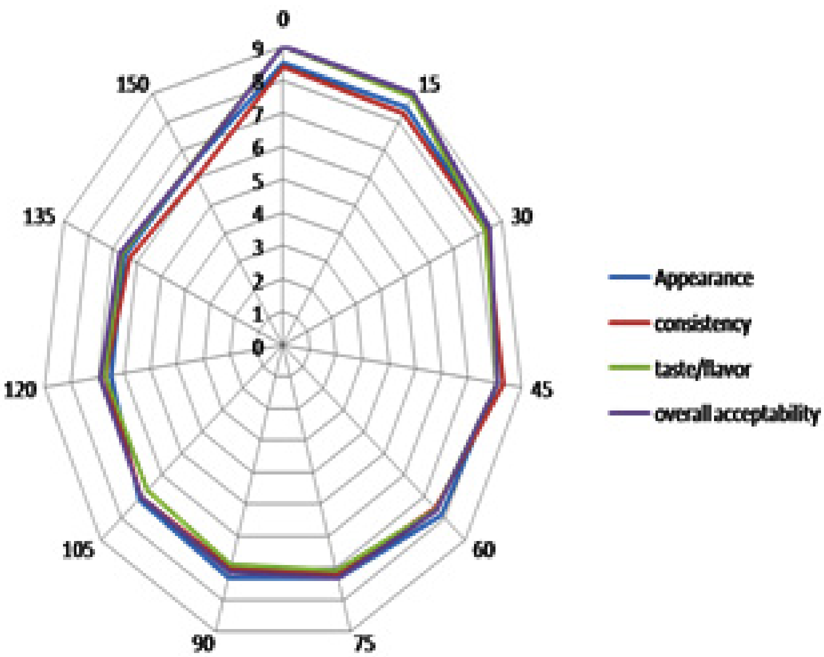


Fig. 2. Sensory scores during the storage of instant buckwheat soup mix

akin findings were observed by Gandhi (2017).[11] The changes in apparent viscosity of soup while the shear rate rises from 0.1 S^{-1} to 1000 S^{-1} at 25 °C and 60 °C. In Power-law and Herschel-Bulkley model the flow behaviour index (n) was witnessed to be lesser than one which confirmed the shear-thinning behaviour of every soup samples. The Nearly 0.999 R^2 was obtained. Hence, the models showed perfect fit which implies that they exhibited a notable difference in all of the samples and in complete accord with the findings of tomato concentrate.[14] The viscosity of the different soup formulations was found to increase when the temperature was raised. Rheological properties reflect the force required for the deformation to occur or flow to set in. During gelatinisation, granules of starch expand to numerous times than their original volume. Leaching of granule components (predominantly amylose) and swelling leads to the three-dimensional (3D) structural network formation.[14] These differences are responsible for the rheological characteristics of soup while shearing and heating.

Sensory analysis is an important tool which is used to understand the difficulties connected with food acceptableness. Organoleptic analysis is a valuable method in product development, improvement, and maintenance of quality.[9] The acceptable sensory attributes, including aroma and flavour of the added ingredients is crucial factors for an optimized dry soup mix. Table 3 presents the sensory scores of resultant formulations of buckwheat soup mix. The results showed that all buckwheat soup mix combinations notably influences sensory attributes of the developed product. The 30% level of incorporation of baby corn recorded the highest sensorial score for all sensory attributes by panellists. Seventy per cent of the panel members evaluated the product as “very good”.[9] From the statistical analysis it is found to be accept the alternative hypothesis (p=0.0156*). Thus 30% buckwheat flour included soup mix was selected best among all combinations and evaluated further for shelf life.

Morphological structure of optimised buckwheat soup mix

SEM was used to observe buckwheat incorporated soup mix cellular structures. SEM has an essential role in interpreting granular structures of soup mixes and powders. Figure 1 portrays the morphological structures of the soup mix, which seemed round and hexagonal. Buckwheat soup mix with other ingredients revealed a notable difference in shape and size of granules than the control. As the incorporation of buckwheat flour increases, the agglomeration between particles was observed less. The agglomeration was shown to affect the soup mixes’ size and shape and narrow size dispersion was indicated. It was perceived to be following earlier studies for instant vegetable soup mix prepared from high amylose rice starch.[11]

Effect of storage on the selected formulation of buckwheat soup mix

To study the shelf-life of the developed buckwheat soup mix, the finalised 30% buckwheat formulation was kept in laminated aluminium pouches, adequately packed and stored at ambient conditions. During the storage study, the periodical evaluation of sensory attributes, such as colour & appearance, flavour, taste, consistency and general overall acceptability, was carried out. Figure 2, represents the sensory scores of buckwheat soup mix, which was stored at room temperature. The significant declination in the scores for taste, appearance, consistency and flavour, scores was noticed during the storage. It resulted in a lessening in the soup mix’s overall acceptability. Likewise, Gandhi (2017) mentioned that sensory features were nearly identical during six months of storage. There was no notable variation in different treatments incorporated into the soup mix.[10] The sensory evaluation results during the storage revealed that all the soup mix was organoleptically tolerable up to storage for five months. The minute browning of the colour of the soup mix was noticed during storage owing to functional compounds’ i.e. phenolics and flavonoids oxidation. However, there was the slightest variation in the flavour of soup made from the mix. It can be concluded from the results that the 30% of buckwheat flour added to the soup mix had a shelf life of five months. Table 4, depicts the total plate count (TPC) of the buckwheat soup mix. The periodical estimation of TPC of the soup mix was carried out during the storage. It was inferred from the results that the TPC was increased significantly with days of storage. The dry soup mix product should have less than $19X10^4$cfu/g to consider it as a microbiologically safe product.

The current study results were found to be similar to the conclusions of the evaluation of shelf life of soup mix made baby corn.[11]

CONCLUSION

Buckwheat is an underutilised and neglected crop; however, it has many advantages for growers and consumers. Buckwheat can be favourably applied at a 30% level of inclusion for the development of soup mix. This formulation was found to have 7.71% protein, 5.61% fibre, 1.32% ash content, and they were rich in phenolics and flavonoids that could better consumers' nutrition status. The total plate count was increased during the storage study of the soup mix. Conversely, minor changes with regard to sensory characteristics were noticed. However, the product persisted acceptable for five months period. Therefore, the instant buckwheat soup mix could be effectively utilised commercially, and it also helps the consumers to have better health. It will deserve to screen different types of buckwheat for antioxidant functions and to include the most suitable variety to enhance health benefits. Highly potent buckwheat species can be farmed or processed to develop value-added commodities.

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Conflict of interest

The author declared that there is no conflict of interest.

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