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ORIGINAL ARTICLE

Formulation and Evaluation of Nutritional Properties and Shelf Life of Buckwheat Incorporated Nutri Ball

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Abstract

Objectives: To formulate and evaluate the nutritional composition and shelf life of buckwheat incorporated nutri ball. **Methods:** The moisture, fat, total ash in the control and various percentage of buckwheat incorporated nutri balls were analysed by using American Association of Cereal Chemists (AACC, 2000). The quantity of protein was estimated using the micro Kjeldahl method supported by AOAC. AOAC (1999) method was employed to quantify dietary fibre. Total phenolics, flavonoids and antioxidants analysis were done in methanolic extract of the various formulations of buckwheat nutri ball. **Findings** Nutritional analyses indicated that higher levels of protein (13.56±0.16), fiber (6.07±0.13), total phenolic content (5.97±0.11), total antioxidant capacity (34.21±0.17) and total flavonoids (2.96±0.03) were observed in 30% of buckwheat flour incorporated nutri balls. The total phenolics, flavonoids and antioxidant capacity was notably improved on the addition of buckwheat flour. Color properties of different formulations of buckwheat nutri balls showed decrease in l*, a* and b* values. The storage results indicated that the developed Nutri balls were sensorily satisfactory for up to two months when it is stored at room temperature. Moreover, raise in buckwheat flour content from 0 to 30% resulted in an insignificant difference from sensory scores of control. Hence, it is concluded that 30% buckwheat incorporated nutri balls are more acceptable. **Novelty:** This study proves that the novel gluten free nutri balls has plenty of bio active compounds.

Keywords: Buckwheat; nutri balls; proximate analysis; sensory attributes; shelflife

1 Introduction

Buckwheat is a pseudo-cereal which has been grown for years and is used as a functional ingredient in food production. Buckwheat is a rich source of high-quality proteins, dietary fiber, total phenolic contents, total flavonoids and antioxidant substances; government of India named buckwheat as “Nutri-cereal”.

Most of the nutraceutical compounds are present in the seeds and tissues of buckwheat. Buckwheat has been considered and will also be considered a significant food material for developing functional foods. Various research on buckwheat has been accomplished to prove the nutraceutical properties of its components, i.e. general proteins and thiamine binding proteins, flavones, lysine, iron, copper, magnesium, phytosterols and other golden components in the seeds of buckwheat. Proteins of buckwheat possess a special amino acid composition with remarkable biological activities such as anti-cholesterol, anti-obesity and antihypertension impacts by functioning equal to dietary fibre, and it also enhances the metabolisms.[(1)]

The most promising tendency in the food industry is the production of highly effective functional foods. One of the wealthiest markets in the food and beverages field is the market for gluten-free products. Recently, producing gluten-free functional food products with many health-improving compounds such as fibre, phenolics, flavonoids, and antioxidants has been very interesting. Also, the recipe optimization and analyze the whole product for organoleptic and health-promoting properties have gained attention. The complete removal of gluten from the food of celiac disease patients is the sole solution for treating celiac disease. However, gluten-free products are not only consumed by gluten-intolerant people but everyone. Latterly, it is understood that there is an increase in the demand for products which are free from gluten. In recent days, the intake of food products without gluten has increased rapidly. The global market for gluten-free food products has a yearly growth percentage of 10.2 based on 2018 data. It is also forecasted to attain $6206.2 million value.[(2)] This shows the importance and market potential of nutrients rich buckwheat-based food products which are free from gluten. The buckwheat-based food products kept increasing in the market recently. The production of food products with high nutritional value and health-promoting properties has become the most prominent trend in the food industry now a days.[(1)] Considering the demand for buckwheat-based products which are free from gluten in the market, the effort was made to develop buckwheat-based Nutri balls and to study the nutritional, physical and sensory properties.

2 Materials and methods

2.1 Obtainment of raw materials and preparation of nutri balls

The peanuts and buckwheat flour were purchased from local market, Salem, Tamil Nadu, India. Before the nutri balls preparation, the buckwheat and peanuts were roasted at 250°C for 10-15 mins till the browning. The roasted peanuts were powdered using the mixer. The buckwheat flour, and powdered peanuts were mixed together with a pinch of salt a specific composition as mentioned in Table 1. The ball was made out of the prepared blend using hands. The nutri ball without buckwheat flour incorporation was kept as control (T0). Photograph of different levels of buckwheat flour incorporated nutri balls is given in Figure 1 .

Table 1. Ingredient composition of different buckwheat incorporatednutri balls formulation

Ingredients	T0	T1	T2	T3	T4
Peanut flour	100 g	90 g	80 g	70 g	60 g
Roasted buckwheat flour	-	10 g	20 g	30 g	40 g

Values are expressed in g; T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 -30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation

2.2 Nutritional analysis

The proximate composition such as moisture, total ash, curde fat and protein and dietary fiber of control and different composition of buckwheat incorporated nutri balls were analysed based on the American Association of Cereal Chemists (AACC, 1999 & 2000) standard procedures.[(3,4)] Triplicates were used for every analysis.

2.3 Estimation of total phenolics, flavonoids and total antioxidant capacity

The extracts of nutri balls samples with methanol were prepare as follow which was further used to analyse total antioxidant activity, flavonoids and phenolics. 10 g of nutri balls sample was dissolved in 50 ml of 80% methanol and kept for shaking for 8 h in incubator cum shaker (Orbital, Mumbai) at 250 rpm at room temperature.[(5)] Folin Ciocalteu's approach with slight changes was employed to analyse the toal phenolic content in the samples.[(6,7)] Aluminium chloride based colourimetric estimation was performed with few modifications to estimate the total flavonoids in the developed product.[(8,9)] Free radical scavenging activity

Fig 1. Photograph of different levels of buckwheat flour incorporated nutri balls (T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 -30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation)

of nutri ball was determined by ABTS radical cation decolourization assay.[10]

2.4 Color properties

Colour measurement of the different composition of buckwheat based nutri balls were carried out in triplicate using colour meter (Minolta chromameter CR-300, Japan). The values of color defined as follows: the degree of darkness to lightness is mentioned as L value (less L value: black, high L value: white), the degree of greenness to redness is mentioned as a value (high a value: red and less a value: green) and the degree of blueness to yellowness is shown as b value (high b value: yellow and less b value: blue).[11]

2.5 Sensory evaluation of nutri balls

The different composition of buckwheat based nutri balls were noted and proceeded to sensory analysis. A total of thirty people who are semi-trained were selected to act as panelist group. They evaluated the organoleptic quality characteristics i.e. texture, colour, appearance, flavor and taste with the help of a 9 points hedonic score sheet. The mean of the scores of each attribute was computed and the scores of quality parameters were quantified.[12]

2.6 Shelf-life study

The containers with aluminium foils were utilised to pack the nutri balls for storage study. The aluminium foils reduce the transfer of moisutre and minimize the spoilage of the product chiefly the rancidity. The packed nutri balls were stored for three months to analyze the shelf-life. The microbial (total plate count was checked periodically examined every two weeks for nutri balls kept at ambient conditions. The total plate count was analysed by the procedure followed by Swanson et al. (2001).[13]

2.7 Statistical analysis

The calculation of the mean and standard deviation (SD) for all the experimental data in triplicate was calculated. The significance of the data was computed at $p \leq 0.05$ by Duncan's new multiple range tests (DMRT).

3 Results and discussion

3.1 Nutritional analysis

The result of the addition of buckwheat flour on nutritional composition of Nutri balls are presented in Table 2. The percentage of moisture present in the buckwheat added nutri balls was notably raised when the quantity of buckwheat added was increased. The highest percentage of moisture was observed in the control whereas the lowest moisture content was perceived in T4. The change in the percentage of moisture might be due to the drop in the quantity of moisture and reduced absorption of water.[14]

T4 was observed to have the highest quantity of ash and control had the lowest percentage of total ash. As the buckwheat flour is source of high ash content, it increased percentage of ash in buckwheat incorporated nutri balls too. The inclusion of buckwheat flour increases the percentage of ash was reported by Baljeet et al. (2010).[15] As the buckwheat flour inclusion increased, a constant and notable improvement in the quantity of protein was spotted. The results of total protein percentage in the buckwheat-based nutri balls are shown in Table 2. T4 was observed to have the highest quantity of protein and control had the lowest percentage of total protein. As the supplementation of buckwheat flour in the nutri balls improved, the crude protein content was increased. The buckwheat incorporated noodles and cookies showed the improvement in the total protein content from 5 to 7%. It is also documented that the content of crude protein between 9.7 to 15% in buckwheat flour.[16] The highest fat content was observed in T4 and the lowest fat percentage was observed in control. In accordance with the results of Bilgicli (2009), the percentage of fat is observed to be higher in the buckwheat flour than wheat flour.[17] Buckwheat grain is the source for various functional components such as proteins, fiber, phenolics and flavonoids. Moroni et al. (2012) observed the drop in the percentage of fat in food products without gluten and prepared with buckwheat.[18] The highest fiber content was found in T4 and the lowest percentage of fiber content was found in control. The buckwheat grains are source for high biological value fiber.[19]

3.2 Total phenolics, total flavonoids and total antioxidant capacity

The total phenols content at different level of buckwheat flour incorporated nutri balls are shown in Table 2. As presented, the phenols varied from 1.23 mg GAE/g (control) to 6.87 mg GAE/g (T4). The improvement in total phenolics, flavonoids and total antioxidant capacity were noted with an increase in the addition of buckwheat to nutriball. Substituting buckwheat flour in different products make the product promising because of its high concentration of functional compounds i.e. phenolics, flavonoids (rutin, quercetin) which have lots of health benefits. The significant quantity of flavonoids present in the buckwheat incorporated nutri balls make it as a promising functional food. It supplies customers with the excellent health-promoting properties. The methanolic extracts showed the total phenolics, flavonoids and antioxidant capacity in the descending order T4> T3> T2 > T1 >control. The quantified content of total flavonoids expressed as rutin equivalents whereas, the total phenolics expressed as gallic acid equivalents. In control samples were 0.75 mg/g and 1.23 mg/g, respectively. The highest quantity of total phenolics and flavonoids were observed in the highest level of WBW flour incorporated nutria ball which were 3.54 mg/g and 6.87 mg/g respectively. The changes in the antioxidant activities between the buckwheat supplemented nutri balls were significant (Table 2). Buckwheat incorporation showed large increment in the antioxidant activities. The antioxidant activity of 40% of buckwheat added nutri balls increased by nearly 5 folds when compared to those for the control. Alvarez-Jubete et al. (2010) reported about the addition of pseudo-cereals in the gluten-free food products. The buckwheat was examined as vital element for gluten-free cookies and bread. The cookies prepared with the buckwheat flour showed notably higher quantity of total phenolics, flavonoids and antioxidant capacity than the cookies prepared with rice flour.[20]

Table 2. Nutritional characteristics of buckwheat basednutri balls

Parameters	T0	T1	T2	T3	T4
Moisture (%)	29.12 ± 0.03^{e}	26.64 ± 0.05^{d}	25.08 ± 0.09^{c}	21.94 ± 0.21^{b}	20.16 ± 0.14^{a}
Protein (%)	12.59 ± 0.08^{a}	13.05 ± 0.14^{ab}	13.29 ± 0.07^{bc}	13.56 ± 0.16^{cd}	13.99 ± 0.03^{de}
Fat (%)	22.87 ± 0.15^{a}	18.19 ± 0.18^{b}	16.05 ± 0.07^{c}	13.96 ± 0.09^{d}	11.67 ± 0.16^{e}
Ash (%)	1.63 ± 0.12^{a}	1.83 ± 0.03^{b}	1.93 ± 0.02^{c}	2.11 ± 0.05^{d}	2.32 ± 0.08^{e}
Fibre (%)	4.97 ± 0.04^{a}	5.21 ± 0.15^{b}	5.74 ± 0.11^{c}	6.07 ± 0.13^{d}	6.21 ± 0.02^{e}
Total phenolic content (mg GAE /g)	1.23 ± 0.08^{a}	3.06 ± 0.03^{b}	4.31 ± 0.06^{c}	5.97 ± 0.11^{d}	6.87 ± 0.05^{e}
Total antioxidant capacity (mM TE /g)	10.08 ± 0.06^{a}	18.16 ± 0.16^{b}	25.93 ± 0.14^{c}	34.21 ± 0.17^{d}	47.31 ± 0.04^{e}
Total flavonoids (mg QE /g)	0.75 ± 0.06^{a}	1.19 ± 0.11^{b}	2.05 ± 0.14^{c}	2.96 ± 0.03^{d}	3.54 ± 0.11^{e}

Values are mean ± standard deviation. Values in different superscripts within the row are significantly different from each other ($p\leq0.05$); T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 - 30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation

3.3 Color properties

Table 3 shows the color characteristics,i.e. L*- the degree of darkness to lightness (less L value: black, high L value: white), a* - the degree of greeness to redness (high a value: red and less a value: green), b* - the degree of blueness to yellowness (high b value: yellow and less b value: blue) of the various buckwheat incorporated nutri balls. There were variations in L*, a* and b*

between the samples examined. Especially, higher l*, a* and b* were found in control. As the supplementation of buckwheat rises, there was a reduction in the readings of l*, a* and b* Interestingly, the value of a* of various buckwheat significantly ($P < 0.05$) correlated to the copper, magnesium, potassium and phosphorus contents of the buckwheat. Furthermore, the L* value of the buckwheat significantly correlated to the manganese content of the buckwheat. The results were akin to the results of Pathare et al., 2013. [21]

Table 3. Color properties of different levels of buckwheat flour incorporatednutri balls

Color parameters	T0	T1	T2	T3	T4
L*(D65)	57.82 ± 0.05^{e}	49.05 ± 0.17^{d}	43.47 ± 0.09^{c}	39.84 ± 0.25^{b}	34.06 ± 0.11^{a}
a*(D65)	2.85 ± 0.06^{de}	2.61 ± 0.15^{cd}	2.53 ± 0.12^{c}	2.32 ± 0.11^{b}	2.13 ± 0.02^{a}
b*(D65)	22.12 ± 0.11^{e}	18.28 ± 0.14^{d}	15.72 ± 0.17^{c}	12.12 ± 0.24^{b}	10.19 ± 0.18^{a}

Values are mean ± standard deviation. Values in different superscripts within the row are significantly different from each other ($p\leq0.05$); T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 – 30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation

3.4 Sensory evaluation

In Figure 3 the results of sensory analysis of the buckwheat added nutri balls based on the appearance, texture, color and taste is shown. This study was supported by Jaiswal et al., (2020) developed nutri-rich energy bar and jaggery balls using nutritious ingredients like peanuts, pumpkin seed powder, wheat flour and jaggery. [22] Sensory evaluation showed that up to 30% of buckwheat flour incorporation in nutri balls showed insignificant difference. The 30% buckwheat flour incorporation recognized as the most highly acceptable. Hence, the recommendation of buckwheat based nutri balls for protein energy deficient malnourished children who are affected by severe wasting and defects in the growth could be beneficial. The increase in the supplementation of buckwheat in the nutriballs slightly and constantly reduced the taste of the product. This is due to the higher concentration of total ash in the buckwheat. Kim et al. (2004) demonstrated that high ash content in the product in due to the presence of undesired materials i.e. bran which causes the poor quality of texture. [23] According to the study by Baljeet et al. (2010) the phenolics and flavonoids present in the buckwheat flour cause the bitter taste in the final product and reduce the sensory scores.16 (Values are mean ± standard deviation. T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 - 30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation). [15]

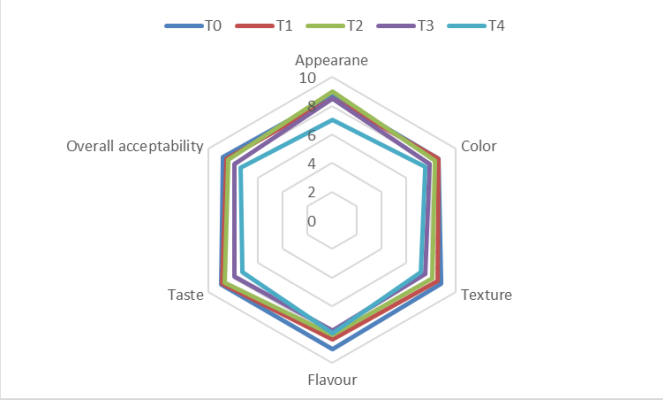

Fig 2. Sensory scores of buckwheat flour incorporated nutri balls
(Values are mean ± standard deviation. T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 - 30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation)

3.5 Shelf-life study

The effect of storage on total plate count of nutri balls is presented Figure 3. Water activity, time, moisture, optimum pH and nutrients, temperature is essential for the proliferation of microbes in the food or any ecosystem. To increase the storage / shelf-

life of food product managing these factors are crucial. The total plate count data disclosed that there was steady increase growth of microbes during the storage period. However, the colony forming units were seen not more than the permissible limitations. It can be extrapolated that nutri ball has a storage period / shelf life of two months at ambient conditions. After which, the TPC was increased beyond the limit. The refrigeration temperature might have extended the shelf life may be extended of the nutri balls. The outcomes of shelf-life analysis of nutri balls demonstrated that nutri balls had sensory satisfactory for two months period of storage. The oxidation of phenolics present in the buckwheat of the product caused the mild browning of the nutri balls. However, the flavour of the nutri balls did not show any difference. The outcomes of this study were akin to the findings of Ibeanu et al., 2015. [24]

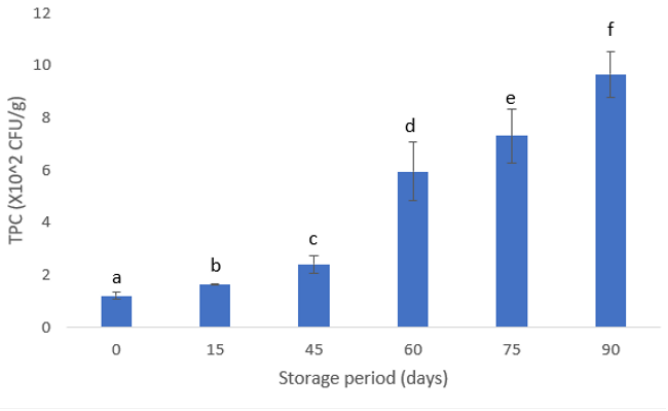

Fig 3. Effect of storage period on total plate count of different levels of buckwheat flour incorporated nutri balls
(Values are mean ± standard deviation. Values in different superscripts are significantly different from each other ($p \leq 0.05$); T0 - Control (without buckwheat flour incorporation); T1 - 10% of buckwheat flour incorporation; T2 - 20% of buckwheat flour incorporation; T3 – 30% of buckwheat flour incorporation; T4 – 40% buckwheat flour incorporation)

4 Conclusion

The inclusion of buckwheat flour in nutri balls had substantial impacts on nutritional, sensory and color value of nutri balls. When the addition percentage of buckwheat flour improved in nutri balls, the fiber, ash, protein, phenolics, flavonoids and total antioxidant capacity was also increased. Upto 30% supplementation of buckwheat flour (T3) showed a better overall acceptance of nutri balls in sensory analysis. The health-promoting properties of buckwheat such as improving diabetes, hypertension, obesity, high-cholesterol were proven in many preclinical and clinical trials. The most interesting areas in food industry is the development and production of functional food products which have health benefits. Recently, the customers interest on gluten free food products keep increasing and various products without gluten have come to the market. From the current study, it could be inferred that supplementation of buckwheat flour in nutri balls improved the quality of nutrients in the final product. However, the organoleptic properties mainly the color was affected negatively when the addition of buckwheat increased more than 30% in the nutri balls. There are only insufficient studies that support the safety of buckwheat-based products against inflammatory bowel disease or celiac disease even though the buckwheat obtained a high attention as a product without gluten. Hence, the clinical trials are essential to study the buckwheat-based gluten-free food products to treat celiac disease without producing adverse immunological reaction.

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