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Optimization and Characterization of Cookies from Malted Foxtail Millet and Lentil Flour

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Abstract: The aim of this study was to develop a nutritionally rich cookie by replacing a portion of refined wheat flour with malted foxtail millet flour, and malted lentil flour. Mixture design was employed to optimize the combination of different flours on the basis of various quality parameters such as spread ratio, hardness and overall acceptability of the cookies. Physicochemical properties such as proximate analysis and colour was determined along with the sensory attributes. Considering the desirability of spread ratio, hardness and overall acceptability of cookies, the optimized formulation was found to be 59.5% refined wheat flour, 10% malted foxtail millet flour, and 30.5% malted lentil flour resulting in spread ratio, hardness, and an overall acceptability score of 5.65±0.05, 6.84±.15N, and 7.66±0.25, respectively. The optimized cookies obtained was characterized as a product rich in fibres (3.82±0.05%), good source of protein (10.05±0.05%), rich source of antioxidant [DPPH (%inhibition) 42.37±0.87, FRAP (mmTE/100g) 70.05±0.52] and total polyphenols (300.05±0.50 mgGAE/100g). The developed nutritionally rich cookies can be used for adolescent children as a good source of protein.

Keywords: Cookies, malted foxtail millet, malted lentil flour, spread ratio, hardness

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1. Introduction

The term "Cookies" is derived from the Dutch word 'KOEKZE'meaning the little cake and occupies a major place in the bakery industry. Due to the ease of availability, taste, and affordable price cookies are consumed worldwide, mainly by adults and children. Cookies are generally prepared with refined wheat flour having high levels of fat and sugar with less amount of water, which restricts the gluten development and makes the cookies crisper (Lee *et al.* 2018). Due to the low amount of water, the shelf-life of cookies is higher when compared to other bakery products (Galic *et al.* 2009). As consumers interest and market dynamics are changing, the industry recorded revenue of USD 27.4 billion generated worldwide in 2016. During the forecast period 2018-2023, the global cookies market is expected to register a CAGR of 4.1% as per research and markets survey. From the past 10 years, the eating culture of humans has been changed considerably as the health consciousness is increasing day by day and people starting to consume multigrain products. It is the current trend in western countries to replace daily snack food such as cookies, pasta etc., with multigrain products. Therefore many researchers have shown that the addition of composite flours like millets and lentils will increase the nutritional content of the cookies (Cheng and Bhat, 2016). It has been reported that the replacement of wheat flour in cookies with 50% of lentil flour increases the protein content from 5 to 9 % and fiber content from 1 to 5% (Portman *et al.* 2019). It was also reported that the addition of 30% germinated millets flour improved the protein content, dietary fiber, total phenolics, and antioxidant activity (Sharma *et al.* 2016). Many research works have been done on the addition of millets and lentil flours to develop cookies, but limited literature is available on effects of malted flours on the physical and nutritional properties of cookies.

The millets are grass crops that are extremely important staple crops for humans and animals. Foxtail millet is a major part of the diet in some Asian countries like China and India. Foxtail millet is one of the oldest cultivated crops originated from China, and is now cultivated throughout the world (Yang *et al.* 2022). India is the second-largest producer of foxtail millets after China. Due to their short time and wide adaptability under various environmental conditions, these are the best-suited crop for sustainable agriculture and future food security. The study on foxtail millets is under-explored as compared to other cereals such as wheat, rice, little millet etc. (Pandey *et al.* 2017). Foxtail millet (Setaria italica) is also known as kangni, tenai, and navane. It has been claimed to have several nutritional and therapeutic characteristics and is recommended by practitioners in ayurvedic and homeopathic products. Foxtail millet, like buckwheat and quinoa, is non-glutinous and non-acid-generating, making it an easily digestible grain (Sharma *et al.* 2015). Foxtail millet is a rich source of fibre (12-14g/100g), protein (11-20g/100g), minerals (2-4g/100g), it can be used in the development of various food products with high nutritional content. Foxtail millet have been reported to have the highest amount of essential amino acids, as high as almost 3g/100g with leucine alone amounting to nearly 1.1g/100g (Kranthi *et al.* 2018). As it is rich source of polyphenolic compounds and antioxidant it may help in prevention of cardiovascular diseases and shows the hypoglycaemic and hypolipidemic effect (Sharma *et al.* 2018).

Lentils are seed crops that belong to the family of Leguminosae. Different varieties of lentils grown around the world are green lentils, red lentils, small brown lentils, French green lentils, and black lentils. Among them, red lentils and green lentils are the most common varieties. Lentils are considered rich sources of complex hydrocarbons and minerals with high protein (20.6 to 31.6%) and low fat (0.70 to 4.3%) (Manickavasagan and Thirunathan, 2020). According to FAOSTAT report in 2019, the lentil production in the world was 5.7 M tonnes and is considered a major staple diet in some Asian countries like India and Bangladesh. Due to their short cooking time, they can be called soft-coated pulses resulting in a small nutrient loss (Faris *et al.* 2013). Among all the pulses, lentils have high total phenolic contents. Lentil seed coat contains different types of flavonoids namely flavones, glycosides, and flavonals (Faris *et al.* 2013). El-Adawy*et al.* studied the impact of germination of lentils and reported that antinutritional factors like phytates and hemagglutinin were decreased and protein, moisture, and total ash contents were increased (El-Adawy *et al.* 2003).

Malting increases, the nutritional value of whole grains by causing the reduction in antinutritional factors like phytic acid, polyphenols, and oxalic acid. Malting is often termed as controlled germination followed by controlled drying as it results in desirable physical and chemical changes in grains which are further stabilized by drying. The malting process consists of four basic unit operations namely pre-cleaning, steeping, germination, and kilning. During malting hydrolytic enzymes develops that are absent in un-germinated grains. Malting may improves the availability of digestible protein through synthesis of lysine-rich proteins and availability of vitamin B (Taylor and Kruger, 2015). Deepali *et al.* reported that after malting, oil absorption capacity was improved in malted foxtail millet, and it is a desirable quality in the development of bakery products such cookies and biscuits, an increase in oil absorption increases the mouthfeel and flavour retention (Deepali *et al.* 2013). It was observed that increase in nutritional quality of malted foxtail millet improved as compared to raw foxtail millets, hence the addition of malted foxtail millet flour to cookies may increase the nutritional quality of products (Chaturvedi, 2015).

This study was carried out to optimize the ratio of malted foxtail millet flour, malted lentil flour and refined wheat flour for the development of nutritionally rich cookies that are sensorially acceptable.

2. Materials and Methods

2.1. *Materials*

All the raw materials including refined wheat flour, malted foxtail millet flour, and malted red lentils flour were purchased from Vedaka brand, an online E-commerce shopping website. The other ingredients like sugar, butter, baker's ammonia, baking soda, milk powder were obtained from the local market of Sonipat, Haryana (India). All the reagents and chemicals used were of scientific grade, and were procured from Sigma Aldrich Research Laboratories Pvt. Ltd., Mumbai, Maharashtra, India.

2.2. *Experimental design*

Refined wheat flour (X_1:40-60%), malted foxtail millet flour (X_2:10-40%), and malted lentil flour (X_3: 10- 40%) were the independent factors and the response variables were spread ratio (Y_1), hardness (kg) (Y_2) and overall acceptability (Y_3). The levels of independent variables were selected based on preliminary trials and literature. A total of 16 experimental runs were obtained using Mixture Design Matrix (Table 1). Composite flour was prepared according to the independent variable composition given by the runs in the experimental design and mean values of the responses were analysed using the quadratic and cubic polynomial regression equation (Eq. 1 and 2).

$$Y = \lambda_1X_1+\lambda_2X_2+\lambda_3X_3+\lambda_1\lambda_2X_1X_2+\lambda_1\lambda_3X_1X_3+\lambda_2\lambda_3X_2X_3 \text{ (quadratic)} \quad (1)$$

$$Y = \lambda_1X_1+\lambda_2X_2+\lambda_3X_3+\lambda_1\lambda_2X_1X_2+\lambda_1\lambda_3X_1X_3+\lambda_2\lambda_3X_2X_3+\lambda_1\lambda_2\lambda_3X_1X_2X_3 \text{ (cubic)} \quad (2)$$

Here Y is the predictive response variable, λ_1,λ_2, and $\lambda_3$were the linear, quadratic and cubic regression coefficients, where X_1, $X_{2,}$ and X_3 are the coded independent variables (Ajay and Pradyuman, 2019).

2.3. *Cookies Preparation*

Cookies were prepared with the method explained by Cheng and Bhat with slight modifications (Cheng and Bhat, 2016). The cookies were packed and

Table 1: Mixture design for cookie optimization with experimental values of responses (Y) against independent variables (X)

Run	X_1	X_2	X_3	Y_1	Y_2	Y_3
1	60.0	13.8	26.2	5.75±0.36	7.55±0.50	8.12±0.12
2	50.1	24.7	25.2	5.30± 0.27	7.80±0.38	7.25±0.15
3	50.0	40.0	10.0	5.28±0.25	8.56±0.45	5.05±0.25
4	60.0	22.9	17.1	5.58±0.33	9.55±0.58	7.15±0.15
5	50.1	24.7	25.2	5.40±0.10	7.55±0.47	8.08±0.08
6	50.1	24.7	25.2	5.45±0.15	7.50±0.52	8.08±0.10
7	50.1	32.6	17.4	5.26±0.29	8.55±0.75	6.23±0.07
8	57.4	32.6	10.0	5.32±0.14	10.03±0.10	7.24±0.16
9	50.0	10.0	40.0	5.46±0.25	6.60±0.28	7.08±0.12
10	43.0	40.0	17.0	5.25±0.32	8.95±0.47	5.35±0.15
11	40.0	32.8	27.2	5.30±0.24	9.85±0.12	6.25±0.15
12	51.6	16.7	31.7	5.48±0.42	6.90±0.21	8.08±0.22
13	50.0	10.0	40.0	5.40±0.30	6.67±0.30	7.18±0.22
14	60.0	13.8	26.2	5.70±0.35	7.49±0.20	8.14±0.26
15	40.0	23.7	36.3	5.30±0.15	10.75±0.10	7.12±0.38
16	40.0	23.7	36.3	5.30±0.15	10.77±0.12	7.05±0.35

Where, X_1(Refined wheat flour, %), X_2 (Malted foxtail millet flour, %), X_3(Malted lentil flour, %), Y_1(Spread ratio), Y_2(Hardness, kg), Y_3 (Overall acceptability). All the triplicate values were represented as mean ± standard deviation.

stored for 24h before analyses were conducted. Cookies prepared from refined wheat flour used as control.

2.4. Evaluation of Cookie Quality

2.4.1. Spread ratio

The spread ratio of the cookies was calculated using the method given by Mudgil *et al.* (2017) with slight modification. The diameter of the cookies was calculated by placing six cookies side by side, and the diameter was recoded and then cookies were rotated to 90°, 180°, 270°, and the average diameter was calculated. The thickness or height of the cookies was calculated by stacking six cookies. Height was measured and the average thickness was calculated by restacking six times. The spread ratio was calculated by dividing the average diameter of cookies by the average thickness measured.

2.4.2. Hardness

The hardness of cookies was recorded using Texture Analyser (Stable Micro System UK, Model No. TA HDi®) attached with a blade set with a knife (load cell: 30 kg, distance: 50% compression mode, speed of pre-test at 1.50 mm/s, test speed of 2.00 mm/s, speed of post-test at 10.00 mm/s). The maximum force at the peak in the force-time graph was recorded as the hardness of cookies (Cheng and Bhat, 2016).

2.4.3. Sensory analysis of cookies

Sensory analysis of the cookies was conducted using a 9-point Hedonic scale (1= dislike extremely, and 9= like extremely). A panel of 30 members consisting of faculty members, students, and employees of the National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Kundli, India was selected for the sensory analysis of cookies. Prior information was provided to all the panellists about the Hedonic scale and the aim of our study before conducting the sensory analysis. All the 16 samples were coded and sensory analysis was carried out at room temperature (26±2°C). For testing each sample, panellists rinsed their mouths with fresh purified drinking water (Singh *et al.* 2013).

2.4.4. Physicochemical properties of control and optimized cookies

Proximate analysis of the control and optimized cookies was calculated according to the standard protocol (AACC, 2000). The colour parameters include L^*(lightness), a^* (redness), b^* (blueness) were measured with a hand-held colorimeter (Konica Minolta CR-400 Japan). Calibration of the machine was done by using a white tile and readings were measured.

2.4.5. Estimation of total phenolic content (TPC)

TPC of the product samples was measured using the modified Folin-Ciocalteu (FC) procedure as used by Kamble *et al.* (2019). To prepare the sample extract, powdered sample (2 g) was mixed vigorously with 20 ml of 60% methanol comprising 0.1% HCl and extracted vigorously (4h/27 °C) in a shaking incubator. The suspensions were centrifuged at 3000 rpm for 15 min/10 °C and supernatant was collected by filtration through Whatman #1 filter paper. The filtrates were stored at deep freezer (–20 °C) until analysis. A 100 µL of sample extract was added to FC reagent of 500 µL and then mixed the solution in 6 ml distilled water. After mixing the sample content, 2 mL of 15% Na_2CO_3 was mixed and vortexed for 1 min. Then distilled water was added to make the volume of 10 mL and tubes were left for incubation for 2 h. Readings were taken at 750 nm by using UV visible spectrophotometer. The data is given as mg gallic acid equivalent/100 g dry basis.

2.4.6. Calculation of antioxidant activity

The antioxidant activity of the control and optimized cookies was measured by three different methods, namely 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay, 2,2-azino-bis-3-ethylbenzo-thiazoline-6-sulfonic acid (ABTS) assay, and ferric-reducing power (FRAP).

2.4.6.1. DPPH radical scavenging assay

DPPH inhibition percentage was measured as per the procedure explained by Williams *et al.* (1995). The DPPH reagent (3.9mL) was combined with sample extract (0.1mL) and the resulting solution was kept for incubation in dark for 30 min. Then absorbance of the sample was recorded at 517 nm against the blank sample as methanol. The scavenging activity of DPPH radical was examined by using the formula as follows:

$$\%\ Inhibition = \frac{Absorbance\ value\ of\ control - Absorbance\ value\ of\ sample}{Absorbance\ value\ of\ control} \times 100$$

2.4.6.2. Ferric reducing antioxidant power (FRAP)

To measure FRAP activity, the method used by (Rani *et al.* 2019) was adopted. The prepared extract of 0.1 mL was combined with 3 mL of FRAP reagent having TPTZ (0.031 mg/10 mL, 40 mM HCl), $FeCl_3.6H_20$ of 20 mM, and acetate buffer of 300 mM with pH 3.6 in the ratio of 1:1:10. The readings of absorbance were recorded at 593 nm after an incubation period of 4 min against blank of FRAP reagent and data were presented as millimole Trolox equivalent per 100 g dry weight (mM TE/100 g dw.).

2.4.6.2. Determination of ABTS antioxidant assay

ABTS test was performed using the method given by (Rani *et al.* 2019). ABTS cation radical made by reacting 2.45 mM potassium persulfate and 7 mM of ABTS taken in the ratio of 1:1 in water and stored in dark conditions for 12-16 h before analysis. The ABTS cation was mixed with methanol (1:60) to obtain an absorbance reading of 0.70±0.02. Then, 20 µL of sample extract was mixed with ABTS reagent of 2 mL of ABTS reagent, and values of absorbance were taken after 6 min at 734 nm wavelength range. The results of ABTS assay were displayed as millimolar Trolox equivalent per 100 g dry weight (mM TE/100 g dw.).

2.4.7. Determination of anti-nutritional factors

Phytate and tannin content of the control and optimized cookies were estimated by the method used by (Kamble *et al.* 2019). To measure the phytate content 0.15 g of powdered sample was mixed to 2.4% of 10 mL of HCl and placed in a biological shaking incubator for 1h at 25 °C. The resulted solution was centrifuged at 3000 g for 30 min and then filtered to obtain a clear extract for phytate analysis. 1 mL of wade reagent consisting of 0.3% sulfosalicylic and 0.03% $FeCl_3.6H_2O$ acid in water was mixed with the sample extract of 3 mL and vortexed for 5 s. The obtained reading at 500 nm of wavelength was recorded immediately. To calculate the tannin content, the sample extract of 0.1 mL was added to 75 mL of distilled water in a 100 mL capacity volumetric flask. Thereafter, 5 mL of Folin-Denis's reagent and 10 mL of Na_2CO_3 solution were introduced before adjusting the final volume up to 100 mL by distilled water. The samples were incubated for 30 min and absorbance of the samples were recorded at 760 nm. The data were recorded as milligram tannic acid equivalent per 100 g of flour weight (mg TAE/100 g.).

2.5. Statistical Analysis

For the experimental design and optimization of cookies, Mixture Design of Design-Expert version.12.0.3.0 (State-Ease, USA) along with one way ANOVA was used to find the significant differences between the means at 95% confidence level. ANOVA tables were generated to check the adequacy and accuracy of the fitted models. To visualize the relationship between the responses and independent variables, surface response and contour plots of the fitted polynomial regression equations were generated using the same software.The data were analysed statistically using SPSS 22 version (SPSS, Inc., Chicago, lL, USA).

3. Results and Discussion

A significant difference was observed for the responses like spread ratio, hardness, and overall acceptability among the samples. The obtained spread ratio ranged from 5.25 to 5.75, hardness from 6.60 to 1077 kg and overall acceptability values from 5 to 8. The second-order and third-order equations were fitted to the experimental data in terms of actual factors (Table 2). The lack of fit was not significant whereas ANOVA results suggest that fitted models were highly significant ($p<0.05$).

3.1. Effect of Independent Variables on Physical and Sensory Responses

3D surface graphs were generated in Design-Expert software to analyse the effects of individual variables and interactive effects on particular responses.

The observed response plots indicate that both malted foxtail millet flour and malted lentil flour have a significant negative impact on the spread ratio. By increasing the content of malted foxtail millet and malted lentil flour, the spread ratio of cookies is decreasing (Figure 1a) though not significant. The reason behind this negative effect may be , increase in the protein content of composite flour (Arepally *et al.* 2020). As the protein content increases the water-binding capacity of the flour increases, which means the proteins in the composite flour absorb more water when compared to the 100% refined wheat flour, as a result, the cookies will spread less. Further, during malting, the hydrophilic nature of the flour increases due to the enzymatic degradation of starch and proteins into smaller sugars and peptides (Sharma *et al.* 2016).

Table 2: Regression analysis for experimental responses

Regression coefficient	*Spread ratio*	*Hardness*	*Overall acceptability*
X_1	0.2794*	0.5039*	0.0237*
X_2	-0.0713*	0.2595*	-0.3331*
X_3	-0.2916*	0.8836*	-0.0743*
X_1X_2	-0.0019	-0.0115*	0.0068
X_1X_3	0.0022	-0.0254*	0.0031
X_2X_3	0.0019	0.0001	0.0063
$X_1X_2X_3$	0.0001	-	-
$X_1X_2(X_1\text{-}X_2)$	-0.000076	-	-
$X_1X_3(X_1\text{-}X_3)$	-0.000099	-	-
$X_2X_3(X_2\text{-}X_3)$	-0.000023	-	-
R^2, %	95.22	98.97	86.41
CV %	0.98	2.07	6.50

Where, X_1(Refined wheat flour, %), X_2 (Malted foxtail millet flour, %), X_3(Malted lentil flour, %), CV= coefficient of variance; R^2= regression coefficient. * Significance at $p< 0.05$.

The replacement of malted flours has shown a significant positive impact on the hardness of cookies (Figure1b). By increasing the percentage of malted flours, the hardness of cookies increased. This increase in hardness may be due to the high fibre content present in composite flour. As fibre content was higher, hydroxyl groups that are present in the composite flour allow more water interaction due to hydrogen bonding, as a result, hardness of composite flour cookies increased. Adebiyi *et al.* (2016) also reported that, while replacing the refined wheat flour with malted pearl millet flour, the hardness of the cookies increased. Same finding also reported by AL-Ansi *et al.* (2018) that hardness of biscuits increased by using composite flour consisting of pearl millet and lentil flour.

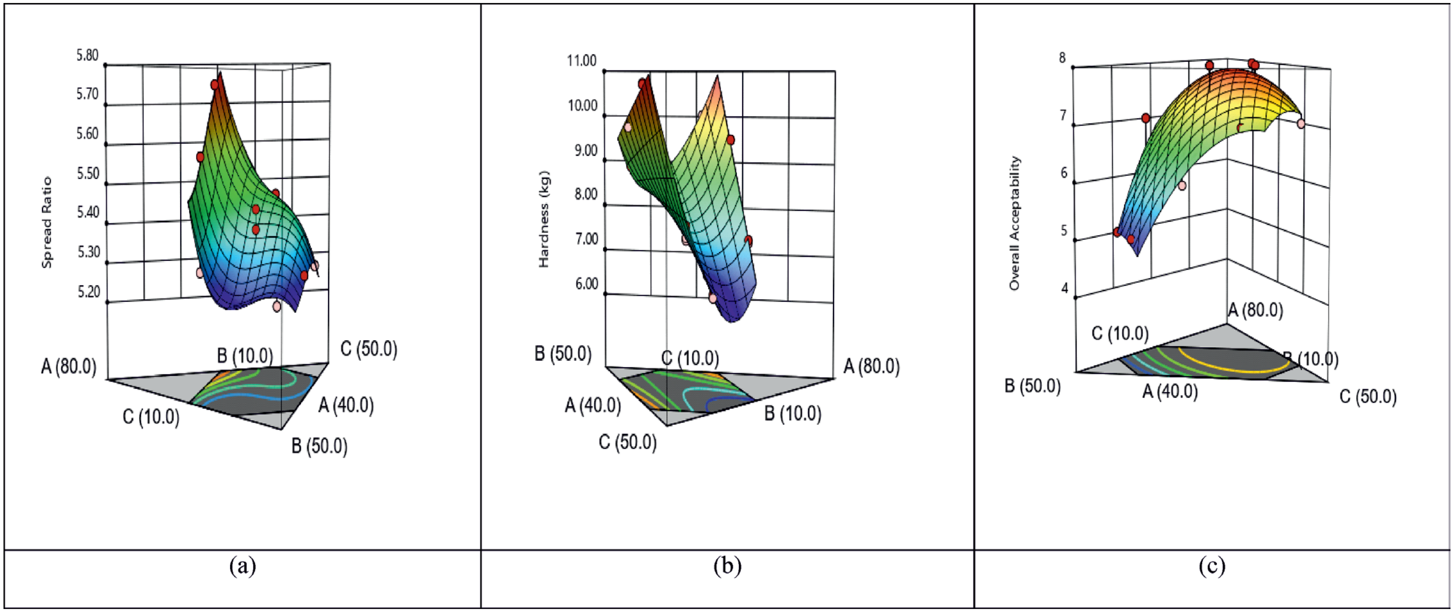
Overall acceptability of the cookies samples varied from 5.05 to 8.14. The overall acceptability values show that refined wheat flour had a significant positive impact on cookie samples (Figure 1c). This may be due to the increasing amount of gluten, it provides a matrix which helps to hold the fat and sugar. While the malted foxtail millet and malted lentil flour have negative impact on overall acceptability. This negative impact on overall acceptability may be due to the darker colour of the cookies prepared with increasing the level of malted lentil flour and malted foxtail millet flour. Similar findings were reported by (Kumar *et al.* 2015), while replacing refined wheat flour with the multi-grain premix flour which consists of barley, sorghum, chickpea, and defatted soy flour.

3.2. Selection of Optimum Conditions

Independent variables were optimized by mathematical optimization process using Design-Expert software (version.12.0.3.0). For getting the optimum processing conditions, certain limits were assigned to independent variables (in range) and response variables i.e., maximize (spread ratio), minimize (hardness) and maximize (overall acceptability). Based on all the suggested combinations from the software, the adequate solution with maximum desirability (0.947) for the prediction of the multigrain cookies was obtained by using 59.5% refined wheat flour, 10% malted foxtail millet flour, and 30.5% malted lentil flour. The sample was prepared as per the optimized levels of the flours. The experimental values of response variables were found close to the predicted values as shown in Table 3.

3.3. Physicochemical and Antioxidant Properties of Control and Optimized Cookies

The obtained results of the nutritional analysis of refined wheat flour cookies (control) and optimized (multigrain) cookies are presented in Table 4. The refined wheat flour cookies (control) had a moisture content of 10.93±0.15 % (db) that was higher than the optimized cookies i.e., 10.36±0.15%. The fat and ash content of the optimized cookies were reported significantly ($p<0.05$) higher than control (refined wheat flour) cookies. The finding is supported by the findings (Sharma *et al.* 2016), Ghumman *et al.* (2016), Ajay and Pradyuman, 2019). The crude fibre content of the optimized cookies (3.82 %) was also found to be significantly higher ($p<0.05$) than the control cookies (1%), it might be due to the higher crude fibre content of malted foxtail and lentil flour. The energy value shows the significant ($p<0.05$) difference between control and



(a) (b) (c)

Figure 1: Impact of independent variables on the spread ratio(a), hardness (b), and overall acceptability (c) of cookies, where A= refined wheat flour, B=malted foxtail millet flour, and C= malted lentil flour

Table 3: Verification of predicted values of responses achieved at an optimal level

Response variable	*Predicted value*	*Experimental value*
Spread ratio	5.750^{b}	5.650±0.05^{a}
Hardness (Kg)	6.60^{a}	6.84±.15^{b}
Overall acceptability	7.55^{a}	7.66±0.25^{a}

Means in the rows with different superscripts are differ significantly ($P \leq 0.05$)

Table 4: Nutritional, physical, and anti-nutritional properties of cookies

Parameter	*Control cookies*	*Optimized cookies*
Nutritional composition		
Moisture (%)	10.93±0.15^{b}	10.36±0.15^{a}
Ash (%)	0.85±0.02^{a}	2.58±0.02^{b}
Protein (%)	7.08±0.03^{a}	10.50±0.05^{b}
Fat (%)	20.85±0.15^{a}	22.66±0.10^{b}
Crude fibre (%)	1.00±0.04^{a}	3.82±0.05^{b}
Carbohydrate (%)	60.29±0.26^{a}	53.9±0.52^{b}
Energy (kcal)	452.00±1.24^{a}	461.54±1.55^{b}
Colour		
L^*	68.55±4.00^{b}	56.86±2.21^{a}
a^*	7.36±2.74^{a}	9.76±0.43^{a}
b^*	36.74±1.59^{b}	27.86±0.95^{a}
Antioxidant activity		
TPC (mg GAE/100g)	71.52±0.10^{a}	300.05±0.50^{b}
DPPH (%inhibition)	42.37±0.87^{a}	60.21±0.82^{b}
FRAP (mm TE/100g)	70.05±0.52^{a}	180.52±0.54^{b}
Anti-nutritional factors		
Tannin (mg TAE/100g)	108.74±0.54^{b}	101.57±0.30^{a}
Phytate (mg /100g)	300.74±0.46^{b}	250.70±0.22^{a}

Note: All the triplicate values were represented as mean ± standard deviation. Different superscripts to the values indicate values differ significantly ($p \leq 0.05$). Where, GAE= gallic acid equivalent, TE= Trolox equivalent, TAE= tannic acid equivalent.

optimized cookies, where optimized cookies were having a higher energy value (461.54±1.55 kcal) as compared to that of control cookies (452.00±1.24 kcal). These higher energy values in the optimized cookies may be due to the higher fat content. The colour values (L^*= 56.86±2.21 and b^*= 27.86±0.95) for the optimized cookies were significantly ($p<0.05$) lower than control cookies, maybe due to the impact of ingredients on colour and lightness. The malted foxtail millet and lentils flours are darker in colour when compared to the refined wheat flour, which may have an impact on the final optimized products compared to control cookies. However, the higher values of a^* for optimized

Figure 2 (a) Cookies made with optimized flour, (b) Cookies made with refined wheat flour

cookies (9.76±0.43) when compared to control cookies (7.36±2.34) indicate that red colour pigment present in the red lentil. The results were consistent with the earlier literature where Cheng and Bhat reported that a* values of the cookies were higher by adding the jering legume flour (Cheng and Bhat, 2016).

It was observed that optimized cookies (300.05±0.50 mg GAE/100g) show significantly ($p<0.05$) higher total phenolic content than control cookies (71.52±0.10 mg GAE/100g). The antioxidant activity calculated from the DPPH, FRAP assay values of optimized cookies was significantly ($p<0.05$) higher than that of control cookies. These higher contents of total phenolic and antioxidant activity assays may be due to the addition of malted foxtail millet flour and lentil flour. The results indicate that the addition of malted foxtail millet and malted lentil flours can be a feasible way to enhance the antioxidant properties of traditional refined wheat flour cookies. Similar findings were reported by various literature that the addition of millet and lentil flour make the products rich in antioxidant activity (Chiremba *et al.* 2009; Shafi *et al.* 2016; Morales *et al.* 2009).

3.5. *Anti-nutritional Factors*

Tannins and phytates are the major anti-nutritional contents present in the cereals, millets, and lentils that cause a decrease in the digestibility of proteins by forming complexes with inhibiting enzymes and proteins. It was observed that anti-nutritional contents such as tannins and phytates in optimized cookies were significantly ($p<0.05$) lesser than the control cookies. Here, tannin and phytate contents of optimized cookies were 101.57±0.30 (mg TAE/100g) and 250.70±0.22 (mg TAE/100g), respectively while that of the control cookies were 108.74±0.54 (mg TAE/100g) and 300.74±0.46 (mg TAE/100g), respectively. This decrease in anti-nutritional contents in optimized cookies may be due to the addition of malted flours. In the lentils during malting, the tannins will be leached into the water and the binding of polyphenols will occur along with other substances like carbohydrates and proteins. The reduction in phytate content is caused by an increase in phytase activity (Fouad and Rehab, 2015). During soaking of foxtail millets, breakdown of tannin compounds occurs in water resulting in decreased tannin contents. The decrease in phytate acid content in foxtail millets is due to phytase activity which forms inositol monophosphate by the hydrolysis of phytate phosphorus (Sharma *et al.* 2018).

4. Conclusion

The present study aimed at partly replacing the refined wheat flour with malted foxtail millet and lentil flours to increase the energy content of the cookies and to reduce the anti-nutritional factors. It was observed that up to 40% of refined wheat flour can be replaced by malted flours (malted foxtail millet flour: 10% and malted lentil flour: 30.5%) to produce nutritionally enriched cookies which are comparable to refined wheat flour cookies on physico chemical aspects. Protein content and crude fibre of optimized cookies increased by 48.3% and 282% respectively than control cookies.The antinutritional factors have been reduced in optimized cookies compared to control cookies. The antioxidants composition of optimized cookies is also significantly higher than control cookies. By the observation in protein, fibre, and energy contents these composite flour cookies can be a good diet for adolescent children. These developed cookies can be marketed by the name of high protein and high fibre content cookies.

Abbreviations

TPC – Total Phenolic content; DPPH-1,1-diphenyl-2-picrylhydrazyl; ABTS- 2,2-azino-bis-3-ethylbenzo-thiazoline-6-sulfonic acid assay; FRAP-ferric-reducing power; ANOVA-analysed statistically with analysis of variance.

Author's Contribution

JST performed the experiments, interpreted the findings, wrote the manuscript. ST designed and supervised the study. RS designed and supervised the study. AS improved the manuscript and revised it. BPK designed the experiments and revised the manuscript. SM performed experiments. VKB revised the manuscript. All authors read and approved the final manuscript.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

Data Availability Statement

The data sets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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