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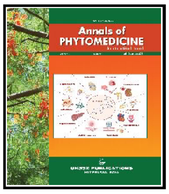

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Process standardization for development of value-added herbal oat cookies with *Terminalia chebula* Retz. powder and *Artocarpus heterophyllus* Lam. seed flour

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Abstract

Cookies also known as "ready to eat" snack item that are consumed universally, are convenient, nutritious, safe, have good shelf life as well as cheaper and regarded to be a good product for value addition, enrichment, or fortification. In this study cookies were made using novel ingredients such as oat flour, *Terminalia chebula* Retz. (TC) powder and *Artocarpus heterophyllus* LAM. seed flour (AHSF). CCRD of Design expert is used to optimize the product with variables as oat flour, AHSF, and TC powder. Sensory characteristics, hardness and fracturability is used as response factor. Oat- 40 g, TC- 2 g, and AHSF-15 g was suggested to be the optimized composition for the cookies. The color analysis of both control as well optimized cookies resulted in the decrease of L* value in optimized cookies while increase in a* and b* value of optimized cookies. Moisture content of the control cookies (3.38 ± 0.08) was higher than that of optimized cookies (2.85 ± 0.04). The crude fiber content of optimized cookies (7.60 ± 0.07) was higher than that of control cookies (8.10 ± 0.98). Overall, the optimized composition showed good sensorial acceptance and proximate values and therefore, oat flour, AHSF, and TC powder can be a good substitute to traditional raw material for cookies. And hence encourages the use of novel ingredients in bakery products.

1. Introduction

Urbanization has led to an increase in the consumption of bakery products, and the food sectors are taking advantage of this trend by producing wholesome and nutritious bakery goods. Cookies make a large proportion of bakery goods because of their extended shelf life and acts as a feasible carrier of nutrients. Because of their low cost of production, increased convenience, and capacity to deliver essential nutrients, cookies have emerged as one of the most popular snacks among young and old alike (Chakroborty *et al*., 2017).

The use of herbs in traditional cuisine is becoming more and more popular now a day. *Terminalia chebula* Retz. is also known as Black myroblans in English and Harad in Hindi, is a plant that is widely used in Homeopathy, Ayurvedic, and Unani medicine and known as "King of medicine" (Kushwaha *et al*., 2017). The fruit of *T. chebula* is the most used part of the plant. It is 20-25 mm long and ovate, with a wrinkled appearance when dried. It contains a wide range of chemical components, including tannins (32- 34%), which contribute to its bitter and astringent taste and are the primary cause of its uncommon acceptance among consumers but in addition to tannins, it also contains flavonoids, sterols, amino acids, fructose, resin, oils, and a wealth of phytochemicals that may offer a good therapeutic substitute (Jha *et al.*, 2023). The fruit of *T. chebula* can also be used as an anti-spasmodic, stomachic tonic, and moderate laxative. The potential benefits of *T. chebula* have also been noted in the following conditions: ophthalmia; digestive disorders (such as constipation, indigestion, decreased appetite, and diarrhoea); wound healing; skin infections; kidney stones, cold and cough, and other pulmonary issues; and teeth related problems. Its protective function in case of cardiovascular problems has also been found evident (Tiwari *et al*., 2024).

Global use of composite flour technology has led to the development of functional foods with the required medicinal or preventive benefits. Aside from increasing the availability of wheat flour, composite flour baked goods are thought of as nutritional transporters and offer other benefits (Raihan *et al*., 2017). The majority of people on the planet eat whole grains on a regular basis, such as wheat, barley, and oats. Oats are a common cereal grain that are abundant in protein and fat. Oats can be a novel alternative to bakery flour as it contains a high concentration of beta-glucan, which has anti-atherogenic qualities, boosts immunity against infection, lowers peak insulin and glucose concentrations, and lowers serum and plasma cholesterol (Negu *et al*., 2020).

AHSF have a good shelf- life and can be used separately or combined with other grain flours to create novel foods like cakes, breads, and biscuits without changing the final product's functional and sensory qualities (Ibrahim *et al.*, 2023). It mimics the cereal flour in many ways. *A. heterophyllus* seed flour's high content of carbohydrates, dietary fibre, protein, and minerals can be utilized to efficiently increase the flour's usage in food products. The seed flour has good water and oil absorption properties and mixes well with wheat flour, making it a potential ingredient in food product development (Mahanta *et al.*, 2015).

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An extensively used statistical model for main effect, interaction, and optimization research is the response surface methodology (RSM). According to reports, the central composite design (CCD) is the ideal model for assessment purposes (Basri *et al.*, 2020) which is also used in this study for the optimization. So, the aim of this research is to ditch the conventional raw materials used in making cookies and to optimize it on the basis of sensory and textural parameters and to find out the proximate composition of the cookies.

2. Materials and Methods

2.1 Procurement of raw materials

The ingredients used were purchased from the market of Varanasi India, *viz*., *T. chebula* seed, whole oatmeal, *A. heterophyllus* seeds, honey, baking powder, baking soda, cookie cutter, *etc*. To prevent varietal variances during the entire inquiry, all the raw components were purchased in large quantities at a time. *T. chebula* seeds and *A. heterophyllus* seed were cleaned and sorted and the latter was subjected to lye peeling. After that, both the seeds were sundried properly, grinded and sieved (Size 45 micron) to make it into powder/flour form. Similarly, whole oatmeal was milled and sieved (Size 45 micron) to make its flour.

2.2 Experimental design using RSM

Using Design Expert version 13.0 (Stat-Ease, USA) and CCRD (Central composite rotatable design), response surface methodology (RSM) was employed for process optimization. The three independent variables were: oat flour (A), *A. heterophyllus* seed Flour (B) and *T. chebula* powder (C). There lower and upper limits have been shown in Table 1. The RSM experimental design was used to create a total of sixteen different experiments. Six axial points, five central points, and eight factorial points make up the coded terms design matrix. The response surface regression approach used the following second-order polynomial equation (eqn.1) to assess the experimental data from the design:

$$Y = \Sigma_{i=0}^{3} \beta_i X_i + \Sigma_{i=1}^{3} \Sigma_{j=i}^{3} \beta_{ij} X_i X_j + \Sigma_{i=1}^{3} \beta_{ii} X_i^2 + \in \qquad ...(1)$$

where, Y is the response variable, the levels of the independent variables are represented by X_i . β_i are the coefficients for the linear terms, β_{ij} are the coefficients for the interaction terms, β_{ii} are the coefficients for the quadratic terms, γ is the error term, and the summation signs represent the sum of terms over the specified ranges. The relationship between the independent factors and the anticipated response is expressed by the equation. 3D graphs were generated utilizing the fitted quadratic polynomial models using the Software Design Expert 13.0.

Table 1: Levels of independent variables for the experimental design

Independent variables	Lower value (g)	Higher value (g)
Oats	40	55
A. heterophyllus seed flour	5	15
T. chebula powder	2	5

The coefficient of determination (R^2) was used to determine the model fit, and the F value was considered for statistical significance. The coefficient of determination (R^2) in a regression model indicates the extent to which the independent variables account for the variation of a dependent variable. Adjusted R-squared is a modified version of R-squared that takes the number of predictors in the model into account. Projected R-squared indicates how effectively a regression model predicts responses to new observations. Refusing the temptation to over add independent variables to the model is made easier by adjusted and predicted R-square. Modified R-squared evaluates models with varying variable counts. Overly complex models can be avoided with the help of predicted R-squared. The signal-to-noise ratio is measured with adequate precision (Nazim *et. al.*, 2024). Regression coefficients (R^2) one-way analysis, and analysis of variance (ANOVA) are applied to the data to determine the optimum solution. To validate the model's high significance, it is necessary for the adjusted determination coefficient (adjusted R^2) to also possess a high value (Yadav *et al.*, 2024). It is ideal for the coefficient of determination (R^2) values to be near 1. The Predictive R^2 and the adjusted R^2 should reasonably coincide. R^2 is defined as the ratio of explained variation to total variation as a measure of the degree of fit (Tripathi *et al.,* 2017). The design matrix for the RSM experiments is given in Table 2.

Table 2: Sensory score and Textural score for different variables (Design matrix for RSM)

Run	Variables			Colour	Aroma	Taste	Overall acceptiblity	Hardness (kg/cm²)	Fracturability (mm)
	Oats (g)	AHSF (g)	TC (g)						
1.	47.5	1.59	3.5	6.89	7.95	6.48	7.11	7.78	2.72
2.	47.5	10	6.02	4.06	7.55	5.25	5.13	8.45	3.35
3.	47.5	10	3.5	7.2	7.88	6.45	7.33	7.21	2.85
4.	55	15	5	6.34	7.56	6.08	5.05	8.19	2.89
5.	34.89	10	3.5	6.54	7.65	6.4	6.9	7.91	2.84
6.	47.5	18.41	3.5	7.01	7.79	6.85	6.61	7.75	2.74
7.	40	5	2	8.03	7.98	7.2	8.45	7.01	2.65
8.	60.11	10	3.5	6.7	7.39	6.79	5.9	6.58	2.7
9.	55	5	2	8.4	7.89	7.4	8.43	6.9	2.4

10.	40	15	5	6.22	7.67	5.91	5.57	8.37	2.92
11.	40	15	2	8.78	8.28	8.70	8.70	6.78	2.55
12.	47.5	10	0.97	8.48	7.93	8.86	7.8	6.88	2.78
13.	55	5	5	6.01	7.59	5.85	6.29	8.43	3
14.	47.5	10	3.5	7.26	7.82	6.5	7.5	7.17	2.8
15.	55	15	2	8.58	7.78	8.2	8.43	6.55	2.23
16.	40	5	5	5.82	7.71	5.75	6.56	8.41	3.22

2.3 Optimization

The responses chosen were the sensory parameters (colour, aroma, taste and overall acceptability) and the textural parameter (hardness and fracturability).

2.4 Sensory analysis

A panel of 10 semi-trained adjudicators from the Department of Dairy Science and Food Technology, IAS, Banaras Hindu University, Varanasi, ranging in age from 25 to 65, was served with the optimized and control samples for the sensory analysis. A nine-point hedonic rating system-which ranges from 1 for severely disliked to 9 for strongly liked-was used for the sensory evaluation, which took place between 25 and 30°C.

2.5 Texture profile analysis

Using a cutting knife probe to record the force mean distance at (mm) and peak force (g), the Texture Analyser (TA. XT plus texture profile analyser stable micro system, UK) the fracturability and hardness of cookies as explained by (Choudhury *et al.*, 2023). Finding the ideal cookie formulation levels to provide the best response was the aim of the optimization process.

Desirability was determined by setting the lower, upper, and target levels for each answer independently. Each parameter's desirability has a value between 0 (the product is totally undesired) and 1 (the product is wholly desired). To determine the concentrations of each factor that maximized desirability, the optimization procedure was used. In accordance with the optimal formulation that was reached, cookies were made, their quality characteristics were established, and the results of the experiments were compared to the results obtained numerically. For further analysis, optimized cookies were compared with control cookies (cookies that does not contain *T. chebula* powder and *A. heterophyllus* seed flour).

2.6 Preparation of cookies

Cookies were prepared as per AACC Method (2000) with some modifications. The preparation of the cookies is given in the flow diagram below in Figure 1.

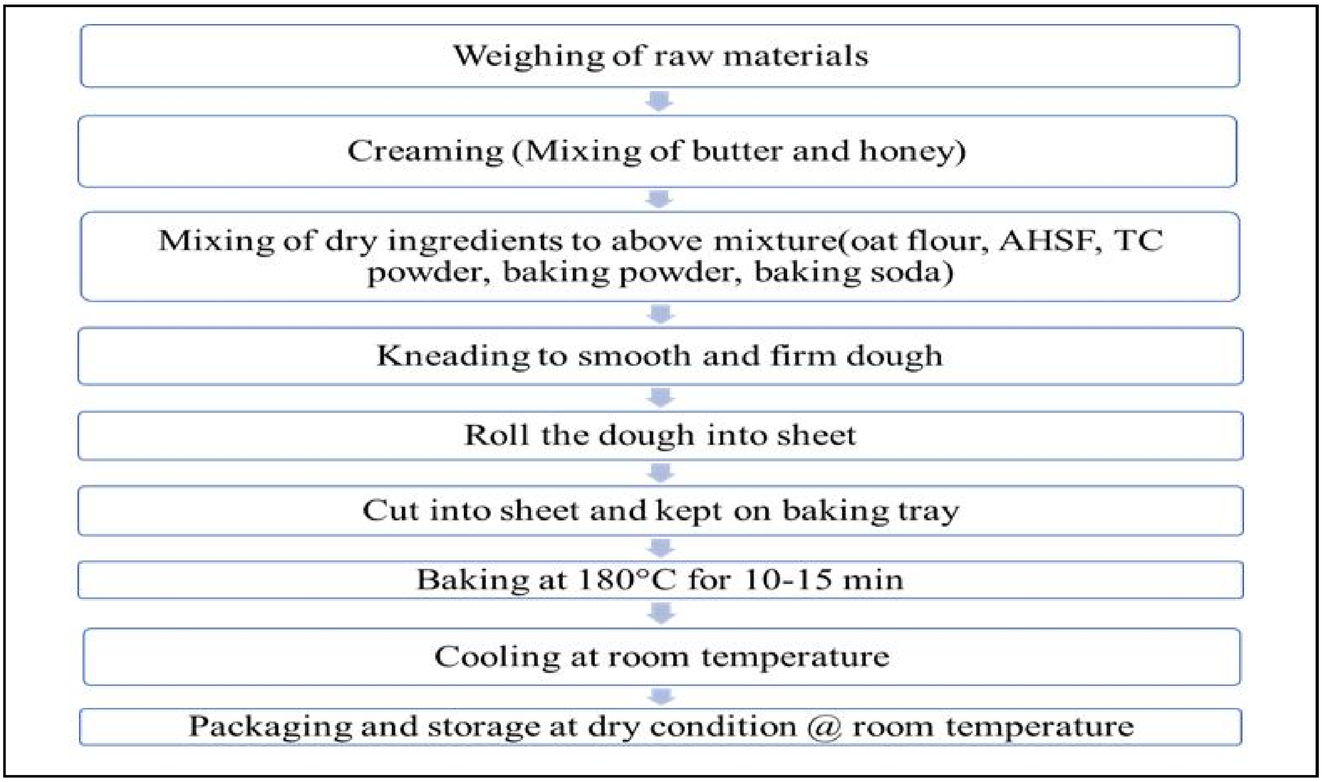

Figure1: Flow diagram of the preparation of cookies.

2.7 Physicochemical analysis of cookies

2.7.1 Physical analysis of cookies

Cookies were stacked on top of one another to determine the thickness (t) (in centimetres), and the average value was recorded. Similarly using a scale, six cookies were arranged edge to edge, rotated 90 degrees, and then measured once more to get the average diameter (d) (in centimetres). spread ratio was calculated as diameter/ thickness. L*, a* and b* values of samples were analysed by Color Flex EZ; s/n CFEZ1048, Hunter Lab. L* (100 for perfect lightness or zero for perfect darkness), a* (+redness / "greenness) and b* (+yellowness / "blueness) as per Tyagi *et al.* (2020).

2.7.2 Proximate analysis of cookies

Using a hot air oven, the moisture content of the cookies was assessed, and using a muffle furnace, the ash content of the developed cookies was examined in accordance with AOAC (2012). The crude fat and crude fibre present in the cookies were also determined by AOAC (2012). Using the Kjeldahl digestion method (AOAC, 2012), the crude protein content of the cookies was determined. The carbohydrate content was determined by difference method that is by subtracting the measure protein, fat, ash, moisture, and crude fibre from 100.

2.8 Statistical analysis

One-way ANOVA was used to examine the antioxidant potential and physicochemical features of the cookies, with the findings expressed as Mean ± SD. All the data were taken in duplicates except for ICPMS analysis.

3. Results

3.1 Model fitting and interactive effects of process variables on the responses

RSM allows for the simultaneous determination of the impact of the independent variable either main and interaction, evaluated as linear, quadratic, and interaction terms of oats (A), *A. heterophyllus* seed flour (B) and *T. chebula* (C), and on each response. The quadratic models for each response were determined by the coefficient regression model, and the significance of the model coefficients was assessed using analysis of variance (ANOVA).

Table 3: Regression coefficients and ANOVA of sensory and textural characteristic

Factor	Color	Aroma	Taste	Overall acceptability	Hardness	Fracturability
Intercept	7.16	7.84	6.46	7.35	7.19	2.84
Oats (A)	0.0629	-0.0723	0.0327	-0.2176	-0.2004	-0.0773
A. heterophyllus seed flour (B)	0.1736	-0.0307	0.2557	-0.2219	-0.667	-0.0473
T. chebula powder (C)	-1.3093	-0.1295	-1.04	-0.1.12	0.6444	0.2313
A^2	-0.05	-0.0998	0.0702	-0.1988	0.0193	-0.0484
B^2	0.06	0.0239	0.0949	-0.0361	0.2031	-0.0625
C^2	-0.11	-0.0221	0.2328	-0.1758	0.1678	0.0559
AB	-0.066	-0.0163	-0.1012	-0.0362	-0.0400	0.0150
AC	0.0037	0.0112	0.0938	-0.0362	0.0225	0.0400
BC	-0.0887	0.0012	-0.2612	-0.2837	0.0375	-0.0175
R^2	0.92	0.9446	0.9743	0.8810	0.9068	0.8806
Adequate precision	9.95	10.576	16.21	7.1609	8.038	8.1280
PRESS	14.23	0.2012	3.55	19.94	5.37	1.04
Model F-value	8.61	11.36	25.23	4.93	6.49	4.92
Lack of fit	NS	NS	NS	NS	NS	NS

ANOVA table is given in Table 3. The model F-value of colour, aroma, taste, texture, hardness and fracturability indicated that F-value is less than 0.05 indicates and thus the model is significant. The non-significant lack of fit of all responses indicates that all design points were satisfactorily fitted by the polynomial model. A value of more than 0.80 for R^2, Adj R^2, and Pred R^2 suggests statistical significance for the design expert model (Shrivastava *et al.*, 2021).

3.1.1 Effect of variables on the color of the cookies

The data fitted the following quadratic equation (eqn. 2) $5.67995 + 0.115015 \times A + 0.0796158 * B - 0.305469 \times C - 0.00116667 \times AB - 0.00166667 \times AC - 0.0118333 \times BC - 0.000919691 \times A^2 + 0.0025976 \times B^2 - 0.0528479 \times C^2$ … (2)

Trial 11 showed the highest score for color, *i.e.*, 8.78 while Trial 2. showed the least, *i.e.,* 4.06. There was a 0.92 coefficient of determination (R^2). The components' linear and square interactions were statistically significant ($p<0.05$). The signal-to-noise ratio, or adequate precision, was determined to be higher (9.95) than 4, which indicates the response's suitability for the color of the cookies.

The three-dimensional graph that shows the response surface for color as influenced by the amount of *T. chebula, A. heterophyllus* seed Flour, and Oat Flour is shown in Figure 2 a, b, and c. From the 3d plot it is evident that the addition of more amount of TC powder has a negative effect on color score. However, the addition of AHSF has a no effect on color score.

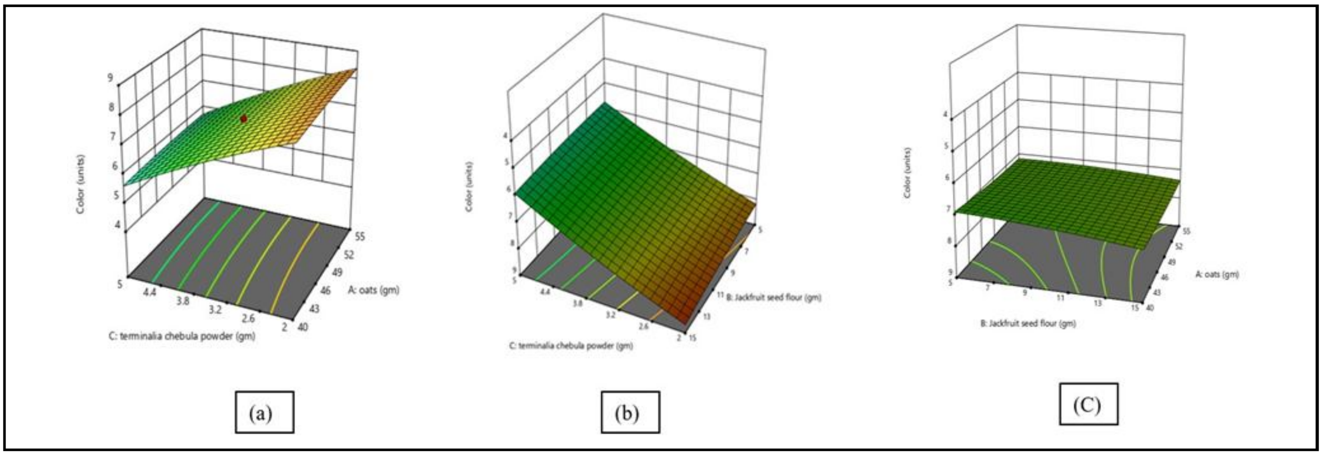

Figure 2: Model graph for interaction of variables for color.

3.1.2 Effect of variables on the aroma of the cookies

The data fitted the following quadratic equation (eqn.3)

$4.4115 + 0.170544 \times A - 0.0192629 \times B - 0.0671618 \times C - 0.000166667 \times AB + 0.000111111 \times AC + 0.0015 \times BC - 0.00187499 \times A^2 + 0.000731028 \times B^2 - 0.0060196 \times C^2$ … (3)

Trial 11 shows the highest score for Aroma, i.e., 8.28 while Trial 2 shows the least, *i.e.*, 7.55. The coefficient of determination (R^2) was 0.97. Ingredient interactions were both linear and square, and they were statistically significant ($p<0.05$). The signal-to-noise ratio, or adequate precision, was determined to be higher (10.57) than 4, which indicates the response's suitability for the aroma of the cookies.

The three-dimensional graph that indicates the response surface for aroma as influenced by the amounts of *T. chebula*, *A. heterophyllus* seed flour, and oat flour is shown in Figure 3 a, b, and c. Graphs show that by increasing the TC powder the aroma scores decrease; however, no significant increase or decrease in the aroma scores was seen because AHSF.

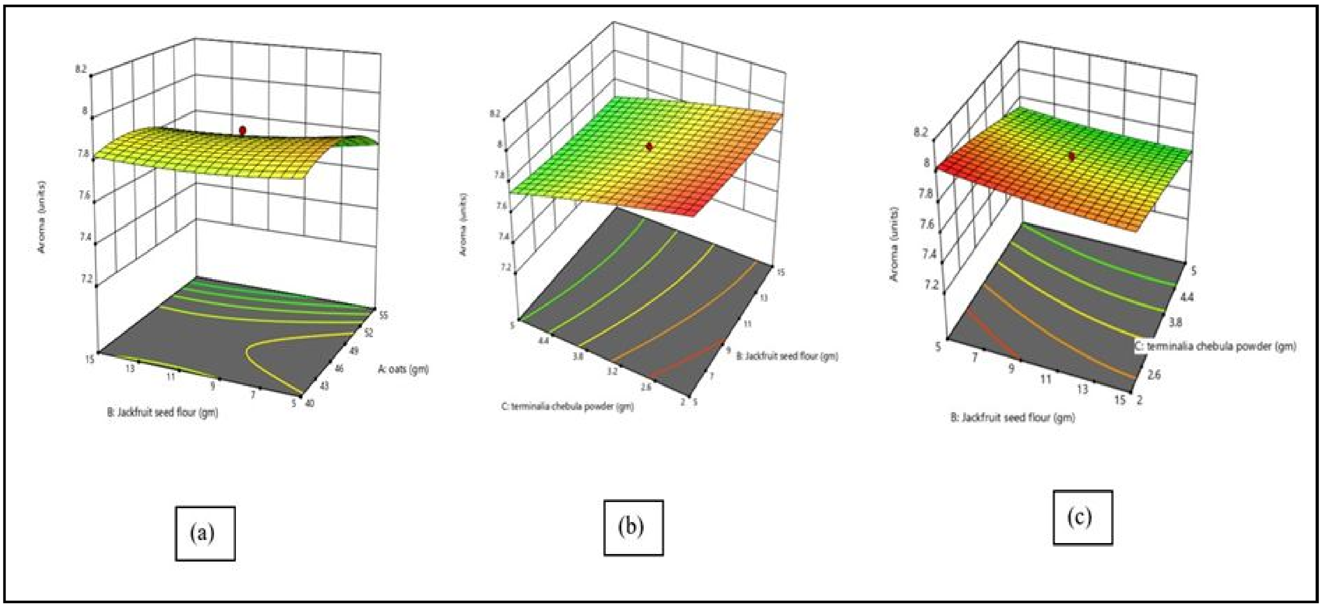

Figure 3: Model graph for interaction of variables for aroma.

3.1.3 Effect of variables on the taste of the cookies

The data fitted the following quadratic equation (eqn.4)

$$9.46268 + -0.0337633 \times A - 0.0408847 \times B - 0.822402 \times C + 0.00156667 \times AB - 0.00588889 \times AC - 0.0135 \times BC + 0.00058482 \times A^2 + 0.00230579 \times B^2 + 0.0869025 \times C^2 \quad \ldots\ldots (4)$$

Trial 11 showed the highest score for taste, *i.e.*, 8.70 and Trial 2 showed the least score. The coefficient of determination (R^2) was 0.98. Ingredient interactions were both linear and square, and they were statistically significant ($p<0.05$). The signal-to-noise ratio, or adequate precision, was determined to be higher (16.21) than 4, which indicates the response's suitability for the taste of the cookies. The three-dimensional graph that indicates the response surface for taste as influenced by the amounts of oat flour, *A. heterophyllus* seed flour, and *T. chebula* is shown in Figure 4 a, b, and c. The total effect demonstrates that TC powder negatively affects flavour. The reason may be bitterness of TC powder. AHSF has a positive effect on taste score.

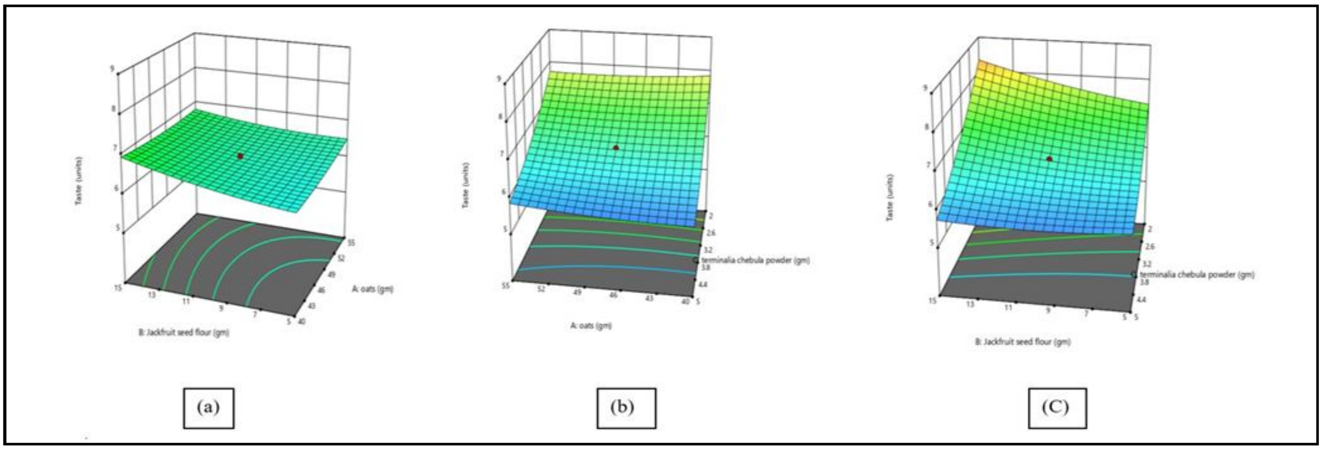

Figure 4: Model graph for interaction of variables for taste.

3.1.4 Effect of variables on the overall acceptability of the cookies

The data fitted the following quadratic equation (eqn.5)

$$0.236761 + 0.333448 \times A + 0.144139 \times B + 0.379389 \times C - 0.000666667 \times AB - 0.00422222 \times AC - 0.0363333 \times BC - 0.0035804 \times A^2 + -0.00155053 \times B^2 - 0.0792963 \times C^2 \quad .... (5)$$

A number of criteria is being taken into consideration when choosing a suitable ratio, but the examiners' overall acceptability" is the main determinant. Trial 11 showed the highest score of overall-acceptability, *i.e.*, 8.70 and Trial 2 showed the least score, *i.e.*, 5.13. The coefficient of determination (R^2) was 0.88. Ingredient interactions were both linear and square, and they were statistically significant ($p<0.05$). The signal-to-noise ratio, or adequate precision, was determined to be higher (7.16) than 4, which indicates the response's suitability for the overall-acceptability of the cookies. The three-dimensional graph that indicates the response surface for overall acceptability as affected by the amount of oat flour, *A. heterophyllus* seed flour, and *T. chebula* is displayed in Figures 5 a, b, and c. From the plot, cumulative effect of all the factors defines that increasing the TC powder decreases the overall-acceptability. This can be due to the bitter taste of *T. chebula* powder. However, no significant changes are being seen because of addition of AHSF at the given ratios and hence score for overall acceptability is not affected because of it.

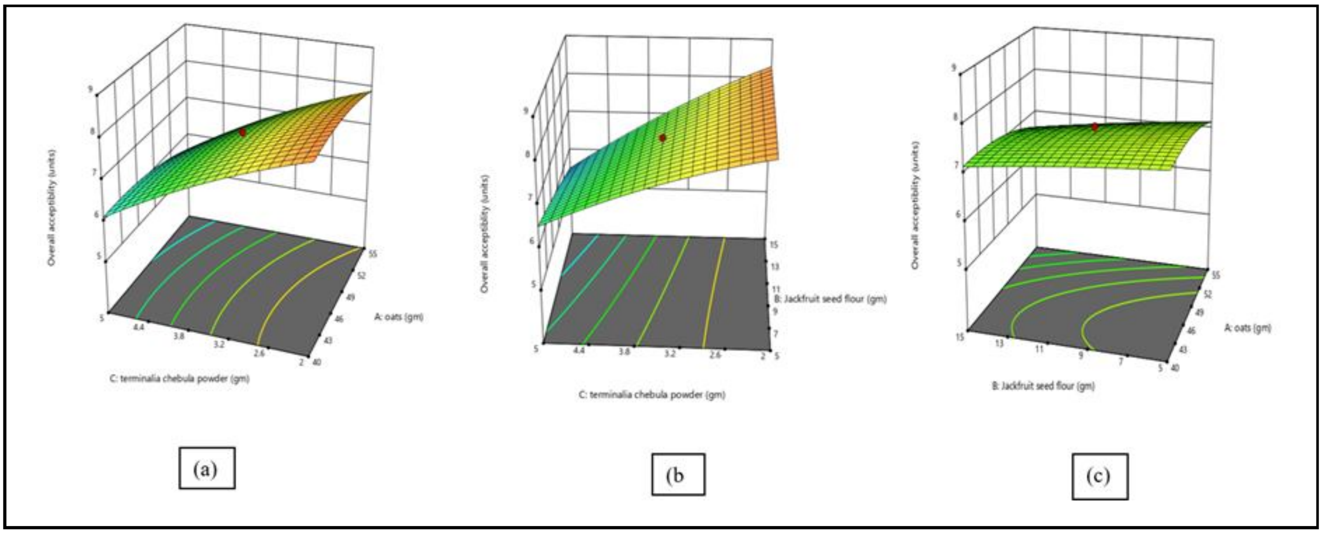

Figure 5: Model graph for interaction of variables for overall acceptability.

3.1.5 Effect of variables on the hardness of the cookies

The data fitted the following quadratic equation (eqn.6)

$$9.58949 - 0.0556279 \times A + -0.142675 \times B + -0.237386 \times C + -0.00106667 \times AB + 0.002 \times AC + 0.005 \times BC + 0.000342895 \times A^2 + 0.00812542 \times B^2 + 0.074569 \times C^2 \quad \dots (6)$$

Trial 2 showed the highest score for hardness i.e. 8.45 and Trial 15 showed the least score, *i.e.*, 6.55. The coefficient of determination (R^2) was 0.90. Ingredient interactions were both linear and square, and they were statistically significant (p<0.05). The signal-to-noise ratio, or adequate precision, was determined to be higher (8.03) than 4, which indicates the response's suitability for the taste of the cookies. The three-dimensional graph that indicates the response surface for hardness as influenced by the amounts of oat flour, *A. heterophyllus* seed flour, and *T. chebula* is shown in Figures 6 a, b, and c. The cumulative effect shows that increasing the TC powder increases the hardness however increasing the oat flour decreases the hardness.

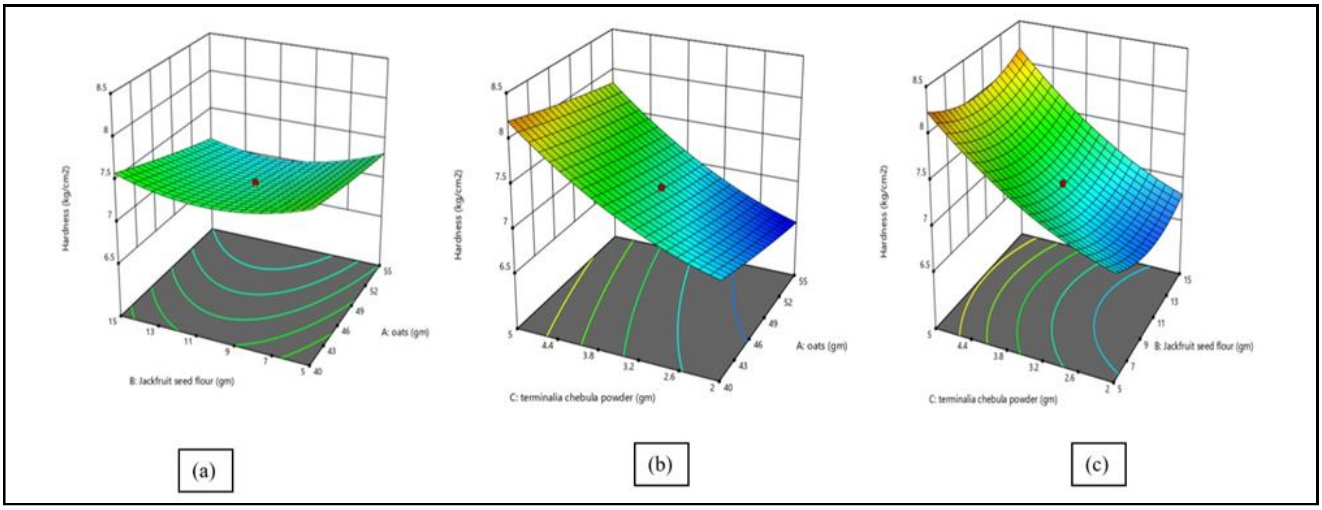

Figure 6: Model graph for interaction of variables for hardness.

3.1.6 Effect of variables on the fracturability of cookies

The data fitted the following quadratic equation (eqn.7)

$$1.69344 + 0.0550015 \times A + 0.0297385 \times B - 0.165256 \times C + 0.0004 \times AB + 0.00355556 \times AC - 0.00233333 \times BC - 0.000860531 \times A^2 - 0.00250188 \times B^2 + 0.0248415 \times C^2 \dots (7)$$

Trial 2 showed the highest score for fracturability, *i.e.,* 3.35 and Trial 15 showed the least score, *i.e.*, 2.23. The coefficient of determination (R^2) was 0.88. Ingredient interactions were both linear and square, and they were statistically significant (p<0.05). The signal-to-noise ratio, or adequate precision, was determined to be higher (8.12) than 4, which indicates the response's suitability for the taste of the cookies. The three-dimensional graph that indicates the response surface for fracturability as affected by the amount of *T. chebula, A. heterophyllus* seed flour, and oat flour is displayed in Figure 6 a, b, and c. The cumulative effect shows that increasing the TC powder increases the fracturability; however, increasing the oat flour and AHSF has a minimal effect on fracturability.

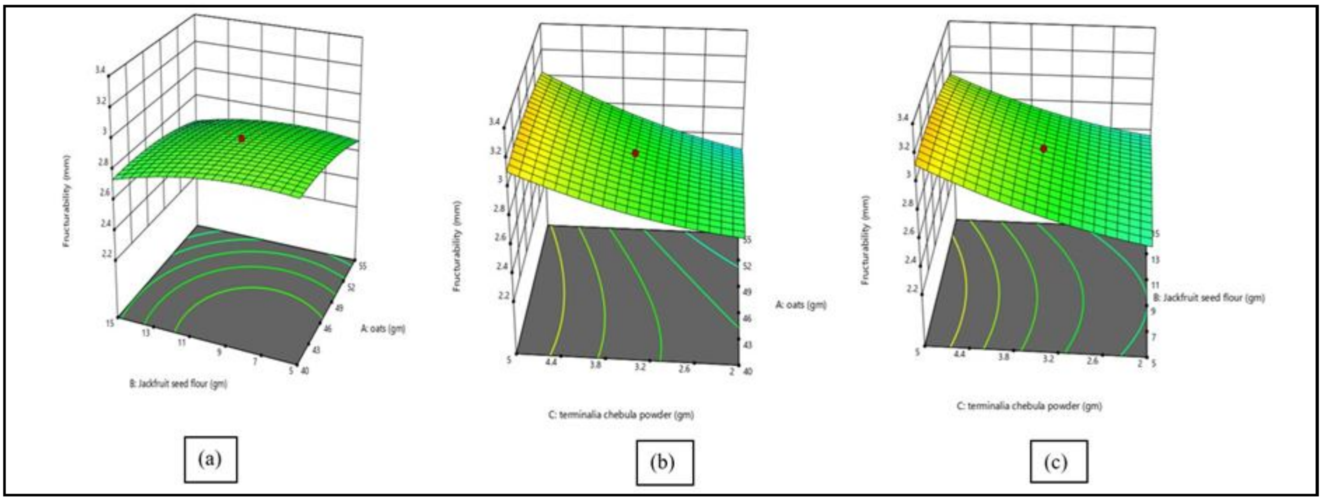

Figure 7: Model graph for interaction of variables for fracturibility.

3.2 Optimization and validation

To optimize each response with various targets, a numerical optimization technique was applied. Oats and *T. chebula* powder was minimized while AHSF along with the sensory attributes were maximized. However, the level for hardness and fracturability was minimized. It was found that solution No. 11 obtained highest desirability values of 0.91. Sensory and textural parameter were done to compare the actual values with the predicted one (Table 4). The results of experiments with optimized independent variables were found to be similar to those of numerically determined solution. Using the optimized solution, cookies were made for the further analysis and comparison with that of control one.

Table 4: Verification of the predicted and actual values

S.No.	Color	Aroma	Taste	Overall acceptability	Hardness	Fracturability
Predicted value	8.63	7.942	8.578	8.33	7.095	2.623
Actual value	8.78 ± 1.05	8.28 ± 0.05	8.70 ± 0.29	8.49 ± 1.56	6.78 ± 0.44	2.55 ± 0.60

Data are presented as mean ± SD (n=15)

3.3 Physical properties of cookies

The physical properties of both control and optimized cookies are given in Table 5.

Table 5: Physical properties of cookies

Physical properties	Values	
	C C	O C
Thickness (cm)	0.84 ± 0.005^{a}	1.08 ± 0.12^{a}
Diameter (cm)	4.88 ± 0.65^{b}	4.76 ± 0.24^{b}
Spread ratio	5.78 ± 0.29^{c}	4.40 ± 0.22^{b}
L*	59.62 ± 4.22^{abc}	54.90 ± 4.18^{abc}
a*	9.71 ± 0.82^{d}	10.02 ± 0.82^{c}
b*	22.74 ± 1.55^{ab}	32.67 ± 1.95^{d}
C* (Chroma)	24.72 ± 1.48^{abc}	34.17 ± 2.45^{ab}

Data are presented as mean ± SD (n=3). Means followed by different superscripts within a row for parameter are significantly different (p<0.05).

3.4 Proximate analysis of cookies

Table 6: Proximate analysis of cookies

Parameter	C C	O C
Moisture (%)	3.38 ± 0.08^{b}	2.85 ± 0.04^{a}
Protein (%)	13.45 ± 0.72^{c}	14.79 ± 0.85^{b}
Fat (%)	17.42 ± 1.05^{ab}	16.64 ± 1.16^{c}
Ash (%)	2.18 ± 0.04^{a}	2.88 ± 0.05^{a}
Carbohydrate (%)	55.97 ± 0.05^{abc}	54.74 ± 0.65^{ab}
Crude fibre (%)	7.60 ± 0.07^{c}	8.10 ± 0.98

Data are presented as mean ± SD (n=3). Means followed by different superscripts within a row for parameter are significantly different (p<0.05)

The thickness of the optimized cookies was greater than that of control cookies. However, the diameter and spread ratio of the optimized sample is lower than that of control sample. The obtained L* values showed significantly lighter color (higher L* value) of the control cookies than that of optimized cookies and that lightness was decreased significantly with the addition of TC powder. There was an increase in the positive a* (red tonality) and positive b* (yellow tonality) values.

The proximate analysis of value-added cookies was performed for the composition of carbohydrate, protein, fat, ash, moisture, and fibre (Table 6). Moisture content of the control cookies was greater than that of optimized cookies. The protein ash and crude fibre percentage also increased because of addition of AHSF and *T. chebula* powder. Similar results were however the fat percentage decreased because of addition of *T. chebula* powder. The overall carbohydrate percentage decreased because of substitution of flour with AHSF and *T. chebula* powder.

4. Discussion

The incorporation of *T. chebula* has an inversely relation with the color of the cookies. The observation is in agreement with the tulsi powder (herb) being added in the wheat bran cookies where it stated that the cookies become slightly darker in colour as the herb (Tulsi powder) inclusion level increased (Agrawal *et. al.,* 2021). The no detrimental effect of *A. heterophyllus* seed flour on the color of the cookies can been related to the results given by van *et. al*. (2023) and Maskey *et. al.* (2021). *T. chebula* has its strong and natural odour. The aroma score decreases with the increase in *T. chebula* powder. This observation was in agreement with the findings of Aggrawal *et al.* (2021) which found that increasing herb (Tulsi powder) in cookies reduces the odour score. There is no change in aroma due to increase in the AHSF. The finding is also in accordance with Van *et.al*. (2023), who found that at 20 % substitution wheat flour with AHSF has no effect on aroma of the cookies. *T. chebula* has sweet, sour, pungent, bitter and astringent taste. The increase in the amount of *T. chebula* powder has a negative impact on taste of the cookies. This observation was in agreement with the findings of Aggrawal *et. al*. (2021) which found that increasing herb (Tulsi powder) in cookies reduces the taste score. There was no such impact of increasing AHSF on the taste of the cookies. The finding is also in accordance with Van *et. al*. (2023), who found that at 20 % substitution wheat flour with AHSF has no effect on the taste of cookies. The increase in the amount of oat flour had a lowering impact on the hardness of the cookies. The trend for hardness of cookies follows the findings of Mosafa *et al.* (2017) which stated that addition of oat flour lowered the hardness of biscuit. The increase in the amount of *T. chebula* powder increase the hardness of the cookies. This finding is also in accordance with

Pestoric *et al*. (2015) which says increasing the amount of pulverised herbal blend increases the hardness of the cookies. Increasing the *T. chebula* powder increases the fracturability of the cookies. Similar reports have been given by Molnar *et al.* (2015) that increasing the berry powder in cookies increase the fracturability**.** The optimized formulation suggested by the design expert software (oat- 40 g, TC-2 g, and AHSF-15 g) showed a good acceptance. Following the optimization of the biscuits, an organoleptic and physicochemical examination was conducted, as the quality of any food product is the final criterion for acceptability.

The increase in the thickness and decrease in the diameter and spread ratio of the cookies may be due to incorporation of *T. chebula powder* and *A. heterophyllus* seed powder. The decrease in lightness that is L* value and increase in the red (a*) and yellow tonality of the cookies is due to green color of the *T. chebula* powder. The findings were found to be in perfect agreement with the findings of Jadhav *et al.* (2021); Tyagi *et al.* (2020); Maskey *et al*. (2021). According to the nutritional composition of the various treatments, the optimized cookies was superior the control nutritionally. The optimized cookies outperformed the control cookies in terms of crude fibre, protein and ash content. The result is in alignment with the findings of Sowmya *et al*. (2022); Van *et al*. (2023); Mousa *et al*. (2022). Moisture percentage of the optimized cookies because of lower absorption capacity that happened because of adding *T. chebula* powder. The findings were similar to the findings of Sowmya *et al.* (2022), where addition of basil in cookies decreases the moisture content. The decrease in the fat content may be attributed to the addition of *T. chebula powder*. This finding is in alignment with the result of Thorat *et al.* (2017) where, addition of lemongrass to the cookies decreased the fat content of the cookies.

5. Conclusion

The result clearly shows that the incorporation of AHSF and TC powder enhances the nutritional component of cookies. In summary, it can be said that RSM was effectively utilized to achieve an ideal blend of process variables for producing value added cookies with a satisfactory level of sensory appeal. The nutritional value and functional qualities of oat cookies are greatly improved by the addition of *T. chebula* powder and *A. heterophyllus* seed flour. This is novel cookie recipe that enhances the health advantages of the cookies while also adding to their distinctive sensory appeal. The resulting cookies serve as evidence of the potential of functional ingredients in the creation of food products that promote health.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

AACC (2000). Approved methods of American association of cereal chemists, 10th edn. American Association of Cereal Chemists, St. Paul.

AOAC (2012). Official Methods of Analysis, 19th edn. Association of Official Analytical Chemists. Washington D.C., USA.

Agrawal, R. S.; Shere, P. D.; Ghodke, S. V. and Jadhav, V. K. (2021). Development and quality analysis of wheat bran enriched herbal cookies. Journal of Scientific Research and Reports, **27**(11):13-24.

Chakrabarti, T.; Poonia, A. and Chauhan, A. K. (2017). Process optimization of gluten free cookies using cassava flour. International Journal of Food Science and Nutrition, **2**(5):190-195.

Choudhury, S. S. and Chaudhary, G. (2023). Development of nutritional millet-based biscuits incorporated with amaranth seeds. Ann. Phytomed., **12**(1):1-10.

Ibrahim, A. M.; Magan, M. A.; Perono, Q. W. A. and Larroza, F. K. (2023). Sensory Acceptability of *Artocarpus heterophyllus* (*Artocarpus heterophyllus* Lam.) Seed Food Spread. Journal of Tourism, Hospitality and Culinary Art, **15**(2):48-59.

Jha, A. K. and Sit, N. (2023). Methods of extraction of bioactive compounds from *T. chebula* (Haritaki) and their application in food and pharmaceutical industry: A review. Food Bioengineering, **2**(2):139-150.

Kushwaha, N.; Mondal, D. B. and Singh, K. P. (2017). Comparative evaluation of hepatoprotective efficacy of *T. chebula* Retz. *and Terminalia belerica* (Gaertn.) Roxb. fruits extracts in rat model. Ann. Phytomed., **6**(2):149-155.

Mahaanta, C. L. and Kalita, D. (2015). Processing and utilization of *Artocarpus heterophyllus* seeds. In processing and impact on active components in food. Academic Press, pp:395-400.

Maskey, B.; Subedi, S. and Shrestha, N. K. (2020). Effect of incorporation of *Artocarpus heterophyllus (Artocarpus heterophyllus*) seed flour on the quality of cookies. DristiKon: A Multidisciplinary Journal, **10**(1):60-72.

Mohd Basri, M. S.; Mohd Jais, N.; Sulaiman, A.; Mohd Nor, M. Z.; Abdul Karim ShAHSF, N. N. and Ariffin, S. H. (2020). Optimizing the processing factor and formulation of oat-based cookie dough for enhancement in stickiness and moisture content using response surface methodology and superimposition. Processes, **8**(7):797.

Molnar, D.; Rimac Brncic, S.; Vujic, L.; Gyimes, E. and Krisch, J. (2015). Characterization of biscuits enriched with black currant and jostaberry powder. Hrvatski Easopis za Prehrambenu Tehnologiju, Biotehnologiju i Nutricionizam., **10**(1-2):31-36.

Mosafa, L.; Nadian, N. and Hojatoleslami, M. (2017). Investigating the effect of whole oat flour, maltodextrin and isomalt on textural and sensory characteristics of biscuits using response surface methodology. Journal of Food Measurement and Characterization, **11**:1780-1786.

Nazim, M.; Sangeeta, S.; Rai, S.; Ramachandran, P.; Kumar, A.; Sharma, S. K.; Bisht, S. and Chandola, G. (2024). Process standardization for development of nutritionally rich microwave-roasted germinated horse gram (*Macrotyloma uniflorum* Lam.) snack. Ann. Phytomed., **13**(1):941-950.

Negu, A.; Zegeye, A. and Astatkie, T. (2020). Development and quality evaluation of wheat -based cookies enriched with fenugreek and oat flours. Journal of Food Science and Technology, **57**:3573-3580.

Pestoric, M.; Simurina, O.; Filipcev, B.; Jambrec, D.; Belovic, M.; Misan, A. and Nedeljkovic, N. (2015). Relationship of physicochemical characteristics with sensory profile of cookies enriched with medicinal herbs. International Journal of Food Properties, **18**(12): 2699-2712.

Raihan, M. and Saini, C. S. (2017). Evaluation of various properties of composite flour from oats, sorghum, amaranth and wheat flour and production of cookies thereof. International Food Research Journal, **24**(6):2278-2284.

Suzihaque, M. U. H.; Zaki, N. A. M.; Alwi, H.; IbrAHSFim, U. K.; Abd Karim, S. F. and Anuar, N. K. (2022). *Artocarpus heterophyllus* seed as an alternative replacement for starch flour. Materials Today: Proceedings, **63**:S451-S455

Shrivastava, A.; Tripathi, A. D.; Paul, V. and Rai, D. C. (2021). Optimization of spray drying parameters for custard apple (*Annona squamosa* L.) pulp powder development using response surface methodology (RSM) with improved physicochemical attributes and phytonutrients. LWT-Food Science and Technology, **151**:112091.

Tiwari, M. and BarooAHSF, M. S. (2024). A comprehensive review on the ethno-medicinal and pharmacological properties of *T. chebula* fruit. Phytochemistry Reviews, **23**(1):125-145.

Tripathi, R.; Sharma, D.; Dwivedi, M.; Rizvi, S. I. and Mishra, N. (2017). Wheatgrass incorporation as a viable strategy to enhance nutritional quality of an edible formulation. Ann. Phytomed., **6**(1):68-75.

Tyagi, P.; Chauhan, A. K. and Singh, S. N. (2020). Sensory acceptability of value-added cookies incorporated with *Tinospora cordifolia* (TC) stem powder; improvement in nutritional properties and antioxidant potential. Journal of Food Science and Technology, **57**:2934-2940.

Thorat, P. P.; Sawate, A. R.; Patil, B. M. and Kshirsagar, R. B. (2017). Effect of lemongrass powder on proximate and phytochemical content of herbal cookies. Journal of Pharmacognosy and Phytochemistry, **6**(6):155-159.

Van, C. K.; Nguyen, T. H.; Nguyen, T. T. N. H.; Nguyen, P. T. N.; Tran, T. T. and Hoang, Q. B. (2023). Comparison of the Effects of *Artocarpus heterophyllus* Seed Flour and *Artocarpus heterophyllus* Seed Starch in the Cookie Manufacturing Process. Processes, **11**(11):3194

Yadav, A. K.; Rai, D. C. and Rathaur, A. (2024). Process Optimization for the Development of Ashwagandha Root Extract Enriched Shrikhand Using Response Surface Methodology. Journal of Food Chemistry and Nanotechnology, **10**(S1):S47-S56.

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