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# Optimization and Formulation of Nutrient Rich Millet Pasta using RSM

**M. Mohana priya[a], Dr. V. Sangeetha[b], A. Jeevanantham[c], R. Jeevabharathi[d]**

[a] Assistant Professor, Department of Food Technology, Kongu Engineering College, Perundurai.
[b] Associate Professor, Department of Chemical Engineering, Kongu Engineering College, Perundurai.
[c] Assistant professor, Department of Information Technology, Kongu Engineering College, Perundurai.
[d] M.Tech, Department of Food Technology, Kongu Engineering College, Perundurai.

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**KEYWORDS**

Foxtail millet flour, Kodo millet flour, Guar gum, pasta

**ABSTRACT:** Millet flour is used to supplement pasta as it has high nutritional values. Pasta was prepared using foxtail millet flour (43-50g), kodo millet flour (33-40g), guar gum(1-2g) and other ingredients like wheat flour, oil, salt and water are kept constant for all formulations. The investigation employed a Box-Behnken design to examine the influence of foxtail millet flour, kodo millet flour, and guar gum on cooking quality parameters such as cooking time, solid gruel loss, and swelling index in extruded pasta products. An elevated percentage of millet flour demonstrates an adverse impact on both gruel loss and cooking duration, according to the findings. Addition of Guar gum shows positive effect on solid gruel loss. The optimization outcomes indicated that the ideal proportions for extruded pasta included 50g of foxtail millet flour, 40g of kodo millet, and 1.86g of Guar gum. The resultant pasta exhibited nutritional richness, comprising carbohydrates (62%), protein (8.5%), fat (12%), moisture (7.8%), and ash (2.4%).

**Introduction**

Pasta is the traditional food of Italy and it is consumed by the people all around the world. This unleavened extruded wheat dough is formulated with just flour and water, without additional ingredients. Pasta products include spaghetti, vermicelli, noodles and macaroni. This product is considered convenient due to its ease of storage, transport, and affordability. Moreover, it enjoys widespread popularity as it is well-received by a majority of consumers. Since pasta is very popular food it lacks nutrition such as proteins, vitamins, fiber and minerals. Pasta primarily consists of durum wheat semolina. This key ingredient provides the essential structure and texture to the pasta. Gluten which is a protein part present in wheat is responsible for structure of pasta. However, a notable portion of the population faces gluten intolerance, with gluten being a primary trigger for celiac disease. Consequently, there is a crucial need to develop alternative cereal-based products to cater to the dietary requirements of individuals who cannot tolerate gluten.

Millets, distinct from major staples like wheat and rice, are vital for populations in hot and arid regions due to their adaptability to challenging environmental conditions[1]. Millets are the store house of nutrition. Millets distinguish themselves among various cereals as a distinctive crop owing to their notable abundance in calcium, dietary fiber, protein, and polyphenols [2]. Among the polyphenols found in cereals, phenolic acids and tannins play a significant role as antioxidants ([3],[2]).As per the insights provided by[4], millet stands out as a gluten-free grain, making it a particularly advantageous choice for individuals contending with celiac disease and gluten intolerance. Furthermore, research conducted by[5], [6] and [2] indicates that the magnesium content found in millets may play a role in alleviating the effects of migraines and reducing the risk of heart attacks. Given its comprehensive array of essential nutrients, millet emerges as a versatile option for the production of various food products. Kodo millet is a commercially cultivated crop in India. The antioxidant properties of kodo millet make it advantageous for combating oxidative stress and maintaining glucose levels in individuals with type-2 diabetes. Notably, the lysine content of kodo millet is reported to be 2.85g/16gN, according to ([7] and [8]) emphasize that kodo millet stands out as a notable source

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of dietary fiber among various cereals, containing about 37 to 38% of dietary fiber. Furthermore, the fat in kodo millet is characterized by higher polyunsaturated fatty acids. Foxtail millet (Setaria italica), the second most extensively cultivated millet species, holds paramount importance in East Asia. Research by [2] and [9] revealed the significant antioxidant activity of foxtail millet and its white varieties, as determined by the 1,1-Diphenyl-2-picrylhydrazyl (DPPH) method. Moreover, researchers have documented distinct radical scavenging activities associated with fractionated foxtail millet protein hydrolysate.

In the field of pasta development, the crucial involvement of gums and thickeners like carboxymethyl cellulose and guar gum, is underscored as they play a pivotal role in processes like gelling, thickening, retention of water, and improvement of texture was reported by[10]. These additives are instrumental in enhancing the overall quality and sensory attributes of pasta products. These additives offer valuable properties that enhance the overall quality of pasta products. Despite pasta's relatively low nutritional value due to its richness in starch and lack of dietary fiber, researchers, such as [11], advocate for the incorporation of high-fiber materials to augment both the nutritional and functional aspects of pasta. In line with the aforementioned research findings, this study utilized foxtail millet and pearl millet flour to innovate pasta products. The inclusion of these millet flours not only addresses the nutritional shortcomings associated with traditional pasta but also contributes to the improvement of functional qualities. To further optimize the pasta's attributes, the use of hydrocolloids is considered. The application of hydrocolloids is anticipated to result in pasta with desirable texture and minimal cooking loss, aligning with the objective of creating healthier pasta alternatives. The primary goal of the current investigation was to optimize pasta formulations with elevated nutritional value comprising foxtail millet flour (FMF), kodo millet flour (KMF), and Guar gum

**Materials And Methods**

wheat flour, foxtail millet, and kodo millet were acquired from the local market for the study. foxtail millet and kodo millet underwent processing to obtain their respective flours, following the method outlined by [12]. The analysis was conducted using analytical-grade chemicals to ensure precision in the study.

**Millet Processing**

The processing involved the transformation of millet grains into an edible flour form. Millet grains were subjected to a cleaning process to eliminate any soil particles. Following this, the grains underwent winnowing and were soaked in water for a duration of 24 hours. Subsequently, the soaked grains were steamed for approximately 20 minutes and then shade-dried until reaching a moisture content of 10–12%. Once dried, the grains were milled to produce flour. The milled flour was carefully sieved, rendering it suitable for use in pasta preparation.

**Preparation Of Pasta**

The preparation involved combining a measured quantity of wheat flour and additional supplemented ingredients, as outlined in Table 1 (runs 1–17), in a dough mixer. Gradually, a measured amount of water was added to the mix, and the ingredients were meticulously blended and kneaded until achieving a homogeneous dough .Mixing was done for about 15 min to ensure uniform mixing. After mixing the dough was kept undisturbed for about 30 min to equilibriate the moisture content. The crafted dough was introduced into a conventional cold extruder, and pressure was applied from the top of the extruder. By the application of high pressure the dough emerges through the mould. The extruded dough underwent a drying process in a tray drier set at 50°C for a duration spanning 4-5 hours. During drying the moisture removed off and the final moisture content of the product should about 10 – 12 %. The dried pasta products, obtained from various blends, underwent meticulous packaging in high density polythene bags for subsequent analysis process. This preservation method ensures the integrity and stability of the pasta samples during storage, maintaining their quality for further examination. Figure 1,shows the flow diagram for processing of pasta.

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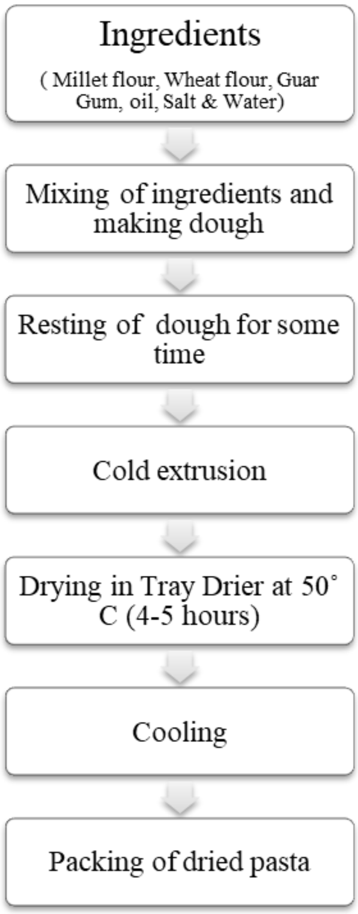


**Fig 1: Pasta Processing Flow Diagram**

**Experimental Design**

In this investigation,BoxBehnken design (BBD) of response surface methodology(RSM) was used to explore the effect of three independent variables such as Foxtail millet flour (FMF), Kodo millet flour (KMF), and Guar gum (GG on the swelling index, gruel loss, and cooking time of pasta. To establish the maximum and minimum limits for these variables (FMF: 43-50g, KMF: 33-40g, GG: 1-2g), insights from existing literature and preliminary trials were considered. The experiment was done for 17 combinations with five center point replication with variations in the foxtail millet flour, kodo millet flour and guar gum as shown in the table 1.The collected experimental results for all responses were subsequently modeled using a second-order polynomial equation, articulating the chosen responses as mathematical functions of the independent factors. This statistical approach allows for a comprehensive understanding of the interplay between the variables and their impact on the specified responses in pasta production.

The significant difference between linear, quadratic and interaction effect of independent variables was determined using analysis of variance (ANOVA).The statistical significance of the polynomial model terms was assessed through F-statistics at probabilities (P) of 0.1, 0.05, and 0.01, accompanied by the evaluation of a non-significant lack-of-fit value. Three-dimensional response surface plots were used to understand the concept clearly by keeping one factor constant at the central point and changing the other two variables within the experimental range. An optimum values of processing parameters were found out by using numerical optimization technique. An attainment of optimal pasta preparation involved integrating predetermined goals for all quality parameters into a comprehensive desirability function.

**Table :1 Box Behnken Design f or Independent variables and their response**

| **Run** | **Foxtail Millet Flour (g)** | **Kodo Millet flour (g)** | **Guar Gum (g)** | **Swelling index** | **Gruel loss (%)** | **Cooking time (min)** |
|---|---|---|---|---|---|---|
| 1 | 50 | 36.5 | 2 | 1.102 | 5.4 | 10.7 |
| 2 | 46.5 | 36.5 | 1.5 | 1.046 | 5.1 | 11.4 |
| 3 | 46.5 | 33 | 1 | 0.964 | 5.3 | 11.54 |
| 4 | 50 | 40 | 1.5 | 1.284 | 5.3 | 10.2 |
| 5 | 46.5 | 36.5 | 1.5 | 1.043 | 5.4 | 11.2 |
| 6 | 50 | 33 | 1.5 | 0.966 | 6.5 | 11.52 |
| 7 | 50 | 36.5 | 1 | 1.058 | 5.8 | 11.29 |
| 8 | 46.5 | 36.5 | 1.5 | 1.044 | 5.3 | 11.3 |
| 9 | 46.5 | 40 | 2 | 1.29 | 4.8 | 10.3 |
| 10 | 46.5 | 36.5 | 1.5 | 0.98 | 5.2 | 11.3 |
| 11 | 46.5 | 36.5 | 1.5 | 1.043 | 5.3 | 11.25 |
| 12 | 43 | 33 | 1.5 | 0.935 | 4.7 | 11.59 |
| 13 | 43 | 40 | 1.5 | 1.196 | 6.1 | 10.43 |
| 14 | 43 | 36.5 | 1 | 1.17 | 6.2 | 10.56 |
| 15 | 46.5 | 40 | 1 | 1.4 | 6.55 | 10 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | 46.5 | 33 | 2 | 1.13 | 5 | 11.32 |
| 17 | 43 | 36.5 | 2 | 1.028 | 4.5 | 11.25 |

**Cooking Parameter Analysis**

**Cooking Of Pasta**

A 25g sample of pasta was placed in 300ml of boiling water and cooked until it reached a full boil.It was checked manually by pressing it with fingers. The cooking time varied based on different compositions.Then the pasta and water were separated for analyzing the cooking quality.

**Solid Gruel Loss**

After cooking of pasta the water was separated and it was used for the determination of solid gruel loss.10ml of cooked water was pipette out and transferred it into the petriplate. Subsequently, the pasta sample was subjected to drying in a hot air oven set at 105°C until reaching a concordant value. It was reported as percentage of original pasta sample using the method followed by [13]

**Cooking Time**

The determination of the minimum time required for starch gelatinization, denoted as cooking time (CT), involved pressing the cooked pasta between two glass plates. The conclusion of the cooking process was marked by the disappearance of the white core of the pasta, and the associated time was documented as the cooking time. This method aligns with the procedure outlined by [14], providing a reliable and standardized approach for assessing the critical parameter of cooking time in pasta.

**Swelling Index**

The swelling index is calculated by evaluating the disparity in weight between the cooked and uncooked pasta. This measurement provides a quantitative indicator of the extent to which the pasta expands during the cooking process. After cooking, the pasta samples were rinsed with water, allowed to drain for 30 seconds, and then weighed to ascertain the gained weight. This analysis serves to indicate the extent of water absorption by the pasta during the cooking process.

**Chemical Analysis**

The chemical analysis for the optimized sample involved several determinations. The moisture content was assessed by drying the sample in a hot air oven and calculating the loss in weight after drying. Protein content was assessed using the Kjeldahl method (N * 5.7), whereas ash content was determined by heating the sample at 600°C for a duration of 3-4 hours until white ash was obtained. Carbohydrate content was measured through the anthrone method, involving the hydrolysis of polysaccharides into simple sugars by acid hydrolysis and estimating the resulting monosaccharides. The fat content was estimated using the Soxhlet method.

**Sensory Evaluation**

Sensory evaluation - a scientific discipline, involves the assessment of consumer products through the application of experimental design and statistical analysis. Human senses are employed to evaluate the products, utilizing panels of human assessors whose responses are systematically recorded. In this investigation, a subjective approach to sensory evaluation was implemented, employing a 9-point hedonic scale that ranged from "like extremely" to "dislike extremely." Variables such as color, smell, texture, taste, and overall acceptability were assessed using this scale. Statistical techniques were applied to derive inferences and insights about the tested products based on the recorded responses.

**Results And Discussion**

To optimize the cooking properties of millet pasta, the application of Response Surface Methodology (RSM) software focused on three key variables: swelling index, gruel loss, and cooking time. Subsequent to optimization, a sensory analysis was performed on the refined product, involving a trained panel. For each variable, models encompassing linear, quadratic, and interaction effects were computed, and an ANOVA test was executed to assess the appropriateness of the models. Notably, all response variable models demonstrated statistical significance ($p < 0.05$, $R^2 = 0.96 – 0.98$), as detailed in Table 2. The F-values, signaling the significance of the models, coupled with the insignificance of the lack of fit, provided additional confirmation of the models' suitability. Linear and interactive effects of each independent variable on responses were elucidated

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through both one factor and 3D response surface plots were shown in Figure.

**Impact Of Independent Variable On Swelling Index Of Pasta**

**Table 1 showcases the variability in the swelling index of millet pasta, ranging from 0.935 to 1.4.**

| **STATISTICAL ANALYSISSource** | **Swelling index** | | **Gruel loss** | | **Cooking time** | |
|---|---|---|---|---|---|---|
| | **F value** | **P value** | **F value** | **P value** | **F value** | **P value** |
| Model | 21.86 | 0.0003 | 25.11 | 0.0002 | 64.56 | <0.0001 |
| A-FMF | 0.613 | 0.4593 | 11.32 | 0.012 | 0.2439 | 0.6365 |
| B-KMF | 129 | <0.0001 | 7.86 | 0.0264 | 430.33 | <0.0001 |
| C-GG | 0.1648 | 0.6969 | 86.67 | <0.0001 | 0.5489 | 0.4829 |
| AB | 0.6072 | 0.4614 | 68.04 | <0.0001 | 0.8674 | 0.3827 |
| AC | 6.47 | 0.0385 | 17.01 | 0.0044 | 55.51 | 0.0001 |
| BC | 14.24 | 0.007 | 21.16 | 0.0025 | 9.16 | 0.0192 |
| $A^2$ | 1.42 | 0.2726 | 8.68 | 0.0215 | 5.42 | 0.0527 |
| $B^2$ | 22.89 | 0.002 | 4.55 | 0.0705 | 37.84 | 0.0005 |
| $C^2$ | 19.9 | 0.0029 | 0.0215 | 0.8877 | 33.56 | 0.0007 |
| Lack of fit | 2.47 | 0.2014 | 3.13 | 0.1499 | 1.8 | 0.2872 |
| **Fit statistics** | | | | | | |
| Std.dev | 0.0366 | | 0.1576 | | 0.0859 | |
| Mean | 1.1 | | 5.44 | | 11.01 | |
| $R^2$ | 0.9656 | | 0.97 | | 0.9881 | |

The highest swelling index (1.29) was noted in pasta composed of 46.50g of foxtail millet flour, 40g of kodo millet flour, and 2g of guar gum (run 9). In contrast, the lowest swelling index (0.935) was observed for pasta with 43g of foxtail millet flour, 33g of kodo millet flour, and 1.50g of guar gum (run 12). A statistically significant quadratic model ($p < 0.05$, R2 = 0.9656) was fitted to the data, with a non-significant lack of fit (F = 2.47). Model terms B, AC, BC, B2, and C2 were found to be significant (see Table 2).

The experimental data was fitted to second order polynomial equation in terms of Coded factors for swelling index are presented as follows:

$$\text{Swelling index} = +1.03 + 0.0101A + 0.1469B - 0.0052C + 0.0142AB + 0.0465AC - 0.0690BC - 0.0212A^2 + 0.0853B^2 + 0.0795C^2.$$

From the equation it was evident that foxtail millet flour (FMF) and kodo millet flour (KMF) showshighly significant ($p < 0.0001$) positive linear effect and a negative linear effect of guar gum. The quadratic terms suggest that kodo millet flour (KMF) and guar gum (GG) exhibit a significant ($p < 0.1$) positive effect.

Figure 2(a) illustrates the impact of Kodo millet flour on the swelling index at the optimised conditions of foxtail millet flour and guar gum, showing an increase in the swelling index with an increase in Kodo millet flour composition. Meanwhile, Figure 2(b) shows the effect of foxtail millet flour at optimised points of Kodo millet flour and guar gum, showcasing a marginal increase in the swelling index up to a certain point and then a slight decrease. Figure 2(c) demonstrates the interactions between the variables in three-dimensional response surface plots. The values on the axes in Figure 1(c) represent real values, indicating the combined effect of foxtail millet flour (FMF) and Kodo millet flour (KMF) on swelling index at a constant guar gum composition (1g). It was observed that foxtail millet flour and guar gum have minimal influence on the swelling index, aligning with similar findings reported by [15] regarding the addition of foxtail millet and barnyard millet showing minimal or no change in volume expansion.

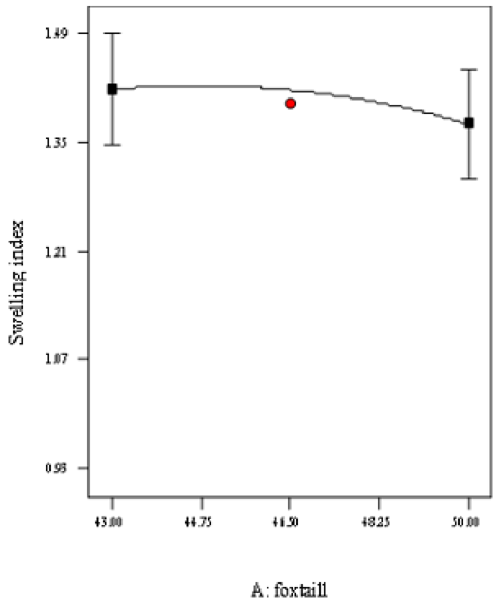


Figure : 2(a)

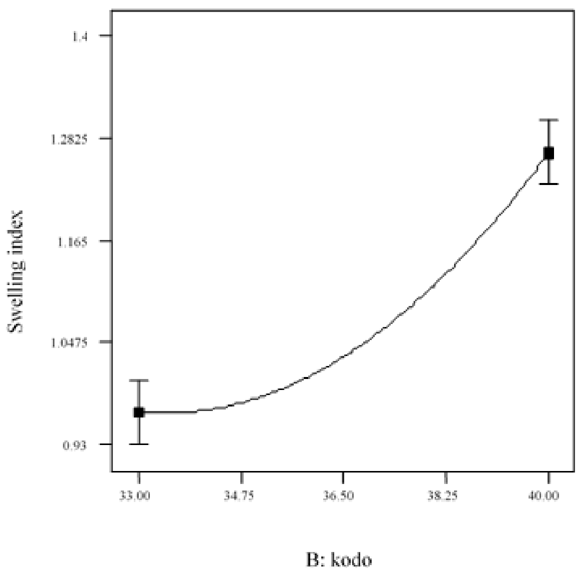


Figure : 2(b)

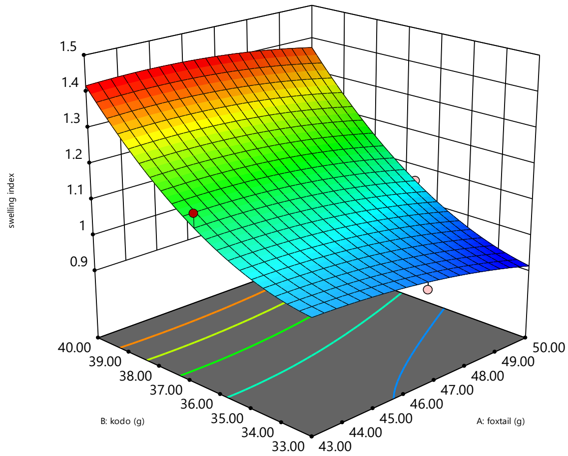


Figure : 2(c)

**Figure 2: One factor and 3D plot for an impact of composition of independent variables on gruel loss of pasta**

**Impact Of Independent Variable On Gruel Loss Of Pasta**

The gruel loss in pasta, signifying the quantity of residue in the cooking water which serves as a critical indicator for the quality of pasta, with lower values indicating higher quality. [13] delivered that pasta having gruel loss within 8%of dry weight are considered as high quality pasta. Cookingloss, a key determinant of structural integrity, significantly impacts the sensory qualities of cooked item [16].Table 1 details the gruel loss of millet flour-incorporated pasta, ranging from 4.5 to 6.55%. The maximum gruel loss occurred in pasta composed of 46.50g foxtail millet flour (FMF), 40g kodo millet flour (KMF), and 1g guar gum (run 15). Conversely, the pasta with 43g foxtail millet flour (FMF), 36.50g kodo millet flour (KMF), and 2g guar gum exhibited the lowest gruel loss (run 17). The quadratic model was fitted for cooking loss, found to be statistically significant ($p < 0.05$, R2 = 0.9313).with a nonsignificant lack of fit (F = 4.13). The terms A, B, $A^2$, $B^2$, AC, BC ($p < 0.05$), C, and AB were found to be significant ($p < 0.01$), as indicated in Table 2.

The experimental data was fitted to second order polynomial equation in terms of Coded factors for gruel loss are presented as follows:

Gruel loss $=+5.26+0.1875A+0.1563B-0.5187C-0.6500AB+0.3250Ac-0.0.3625BC+0.2262A^2$

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$+0.1637B^2-0.0112C^2$

The above equation shows that the gruel loss of pasta posses a highly significant ($P < 0.0001$) positive linear effect of foxtail millet flour (A) and kodo millet flour (B). The linear term for guar gum (C) was not found to be significant ($P > 0.05$). Additionally, all the interaction terms and quadratic terms for foxtail millet flour (FMF) and kodo millet flour (KMF) were not seemed significant ($P > 0.05$).

In Figure 3(a), it is evident that Kodo millet flour demonstrated an inverse impact on gruel loss. At the central points of Kodo millet flour (36.50g) and guar gum (1.5g), the gruel loss increased with the escalation of foxtail millet flour levels from 43 to 50g. Additionally, Figure 3(b) portrays the influence of guar gum on gruel loss with constant levels of foxtail millet flour (46.50g) and Kodo millet flour (36.50g), revealing a decrease in gruel loss as the proportion of guar gum increased from 1 to 2g.This phenomenon is attributed to the gum forming a network around starch granules during cooking, encapsulating them and restricting excessive diffusion of starch content. This observation aligns with findings by [17], who reported a decrease in gruel loss with the addition of carboxymethyl cellulose, and observations by [18] indicating reduced gruel loss in pasta containing gums. Similar results were reported by [13], where the gruel loss significantly decreased with the addition of carboxymethyl cellulose. The gluten-free nature of finger millet flour may contribute to elevated cooking loss, as the absence of gluten weakens the gluten-protein network crucial for maintaining noodle structural integrity during cooking. This weak structure allows more granules to leach out, resulting in heightened cooking residues ([19]; [20];[21]; [22]). Millets, being gluten-free, further compromise the gluten-starch network, facilitating increased solid leaching into the cooking water and, consequently, higher cooking loss ([13]., [23].,[21]).Similar results were reported by [23]for finger millet noodles and by [24] for millet pasta.Figure3(c) indicates the effect of foxtail millet flour (FMF) and Kodo millet flour (KMF) on gruel loss using a 3D response surface plot. The figure demonstrates that both millet flours contribute to an increase in gruel loss, potentially attributed to the gluten-free nature of millets, resulting in poor protein network formation and subsequently higher leaching of solids from the millet pasta

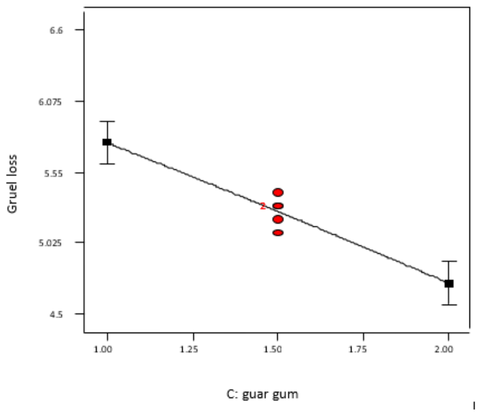


**Figure: 3(a)**

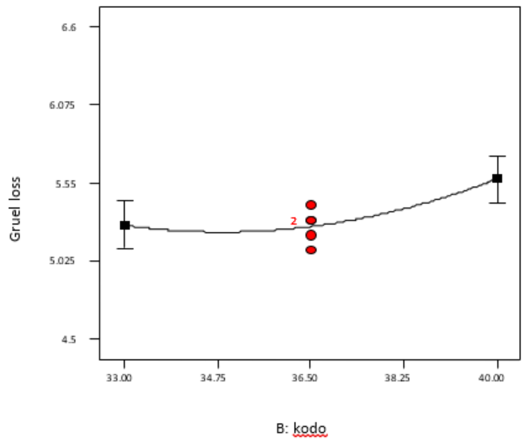


**Figure: 3(b)**

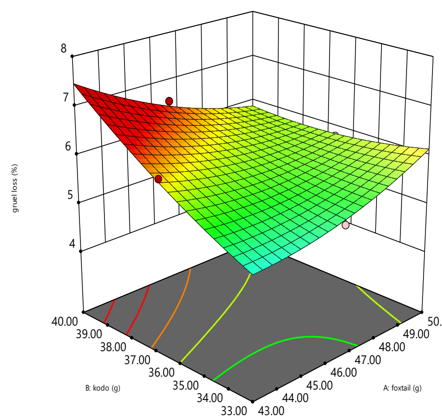


Figure: 3(c)

**Figure 3: One factor and 3D plot for an impact of composition of independent variables on gruel loss of pasta**

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**Impact Of Independent Variable On Cooking Time Of Pasta**

The cooking time for millet pasta ranged from 10 to 11.59 minutes. The maximum cooking time (11.59 min) occurred in run 12, involving 43g of foxtail millet flour (FMF), 33g of Kodo millet flour (KMF), and 1.50g of guar gum. In contrast, the minimum cooking time was recorded in run 15, comprising 46.50g foxtail millet flour (FMF), 40g Kodo millet flour (KMF), and 1g guar gum. As indicated in Table 2, the quadratic model for cooking time was found to be significant ($p < 0.05$, $R^2 = 9.881$), with a lack of fit (F = 1.80), and the terms B and AC were identified as significant ($p < 0.01$).

The experimental data was fitted to second order polynomial equation in terms of Coded factors for cooking time are presented as follows:

Cooking time = 11.29-0.0150A-0.6300B+0.0225C-0.0400AB-0.3200AC+0.1300BC-0.0975$A^2$-0.2575$B^2$-0.2425$C^2$

From the provided equation, it is evident that the cooking time of pasta exhibits a highly significant ($p < 0.05$) negative linear effect of foxtail millet flour (FMF) and kodo millet flour (KMF), along with a positive linear effect of guar gum. However, the interaction terms AC and quadratic terms $B^2$ and $C^2$ were not deemed significant ($p > 0.05$).Cooking time was found to be associated with the carbohydrate content, with a higher amount of carbohydrates leading to easier gelatinization and reduced cooking time . Figure 4(a) illustrates the impact of foxtail millet flour on cooking time. As the composition of foxtail millet flour increases, the cooking time initially rises up to a certain point, and further increases in the composition of foxtail millet flour result in a slight decrease in cooking time. A similar effect is observed with the addition of guar gum, as depicted in Figure 4(b).Increasing the Overall Cooking time was increased by the addition of protein sources like soy protein isolate, mushroom and defatted soy flour have been reported by ([26]., [27]., [28] )observed a linear correlation between optimal cooking time and protein content. In contrast to foxtail millet flour, an increase in the quantity of kodo millet flour was found to decrease the cooking time. various parameters includingthe quantity of protein, gluten quality and flour strength had an impact on cooking time of pasta was reported by [29]. [30] also observed that the result was due to disturbance of gluten network by fiber particles which provides a way for water penetration into the pasta and thus reducing the cooking time. Figure 4(c) illustrates the effect of foxtail millet flour and kodo millet flour at constant points of guar gum using a 3D response surface plot.

**Figure: 4(a)**

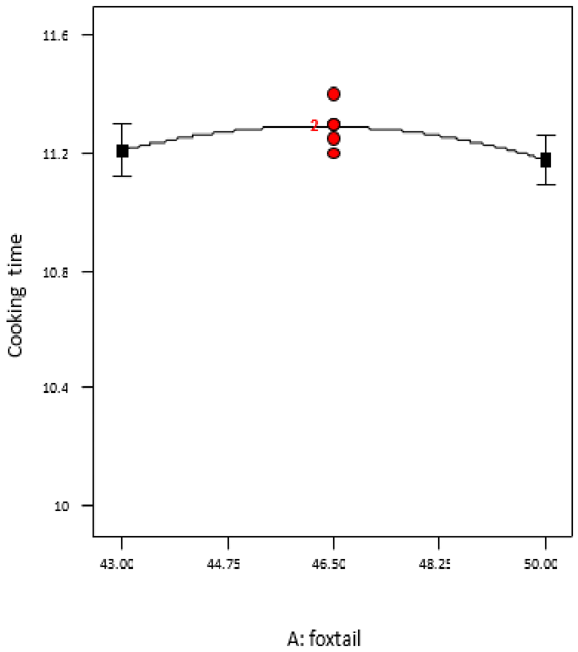


**Figure: 4(a)**

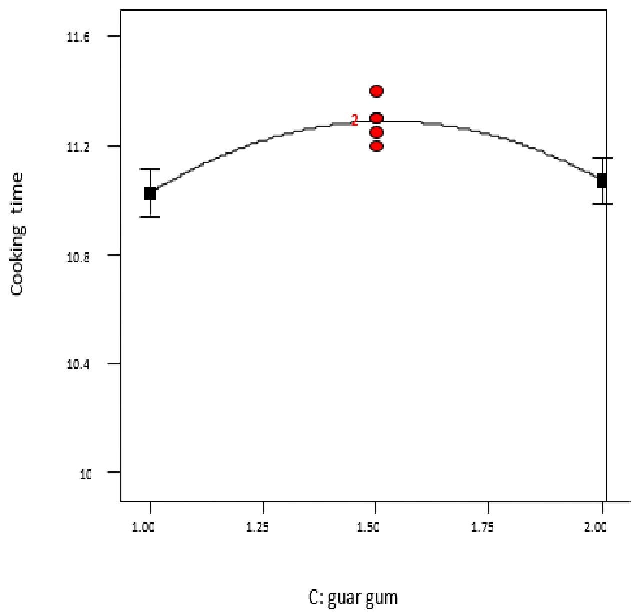


**Figure: 4(b)**

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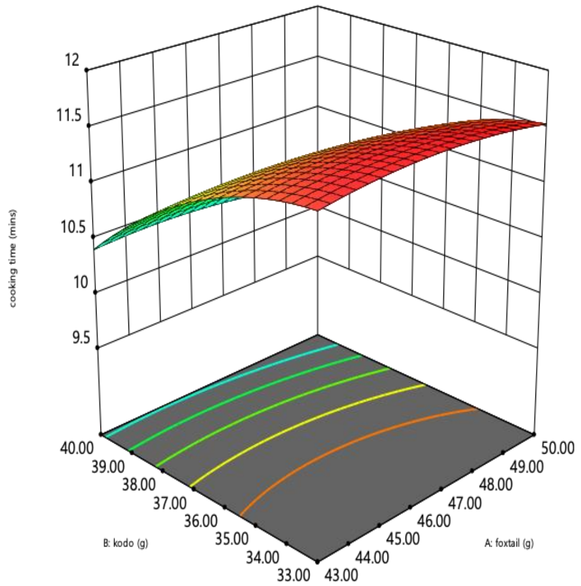


Figure: 4(c)

**Figure 4: One factor and 3D plot for an impact of independent variables on coking time of pasta**

**Optimization**

Design-Expert Software played a crucial role in the numerical optimization process, aiming to achieve the optimum levels of variables and extrapolative values of responses based on predefined goals with a highest desirability function. For the optimization process ,independent variables such as foxtail millet flour (FMF) and Kodo millet flour (KMF), were set to their maximum values, while guar gum was maintained within a specified range. Simultaneously, responses including cooking time were constrained within defined limits, with the goal of minimizing cooking loss and maximizing swelling index (refer to Table 3).From the results of the numerical optimization , it was observed that the maximum desirability point (0.89) could be obtained by formulating pasta with 50g of foxtail millet flour, 40g of kodo millet flour, and 1.86g of guar gum, respectively. At these optimal levels, the predicted values of responses such as swelling index, gruel loss, and cooking time were 1.288, 4.9%, and 10 minutes, respectively. This optimized formulation aligns with the specified goals, emphasizing the significance of balancing and fine-tuning multiple variables to achieve the desired quality attributes in millet pasta.The identified combination met the specified constraints.Subsequently, pasta was prepared using the optimized composition. Chemical analysis and sensory evaluation were conducted on the optimized pasta, revealing that it contained carbohydrates (62%), protein (8.5%), fat (12%), moisture (7.8%), and ash (2.4%) per 100g.

**Table 3: Optimization constraints**

| Name | Goal | Lower Limit | Upper Limit | Lower Weight | Upper Weight | Importance |
|---|---|---|---|---|---|---|
| A: Foxtail | maximize | 43 | 50 | 1 | 1 | 5 |
| B:Kodo | maximize | 33 | 40 | 1 | 1 | 5 |
| C:Guar gum | minimize | 1 | 2 | 1 | 1 | 3 |
| Swelling index | maximize | 0.935 | 1.4 | 1 | 1 | 5 |
| Gruel loss | minimize | 4.5 | 6.55 | 1 | 1 | 3 |
| Cooking time | Is in range | 10 | 11.59 | 1 | 1 | 3 |

**Sensory Properties Of The Final Cooked Millet Pasta**

Texture, color, and taste are critical factors influencing the acceptability of a food product, each playing a pivotal role in creating a sensory experience that meets consumer expectations and preferences. Balancing these elements is essential for the overall appeal and success of the product.The sample was evaluated using 9 point hedonic scale based on 5 parameters ie., Color, taste ,smell, texture and overall acceptability. 9 point hedonic scale consists of various acceptability levels from like extremely to dislike extremely. From the graph it was evident that highest score was found for taste,colour and

odor of the product while comparing to other parameters.However , most panelist shows Overall acceptability of 7 and lowest score for texture of pasta. Asmillets are gluten free rubbery texture cannot be achieved.However, despite these findings, the incorporation of same ingredients such as soy flour [31] and quinoa flour [32] has been reported to lead to decrease in the desirability of pasta sensory scores. Additionally, [33] suggested that fortifying pasta with high-fiber ingredients might dilute the gluten-protein matrix, potentially adversely affecting its sensory attributes.

**Conclusion**

The successful preparation of pasta using millet flour proved to be acceptable and yielded good nutritional value. Employing Response Surface Methodology, a composition comprising foxtail millet (50g), kodo millet (40g), and Guar gum (1.86g) was identified as optimal, and subsequently analyzed for nutritional and sensory characteristics. Nevertheless, it's important to note that gluten-free pasta made from millet exhibits variations in nutritional properties, cooking attributes, and sensory characteristics when compared to traditional wheat pasta. The development of such functional foods not only enhances the nutritional profile for the general population but also provides benefits for individuals dealing with health conditions linked to contemporary lifestyles and environmental factors. The sensory evaluation results indicated a moderate overall liking for the pasta. The introduction of modified pasta products like these can contribute to diversifying the array of protein-rich foods available.

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