Optimization of ingredients composition of non wheat pasta based on cooking quality using response surface methodology (RSM)

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ABSTRACT

The purpose of this study was to develop non wheat millet pasta. Box Benhken Design (BBD) under Response Surface Methodology (RSM) was used to find the better composition by considering cooking quality parameters such as cooking time, solid gruel loss, volume expansion and bulk density. Pasta was prepared using tapioca flour, foxtail millet flour and barnyard millet flour, corn flour, water and salt. The corn flour and salt quantities were kept constant and the remaining flours varied. The dough prepared manually and extruded using cold extruder followed by it was steamed at 80°C for 10 min and dried at hot air oven at 60°C. Ingredients were optimized based on derringer’s desirability function. The optimized composition was found to be tapioca flour (50%), foxtail millet flour (24.6%) and barnyard millet flour (25.78%), at this composition cooking time was 7.17 min, solid gruel loss was 6.198%, volume expansion was 6.99%, bulk density was 321.95kg/m³, carbohydrate was 71.5%, protein was 4.6% and fat was 1.1% with the desirability of 0.829.

Key words: Barnyard millet flour, Box Benhken Design, Cooking quality parameters, Foxtail millet flour, Tapioca flour.

INTRODUCTION

In a rapidly changing world, with altered food habits and modern lifestyle, consumers demand foods with hygiene and nutritious food for their healthier life. Pasta is highly convenient food product and consumed by all age group of people. Generally pasta can be made from durum wheat flour, it is rich gluten protein responsible for elastic property of dough. Gluten causes celiac disease which damaging the small intestine and leads to indigestion resulting unbalanced nutrients in the diet (Vijayakumar et al., 2014). In order to overcome the problem composite flour could be used to prepare pasta. Composite flour is a mixture of cereal flours, millet flours, starches and other ingredients which replace wheat flour totally or partially in bakery products (Noorfarahzilah et al., 2014).

Tapioca or cassava (Manihot esculenta Crantz) is one of the leading and staple crops in the tropical countries in Asia. Starch is abundantly present in tapioca, it can be used in various industries such as food, paper, textile, adhesives, beverages and pharmaceuticals. (Ukwuru and Egbonu., 2013). Barnyard millet is one of the minor millet, it is fairly rich in protein and excellent source of dietary fibre with good quantities of minerals which gives good nutritional and nutraceutical benefits to the consumers with low glycemic index (Ugare et al., 2014). Barnyard millet flour also incorporated in rusk, muffin, pasta, noodles, cakes, biscuits and snacks foods (Jaybhaye et al., 2014). Foxtail millet is underutilized grain, grown in adverse climatic conditions. Among all the millets, foxtail millet low in cereal hydrate content (60.9 g/100 g) and rich in minerals (3 g/100 g) and β-carotene (126-191 μg/100 g), it was reported by Balloli et al., 2014. Corn flour is also added to many bakery products which can enhance the gelatinization behaviour and cooking properties of end products (Li et al., 2014).

Response surface methodology (RSM) is an effective statistical technique was used for generation of response surface plot and to optimize the ingredients composition (Badwaik et al., 2014). A statistical analysis was performed using Design Expert 7.0.0 Star Ease software package. The major ingredients used for the research work is barnyard millet, foxtail millet and tapioca flour. The objective of research work is to study the effects of ingredients composition on cooking qualities using Response Surface Methodology (RSM).

MATERIALS AND METHODS

Raw materials preparation: Tapioca flour, barnyard millet, foxtail millet, corn flour and salt were procured from the local market in Perundurai, Erode, Tamil Nadu, India. The foxtail millet and barnyard millet were ground into flour using a hammer mill available in the laboratory and then it stored in an air tight container for further usage. Salt and corn flour also packed in the airtight package to avoid cross contamination.

Preparation of pasta: The pasta was prepared by using tapioca flour, foxtail flour, barnyard flour and water along with constant proportions of corn flour (5 g), salt (1.5 g). Mixing and kneading the mass for 15 minutes was done
to produce stiff, plastic, homogeneous dough (Badwaik, et al., 2014). The prepared dough put inside the traditional cold extruder and pressure was applied at the top of the extruder due to high pressure the dough emerges through the mould. The extruded dough is steamed for 10 minutes at 80-100°C in the steamer followed by drying was carried in hot air oven at 60°C for 4-5 hours until the constant weight is reached. Finally it could be packed in commercially available low density polyethylene pouches.

Cooking Quality Analysis

Cooking time: Fifty grams of pasta was taken and added into beaker containing 500 ml of boiling water. Cooking time was noted down until disappearance center core of pasta (Menon, et al., 2015). Then the sample was drained and cooked water was collected for further analysis.

Solid gruel loss: Cooked water was stirred well. 20 ml of cooked water was pipetted out and transferred into pre weighed petriplate and then the water was evaporated in a hot air over at a temperature of 105±2°C until concordant value obtained (Sudha, et al., 2012).

Volume expansion: Volume Expansion of pasta was evaluated according to procedure described by Cleary et al.,(2006). It could be expressed as follows,

\[
\text{Volume Expansion (\%) = } \frac{\text{Wt. of cooked pasta-Wt. of pasta after drying}}{\text{Wt. of pasta after drying}}
\]

Bulk density: Bulk density was estimated by filling the known weight of pasta in the 250 ml measuring cylinder (Benhur et al.,2015) and it was calculated by using the formula,

\[
\text{Bulk Density} \left( \frac{\text{kg}}{\text{m}^3} \right) = \frac{\text{Weight of the sample}}{\text{Volume of the sample after tapping}}
\]

Statistical analysis: In this study, a three-factor and three-level Box-Behken design was used, a total of 17 trials of different compositions with five center point were obtained and experiment was performed for those trials. Based on the pre experimental work the levels of independent variables was chosen and tabulated in the Table 1

RESULTS AND DISCUSSION

Design matrix of experimental runs with observed cooking quality responses were shown in Table 2

Effects of composition on cooking time: Effects of composition on cooking time was illustrated in the Fig. 1. Cooking time was related to carbohydrate content, if amount of carbohydrate content is high, it was easily undergoes gelatinization which reduced the cooking time (Shukla et al., 2014). Tapioca flour along with barnyard and foxtail millet flour composition increases, cooking time was increased to some extent and then it was decreased. The absence of gluten network also reduced the time that the water needs to reach the center during cooking process (Chillo. et al., 2007).

Effects of composition on gruel loss: The observed gruel loss with different combinations of the ingredients varied from 5.62 to 9.9 % within the combination of variables used (Table 1). Individual and mixed millet flour samples showed
that higher gruel loss because of absence of tapioca flour which was act as a binding agent. Gruel loss decreased significantly with addition of tapioca flour because of its binding property (Vijayakumar et al., 2014). Increasing the foxtail flour was increases the gruel loss (Fig.2) but increasing the barnyard flour not showed negative effect as foxtail flour which might be due to amylose content of the flour (Shukla et al., 2014).

Effects of composition on volume expansion: Fig.3 represents effects of ingredient composition on volume expansion and it was inferred that foxtail flour and barnyard flour composition increases, there is no or less change in volume expansion it was due to the presence of high protein, lipid, fibre and larger amount of amylose-lipid complex in foxtail and barnyard (Nazni et al., 2010). The tapioca flour composition increases, there was an increase in volume expansion due to the greater hydration capacity of starch (Gurpreet Kaur et al. 2011).

Effects of composition on bulk density: Fig 4 illustrated that the incorporation of tapioca flour showed negative effect on bulk density. If the barnyard flour composition was increases the bulk density also increased to certain level and...
then it was decreased which might be due to the low porosity value and less auto oxidation of millet flour (Nazni et al., 2010).

**Statistical analysis:** Model summary statics of the responses such as cooking time, solid gruel loss, volume expansion and bulk density depicted in the Table 3. Among the models such as Linear, $2^F_1$, Quadratic and Cubic, Quadratic model have been suggested for cooking time, solid gruel loss and bulk density whereas linear model was suggested for volume expansion.

**Optimization of composition:** Optimization was done based on derringer’s desirability function. The optimum composition was found at 50g of tapioca flour, 24.6g of foxtail millet flour and 65.78g of barnyard millet flour under this condition the cooking time was 7.17 min, solid gruel loss was 6.198%, volume expansion was 6.99%, and bulk density was 321.957 kg/m$^3$.

**CONCLUSION**
Cold extrusion of non wheat millet pasta was successfully prepared and composition was optimized using BBD design under RSM. Prepared product had good consumer acceptability and the nutritional value of optimized composition was 71.5% of carbohydrate, 4.6% of protein and 1.1% of fat with the desirability of 0.829.
Table 3: Development of mathematical Model.

<table>
<thead>
<tr>
<th>Source</th>
<th>SD</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>Predicted R²</th>
<th>Press</th>
<th>p value</th>
<th>F value</th>
<th>Remark</th>
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<td></td>
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<td>-0.0230</td>
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<td>-0.2183</td>
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<td>0.9737</td>
<td>0.9398</td>
<td>0.6293</td>
<td>84.61</td>
<td>0.0001</td>
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<td>0.9860</td>
<td>-</td>
<td>-</td>
<td>0.0317</td>
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<tr>
<td>Linear</td>
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<td>0.9892</td>
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<td>0.62</td>
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REFERENCES


