Optimization Of Domestic Garlic Flavored Conventional Parboiled Puffed Rice (ORYZA SATIVA L.) Using Rsm

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Abstract: Rice is one of the popular food grains and is used as the staple food in many countries which provide the symbol of global unity and cultural identity. Flaked rice, expanded rice, popped rice, breakfast cereals, infant foods are some of the processed products of rice. Puffed rice is a whole grain product from pregelatinized milled rice. To overcome the limitations of traditional method of puffing, hot air puffing methodology was used in our study. As garlic is the commercially available spice with many medicinal properties, it was also used as a flavoring agent along with the puffed product to increase the nutritional and sensory characteristics. The puffing characteristics were studied at different soaking time (2 h, 3 h and 4 h), puffing temperature (240 °C, 250 °C and 260 °C) and puffing time (40 s, 50 s and 60 s). The puffing characteristics were found to be desirable for the product prepared at the puffing temperature 260 °C for 60 s and 4-hour soaking time. The sensory analysis was carried out for the optimized garlic flavored puffed rice and found to be highly acceptable.

Index Terms: BBD, Garlic flavor, Hot air puffing, Oryza sativa L, Puffing characteristics, RSM, Sensory characteristics

1 INTRODUCTION

Snacks provide quick fixes when hunger strikes and consumption of junk food is very much increasing nowadays. But the familiar snacks that tantalize our taste buds often contain ingredients that negatively impact our health. Junk foods are high-energy-dense foods because they contain a lot of calories, mostly from fat and sugar, but offer few health benefits. A study published in 2012 in “The American Journal of Clinical Nutrition” found that regularly consuming high-energy-dense junk food decreases sensory-specific satiety, causing consumers to eat more of junk food. Junk food tends to be high in saturated fat and cholesterol which leads to the risk of heart disease and stroke (American Heart Association, 2013). Rice (Oryza sativa), the staple food of south Indians is one of the two most important cereal crops next to wheat (Triticum species) for human consumption. Rice is the most important staple food among the densely populated countries especially India, Bangladesh, China and Indonesia. India is the world's second largest producer of white rice, accounting for 20% of all world rice production. One of the convenient and nutritional rice-based popular snack foods consumed in the most rice growing countries is the puffed rice. A characteristic property of parboiled rice is that it is subjected to high-temperature-short-time (HTST) heat treatment, it puffs out to yield puffed (or expanded) rice (Roberts et al. 1954). The degree of puffing expansion is affected by the conditions of HTST treatment (Chinnaswamy and Bhattacharya 1983a), the rice variety, i.e., mainly its amylose content (Chinnaswamy and Bhattacharya 1983b) and the parboiling conditions. It is a major source of carbohydrate (89 %), and includes other nutritional benefits such as proteins, dietary fiber, vitamins, minerals, and photo chemicals (Joisi et al.2014; Maisont and Narkrgusa 2009; FDA 2006 and Houston et al. 1970). Hot sand roasting, frying in hot oil, hot air puffing and gun puffing are the various methods used for puffing rice. In hot sand roasting process, the grains are fed into a rotating drum where the grains come in contact with the hot sand of about 250°C for a short span for time. Due to the sudden thermal gradient the moisture in the rice grain evaporates and escapes causing the starch to expand and the rice get puffed. This method is mostly practiced in Indian Subcontinent which has the major drawback of over burning and the risk of adherence of silica to the puffed product (Hoke et al. 2005). In hot oil puffing, the grains are fried in hot oil wherein the puffed rice absorbs oil and easily turn rancid on exposure to oxygen during storage. In gun puffing method the rice samples were fed into a rotating drum where super-heated steam is produces inside the grains at the temperature of 115 °C and the pressure in the drum reaches about 8 bar which causes the rice to puff. The conditions for puffing are optimized using RSM (Response Surface Methodology). RSM encompasses a group of techniques used to study the relationship between one or more measured responses and input variables. The Box–Behnken design of RSM was used to determine the optimum zone within the experimental design. Considering the above facts, this paper aims to develop garlic flavored puffed rice and optimize process parameters for puffed rice based on puffing characteristics, nutritional analysis and sensory evaluation.

2. MATERIALS AND METHODS

2.1. Raw materials

Researchers have reported that factors of the grain such as variety, amylose content, protein content, moisture content, and degree of gelatinization affects the puffing quality significantly. Paddy samples selected were of Gurjari variety as suggested by Joshi et al(a), 2014, Joshi et al (b), 2014 and Indian Institute of Crop Processing Technology, Tanjavur. There are 3 different varieties of Garlic available locally such as Nattu Poondu, malaipoond and Chana Poondu. Among these varieties Nattu Poondu was selected as it is good for health and availability is higher.

2.2. Process Methodology

2.2.1. Preliminary Processing

The Gurjari variety paddy samples were cleaned and seived for the removal of undesirable substances and soaked in hot water at 70°C for 24 hours. The soaking duration varies...
with temperature of soaking water. The moisture content of the paddy increases with the increase in soaking time. After soaking, dual stage drying of paddy was adopted in which the paddy was sun dried to the final moisture content 13% d.b in Stage 1. Stage 1 drying was done for at least 6 hours per day for 5 days. The paddy was spreaded in 2-3 cm thickness layer to ensure even drying of the grains. The dried paddy was roasted with sawdust as a fuel in two compartments until the oven attains uniform temperature. Within two minutes the kernels were roasted inside the husk. Sieving was done to remove the sand from paddy and rice using a rotating drum made of brick and clay. The roaster is fabricated without high technology components and uses paddy husk, sawdust or peanut shells as a fuel source. Stage 2 drying of grains was attained by spreading the roasted paddy on drying surfaces such as concrete pavement, mats, and plastic sheets and even on fields to dry naturally. Initially grains were spread in thin layers of 2-4 cm without exceeding 5 cm. In this stage the grains were mixed once in every 30 minutes until grain temperature reach above 50ºC.

2.2.2. Hot air Puffing
The paddy was soaked in garlic water prepared at the concentration of 30% for about 2, 3, 4 h. Salt is added to give taste and it increases the efficiency of puffing ability. Hot air oven was used for puffing the hulled paddy. Puffing was carried out by allowing hot air to pass through a bed of rice at different temperature and time i.e. (240, 250, 260ºC) (30, 45, 60 sec). Under such condition rice gets popped out and puffed. The puffed rice was sorted into two categories as fully puffed rice and semi puffed rice.

2.3. Nutritional analysis
Carbohydrates in the samples were estimated using anthrone method (Yemm, E. W., and A. J. Willis(1954);Clegg, K. M. (1956);Raunkjaer et al (1994);Johnson, Sapna et al(2012)). Protein content of the samples were determined using Kjeldal method. (Abbas, Aadil, et al(2011); Hiller et al (1948); Jung et al (2003); Simonne et al(1997)). The fat content in the puffed rice samples were analyzed using soxhletapparatus (Dobush et al 1985; Asp et al (1983);Priego-Capote et al (2005)). The estimation of minerals was done by ashing method. (Chinnaswamy, R., & Bhattacharya, K. R. (1983); Abbas, Aadil, et al(2011); Pallavi et al (2014); Serna-Saldívar, S. O. (2012). The moisture content was analyzed by AOAC methods using hot air oven method(Maskan, M. (2001); Hu et al (2006); Giri, S. K., & Prasad, S. (2007); Srikiatdern, J., & Roberts, J. S. (2008)). The crude fibre was analyzed as per AOAC methods of analysis using sodium hydroxideand sulphuric acid as reagents (McCleary, B. V. (2003); Van Soest, P. J., & McQueen, R. W. (1973)).

2.4. Puffing characteristics
2.4.1. Volume Expansion Ratio
The volume expansion was measured by sand replacement method. Initial volume of 50 g unpuffed parboiled milled rice was taken in a 500-ml cylinderand filled it with fine sand, and the volume was noted. The same sample was then puffed by hot air puffing as mentioned earlier. Volume expansion ratio was calculated based on the ratio of final volume of puffed rice to the initial volume of puffed rice.

2.4.2. Puffing Yield
After puffing, the unpuffed grains were handpicked and the weight of total puffed grains was recorded. The grains were considered fully puffed when they did not have any unpuffed part and the volume expansion ratio were 4 or more. Grains were considered semi puffed when some part of the kernel was puffed and some part still remained unpuffed, and the volume expansion ratio varied between 2 and 4. Puffing yield was determined considering the ratio of weight of fully puffed grains(W_puf) and weight of semi puffed grains(W_spp) to the weight of whole grain(W).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Name</th>
<th>Units</th>
<th>Coded values</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Puffing Time</td>
<td>Sec</td>
<td>-1 0 +1</td>
</tr>
<tr>
<td>B</td>
<td>Temperature</td>
<td>°C</td>
<td>240 250 260</td>
</tr>
<tr>
<td>C</td>
<td>Soaking Time</td>
<td>h</td>
<td>2 3 4</td>
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Table 2.1 Design Summary - Garlic Flavored Puffed Rice

2.5. Sensory analysis
The sensory analysis was carried out for the optimized sample. The ranking method was adopted for the sensory analysis using 9 point hedonic scale with 30 untrained panelists. The results were concluded based on significant difference between the attributes and panelists using ANOVA – Two factor without replication.

2.6. Process Optimization - Box Behnken Design
In this study, a three-factor and three-level Box–Behnken design of experiment was used. The process factors of interest were Puffing time, Puffing Temperature, Soaking Time. Each process factor was chosen for three different levels. Here -1, 0 and +1 represent low, medium, and high levels, respectively. In accordance with a 3³ Box Behnken design of experiments, 17 runs were conducted under identical environmental conditions and the design summary is shown in Table 2.1. The results of experiments were analyzed by response surface methodology using the statistical software Design Expert 9.

3. RESULTS AND DISCUSSION
3.1. Effect of process variables on puffing Characteristics

![Fig. 3.1 Effect of puffing time and puffing temperature at different soaking time (2, 3 and 4 h) on volume expansion](image-url)
The variation of puffing time and temperature on volume expansion of Garlic flavoured puffed rice at different soaking time is clearly shown figure 3.1. It is seen that volume expansion increases with the increase in puffing temperature for soaking time of 2 h and 3 h respectively. Temperature is the main factor for volume expansion, when conditioned grains are subjected to high thermal gradient, moisture evaporation takes place instantaneously and gets puffed. Thus temperature is directly related to volume expansion. The volume expansion gradually increases with the increase in puffing temperature till 250°C, later the puffing volume starts decreasing for the sample soaked for 4 h (Fig 4.1.(c)) this may be due to the fact that garlic is highly sticky in nature it prevents rice from popping out and hence the volume expansion is lower at two extreme temperatures and slightly higher at centre point. Puffing time is directly related to the volume expansion of flavoured puffed rice in most of the cases except for the samples prepared at 260°C with the soaking interval of 3 h (Fig 4.1(b)). In this case the puffing time plays a negligible effect on volume expansion.

3.2. Effect of process conditions on puffing yield
Puffing temperature and puffing yield are directly proportional until the puffing temperature reaches around 250°C. Puffing yield is low at the extreme (240 and 260°C) temperatures and maximum yield is obtained at 250°C. As puffing time increases puffing yield increases for all the soaking intervals. The puffing yield at the puffing time of 60 sec and puffing temperature of 260°C is found to be 66%, 69% and 73% for the soaking time of 2 h, 3 h and 4 h respectively. Comparing the Figure 4.2(a), Figure 4.2(b) and Figure 4.3(c) it is clearly foreseen that the puffing yield increases with the increase in soaking time and puffing time.

3.3. Nutritional analysis

![Image](https://via.placeholder.com/150)

**Fig 3.2** Effect of puffing temperature and puffing time on puffing yield at soaking interval of 2 h, 3 h and 4 h.

**Fig 3.3** Nutritional values for control and flavored sample

The nutritional analysis showed the similar values in both the control and garlic flavoured puffed rice sample. Protein content might be due to the degradation of protein structure at higher temperature of puffing. Minerals found in garlic tend to promote the mineral content in the flavored sample. Similarly moisture, fat and fibre content were found in the same range in both the the samples.

3.4 Sensory Analysis
The optimized sample is subjected to sensory evaluation. It is soaked for 4 hours and puffed at 250°C for 60 seconds. From the ANOVA table p-value is less than 0.05 for both the parameters. Hence panelist and attributes were significant. From the table it can be concluded that the average in mass and variance is minimum and less than 1. Hence the panelist observations are significant and there lies a significant difference between the attributes.

3.5 Optimization:
Based on the puffing characteristics, nutritional analysis and sensory analysis, the optimized puffing conditions for yield 73%, volume expansion 220% of GFPR are 4 hours soaking and puffing temperature at 260°C for 60 seconds.

![Image](https://via.placeholder.com/150)

**Fig 3.4** Numerical Optimization of Garlic flavored puffed rice

4. CONCLUSION
Flavoring of puffed rice would increase the consumption of puffed rice as it gives more taste and flavor. Hence the factors like puffing temperature, soaking time, puffing time influence the puffing characteristics such as puffing yield and volume expansion. The conditions for puffing is optimized with 4 hours soaking time and puffing temperature at 260°C for 60 seconds with the puffing yield of 73% and volume expansion 220%. The flavoring of puffed rice has very negligible influence on the nutritional content of puffed rice is revealed by the nutritional analysis. The sensory analysis is done to the finally optimized samples which revealed higher consumer acceptance in
terms of taste, texture and flavor. There is a wide scope in incorporation of different flavors in the puffed rice in the commercial production and processing. Different spices may be added as a flavoring agent in the forthcoming levels.

REFERENCE


