JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STANDARDIZATION OF PUFFING PARAMETERS OF RICE

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Abstract: Puffing of rice is an important unit operation for conversion of pre-gelatinized milled rice into ready-to-eat snacks. Unlike corn and paddy, milled rice does not have a barrier to create pressure gradient, which ultimately expands the starch during the water evaporation during heating. To increase sudden vapor pressure in the grain during the volumetric heating, external coating or layer over the rice may provide the vapor pressure. The present investigation was undertaken with the objective to determine some of the physical properties of rice variety 'Ratna', which may influence the rice processing operations. The physical properties namely length, width, thickness and volume of rice were measured at a moisture content of 13.34±0.53% (wet basis) and it was found that the average length, width, thickness, bulk density and coefficient of friction of paddy grains were 9.70 mm, 2.61 mm, 1.89 mm, 0.57gm/cm³ and 0.57 respectively. The present investigation of pretreatments of milled rice and puffing was undertaken with the broad aim of developing and standardizing the technology for production of best quality puffed rice prepared by sand roasting conducted by preheated sand bath (250-280^{0}C) containing fine sea sand: rice ratio as 10:1 and 15: 1for 8, 13, 18, seconds. Combinations of pre-treatments of salt concentration (0, 5, 10 and 15%), soy protein concentration (0, 3 and 5%) were evaluated for the puffing quality with respect to puffing yield and expansion ratio. It was observed that sand rice ratio and roasting time interfered in improving the puffing yield of rice. Also the coating with the soy protein didn't help in improving the puffing quality of rice in terms of expansion ratio and puffing yield. The good quality puffed rice can be produced by pre-treating the milled rice with 15% salt concentrated solution by sand roasting in preheated sand bath (250-280^{0}C) containing fine sea sand: rice ratio as 15: 1 for 13 seconds of roasting time.

***Keywords*: Puffed rice, conditioning, sand roasting, salt, soy protein treatment.**

I. INTRODUCTION

Paddy (*Oryza Sativa L.*) is the second largest major cereal crop, which produces starchy seeds. Rice is used as an important staple food by the people in many parts of the world after wheat. Rice is used as a source of nourishment for more than half of the world's population, thus, making it as second most important cereal grain. Further rice being rich in carbohydrates contributes to about 60 to 70% of the daily energy needs of major chunks of the society. Also rice is extensively used as convenience food such as breakfast cereals, multigrain flakes, puffed, popped and extruded products. The pre-gelatinized and puffed flour has also been utilized as ingredients for cakes, desserts and sweets, formulated baby foods, soups, stews, crackers, noodles, puddings, bread, fermented foods like idli, dosa, dhokla, rice vinegar, wine etc. Rice is a major source of energy and an important source of protein. The availability of nutrients per 100 g of raw white rice provides 361 kcal and 6 g of protein. It also contains substantial amounts of zinc and niacin. On the other hand, it is low in calcium, iron, thiamine and riboflavin and has virtually no beta-carotene (Vitamin A). It is noteworthy that the highest the degree of polishing, the lowest the level of proteins, vitamins and minerals in the final product. Rice is primarily a high energy calorie food. The major part of rice consists of carbohydrate in the form of starch, which is about 72-75 per cent of the total grain composition. The protein content of rice is around 7 percent. The protein of rice contains glutelin, which is also known as oryzenin. The nutritive value of rice protein (biological value =80) is much higher than that of wheat (biological value = 60) and maize (biological value = 50) or other cereals. Rice contains most of

the minerals mainly located in the pericarp. Rice also contains some of the beneficial enzymes. (Basavraj *et al*, 2015).

Puffed rice is a whole-grain puffed product obtained from pre-gelatinized milled parboiled rice, generally prepared from preconditioning of grains by hydrothermal treatment, followed by drying and milling. The milled grains are treated with salt water to an optimum moisture content, which is then subjected to puffing by sand roasting method. Puffed rice is used in snack foods and breakfast cereals and is also a popular street food in some parts of the world. It is also used in temples and gurudwaras as 'Prasad'. In India, mostly the puffing of rice is done at rural areas in local kiln (bhatti) where puffing is usually done by rough method. The different parameters which are involved in this process are not standardized till date. In view of this, the present study was undertaken with objectives to study the physical properties of rough and puffed rice and to study the effect of different pre-treatments and operating parameters on the quality of puffed rice.

II. MATERIALS AND METHODS

The raw materials 12 kg of paddy of variety 'Ratna', 200 gm of soy protein, 1 kg sea salt, polythene bags (for packaging) were used for the experimentation. Weighing balance, vernier caliper, hot air oven (digital type), hot water bath, stone milling machine were used for different measurements during the experimentation. Initially different physical properties namely moisture content, bulk density and coefficient of friction of rough paddy were determined by standard method of AOAC (2005). Different treatment combinations of puffed rice were prepared and carried out in local bhatti (rice kiln) as shown in Fig. 1. Different physical properties of puffed rice namely expansion ratio and puffing yield were determined as per the equation (1) and (2) given by Bhatt and Joshi, 2014.

Paddy (Variety 'Ratna')

⇩

Parboiling of paddy (at 70^0C for 3 to 3.5 hours)

⇩

Drying (Open air drying)

⇩

Milling (5% degree of milling)

⇩

Conditioning

(Pre-treatments of 0, 5, 10, 15% salt concentration and 0, 3, 5% soy protein concentration)

⇩

Sand roasting

(sand bath at 250^0C-280^0C with fine sea sand rice ratio as 10:1 and 15: 1for 8, 13 and 18 seconds)

⇩

Puffed rice

Fig.1. Flow chart for preparation of puffed rice

$$\text{Expansion ratio} = \text{Volume after expansion} / \text{Volume before expansion} \quad (1)$$

$$\text{Puffing yield (\%)} = [\text{Weight of puffed grains in sample (g)} / \text{Total weight of sample (g)}] \times 100 \quad (2)$$

III. RESULTS AND DISCUSSION

The average length, width and thickness of paddy grains were observed as 9.70 mm, 2.61 mm and 1.89 mm respectively. Average Moisture content of rough paddy was observed as 13.34±0.53% (wet basis), average bulk density of rough paddy was recorded as 0.57 g/cm^3, average co-efficient of friction of rough paddy was recorded as 0.57.

3.1 Effect of salt concentration on puffing yield of rice

It can be observed from Fig. 1(a) and 1(b) that, as the salt concentration increases, puffing yield of rice increases for all the roasting times and both the sand rice ratios at 0% soy protein concentration. Maximum puffing yield of rice was obtained at 8 seconds of roasting time and 15% salt concentration at 0% soy protein concentration in both the sand rice ratios. At 10:1 sand rice ratio and 18 seconds of roasting time, puffing yield of rice was increased up to 10% salt concentration and after that it decreased for all the soy protein concentration. At a particular salt concentration, it was observed that puffing yield of rice decreased as soy protein concentration increases from 0% to 5%. This suggests that soy protein interfered in improving the puffing yield. As the results obtained were better at 0% use of soy protein concentrate, it indicated that the coating with the soy protein didn't help in improving the puffing quality of rice.

3.2 Effect of roasting time on puffing yield of rice

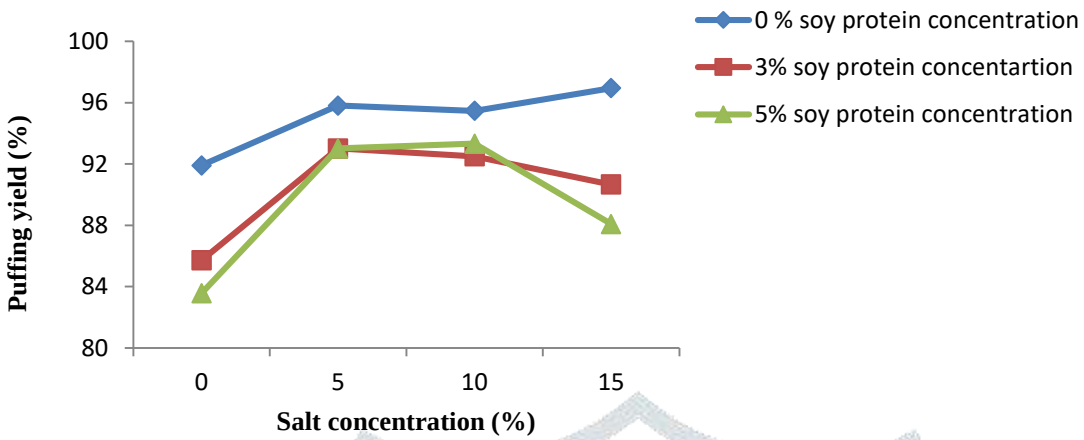
It can be observed from Fig. 2(a), 2(b) and 2(c) that, puffing yield of rice was maximum for 10:1 sand rice ratio at 10 % salt concentration for all the soy protein concentrations. Also it was observed to be maximum for 15:1 sand rice ratio at 15 % salt concentration for all the soy protein concentrations. At all the soy concentrations for 10:1 sand rice ratio, it was observed that puffing yield of rice was increased up to 13 seconds of roasting time and then it decreases for 0% salt concentration. The maximum puffing yield was found at 0% soy concentration, 15% salt concentration, 8 seconds roasting time for10:1 sand rice ratio, whereas it was maximum at 3% soy concentration, 15% salt concentration, 13 seconds roasting time for15:1 sand rice ratio. As sand rice ratio increases from 10:01 to 15:01, puffing yield decreases at 8 seconds of roasting time, but on the other hand puffing yield increases at 18 seconds of roasting time. This suggests that the sand rice ratio and roasting time interfered in improving the puffing yield.

3.3 Effect of salt concentration on expansion ratio of rice

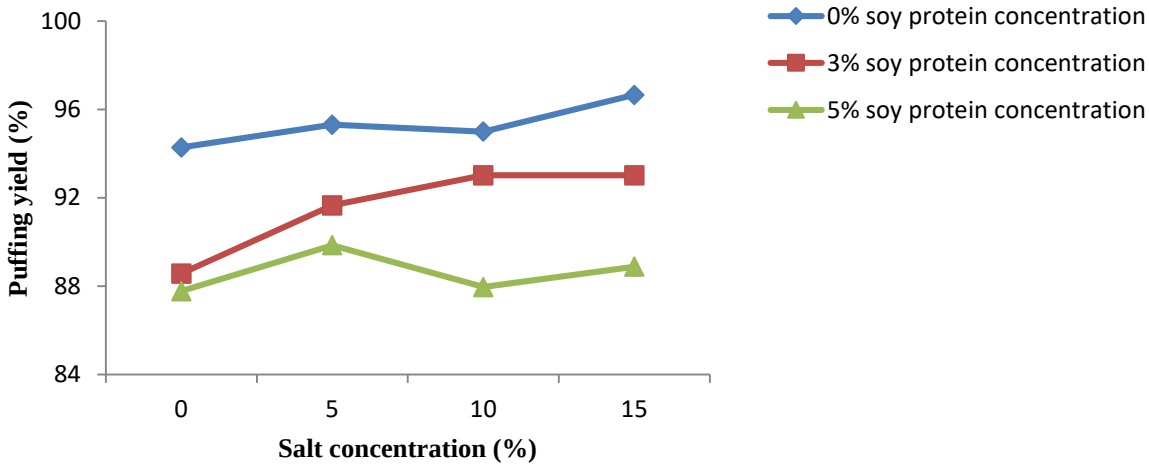
It can be observed from Fig. 3(a) 3(b) that there was increase in expansion ratio with the increase in salt concentration from 0 to 15% with 5% soy protein concentration at 8 and 18 seconds of roasting time and 10:1 sand rice ratio. But for 0% & 3% soy protein concentration at both the sand rice ratio, initially expansion ratio increased with salt concentration from 0% to 5%, after that decreased with salt concentration from 5% to 10% and again increased with salt concentration from 10% to 15%. Also it can be observed that as soy protein concentration increases from 0% to 5%, expansion ratio decreases at all the salt concentrations for 8 and 13 seconds of roasting time and both the sand rice ratio. This suggests that soy protein interfered in improving the expansion ratio. The maximum expansion ratio was found when the rice was treated with 0% soy protein concentration and 15% salt concentration for both the sand rice ratio at 13 seconds of roasting time. This indicates that the coating with the soy protein didn't help in improving the expansion ratio of the rice.

3.4 Effect of roasting time on expansion ratio of rice

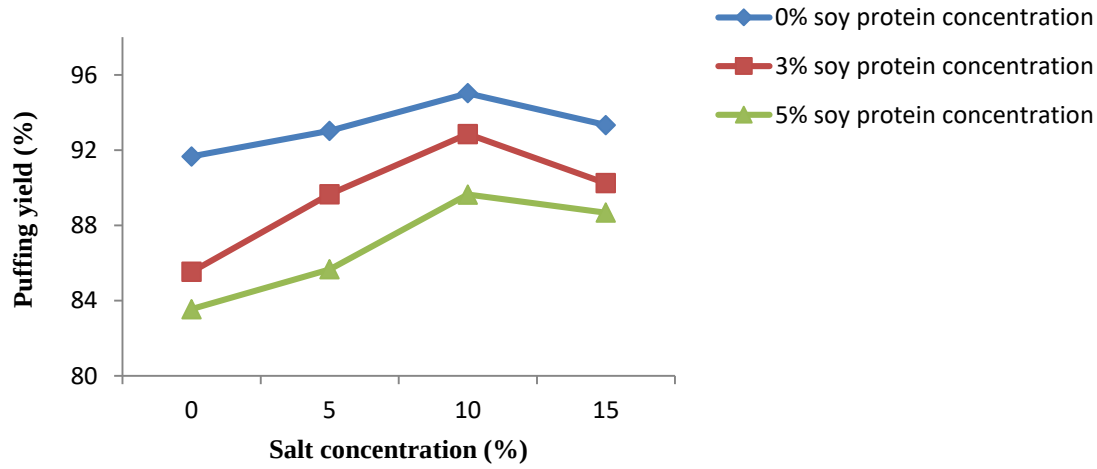
It can be observed from Fig. 4(a), (b) and (c) that as roasting time was increased, expansion ratio of rice also increased. But on the other hand, expansion ratio decreased from 13 to 18 seconds of roasting time at 10:1 sand rice ratio. Expansion ratio increased with roasting time from 8 to 18 seconds of roasting time for 15:1 sand rice ratio. It can be observed from that as sand rice ratio increased from 10:1 to 15:1, expansion ratio increased at all the roasting time. This suggests that the sand rice ratio and roasting time interfered in improving the expansion ratio. The maximum expansion ratio was found when the rice was treated with the combination of 15:1 sand rice ratio and 18 seconds of roasting time and the minimum expansion ratio was found when the rice was treated with of 15:1 sand rice ratio and 8 seconds of roasting time. As the results were better at sand rice ratio of 15:1 and 18 seconds of roasting time, it indicated that sand rice ratio of 15:1 helped in improving the puffing quality of the rice.



At 8 seconds roasting time

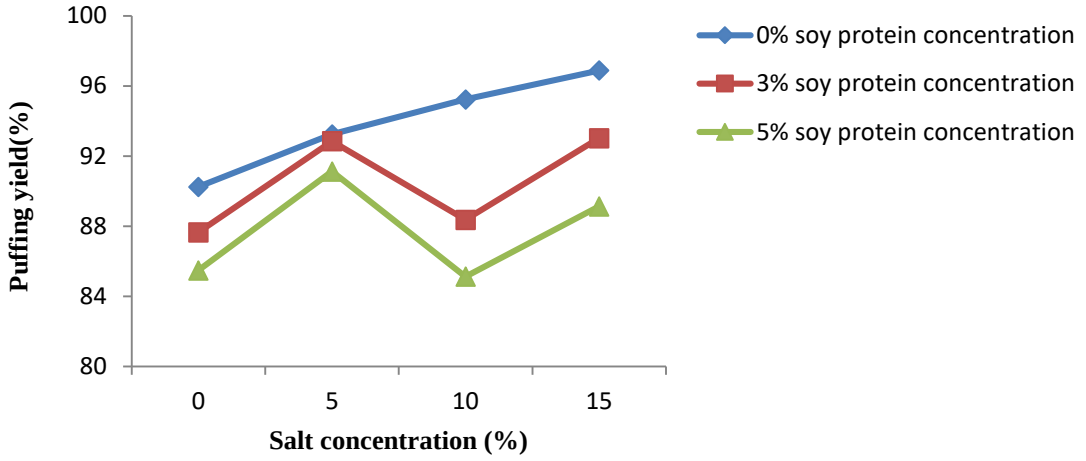


At 13 seconds roasting time

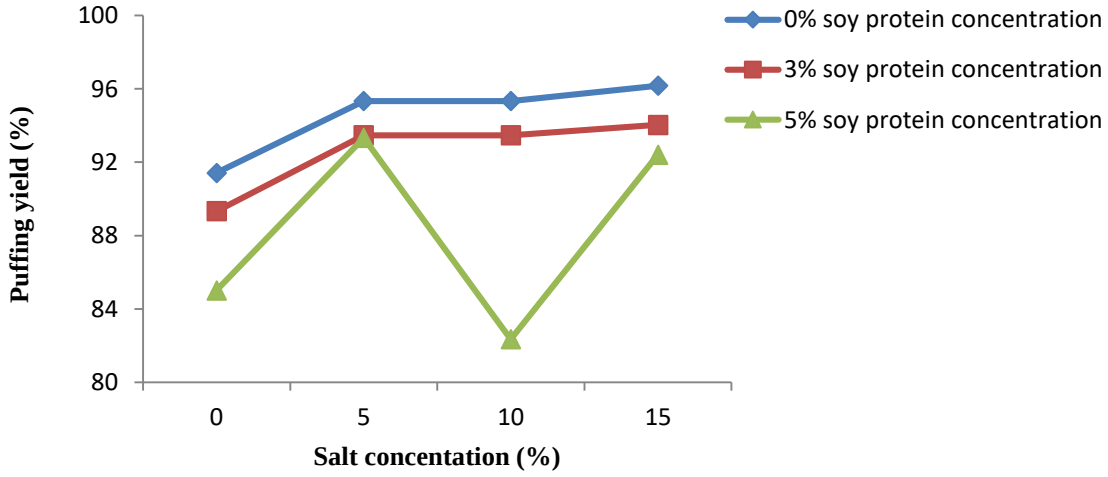


At 18 seconds roasting time

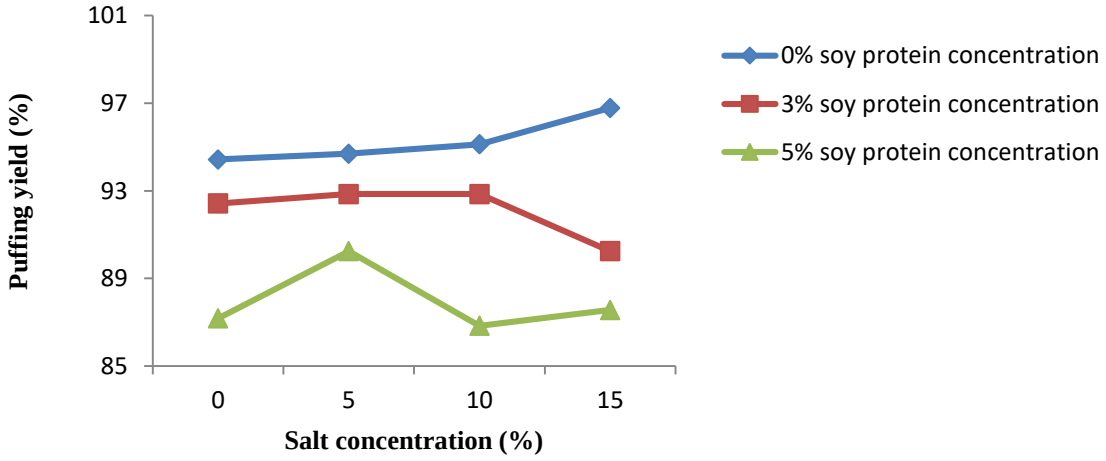
Fig. 1 (a) Effect of salt concentration on puffing yield of rice for 10:1 sand rice ratio



At 8 seconds roasting time

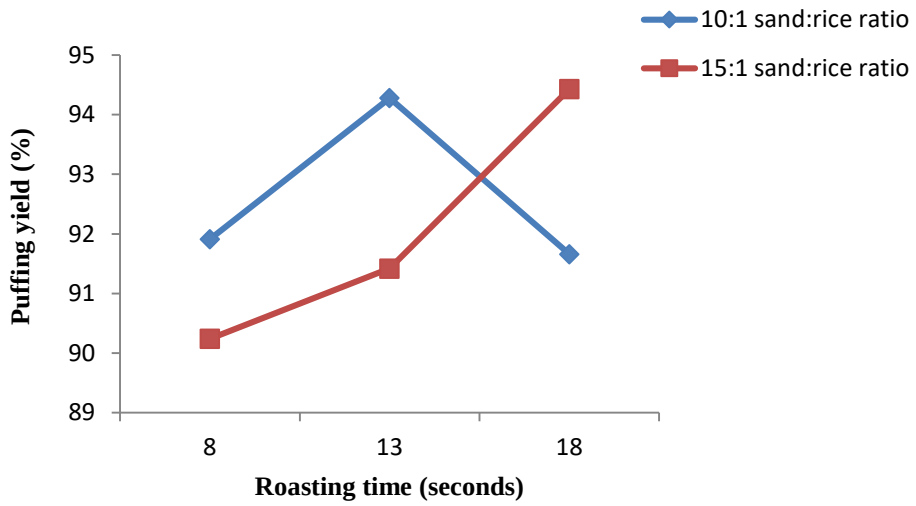


At 13 seconds roasting time

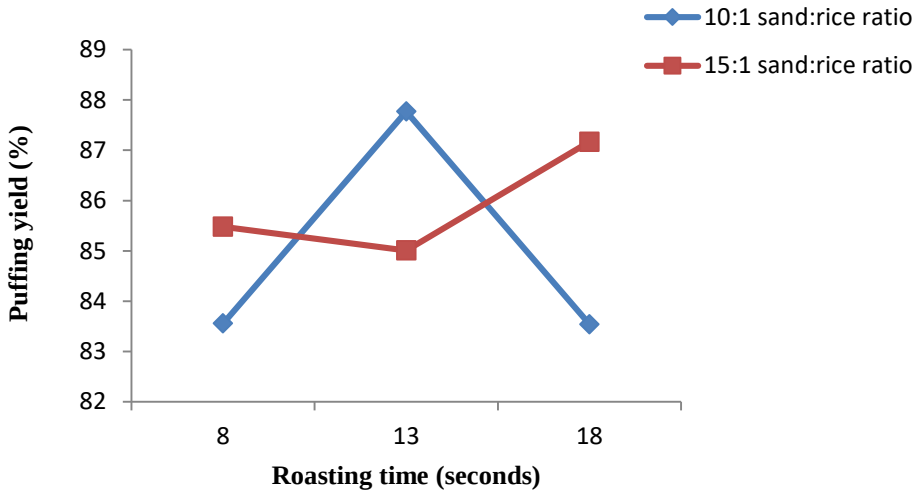


At 18 seconds roasting time

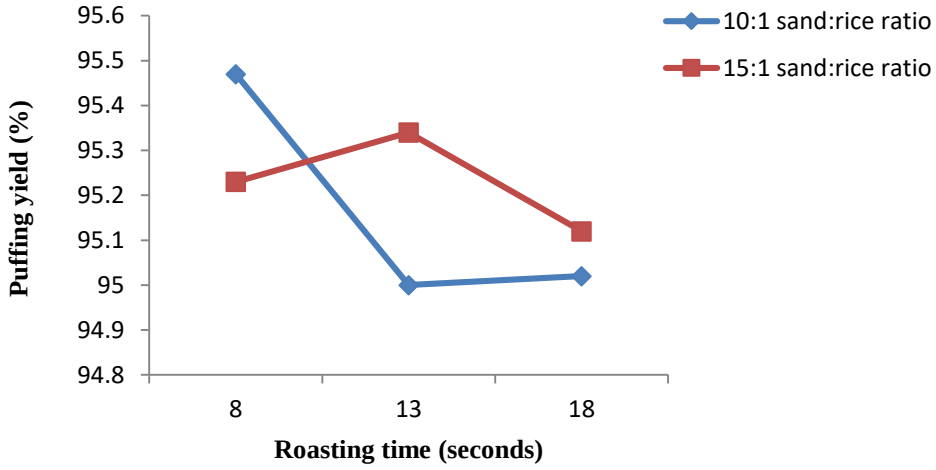
Fig. 1 (b) Effect of salt concentration on puffing yield of rice for 15:1 sand rice ratio



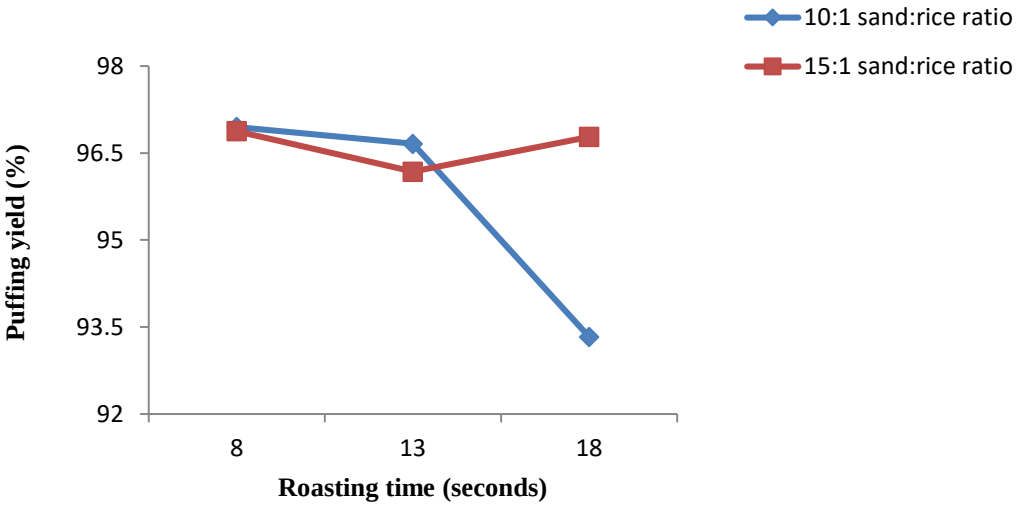
At 0% salt concentration



At 5% salt concentration

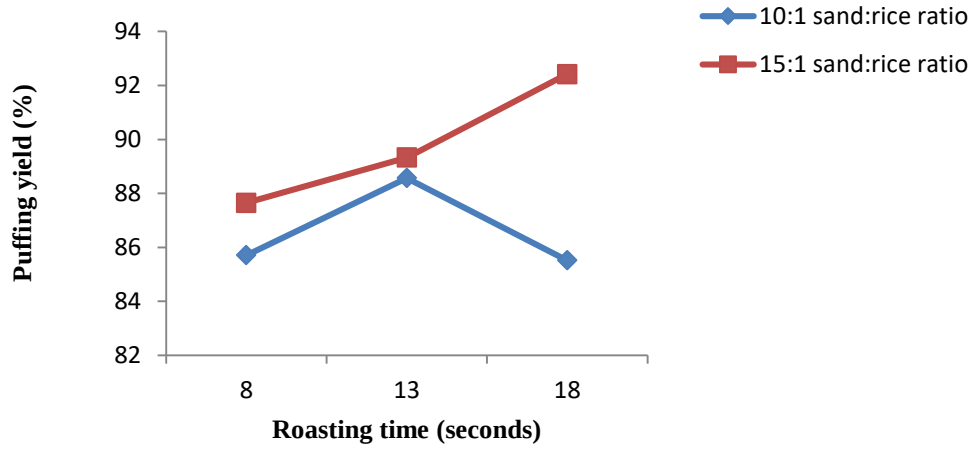


At 10% salt concentration

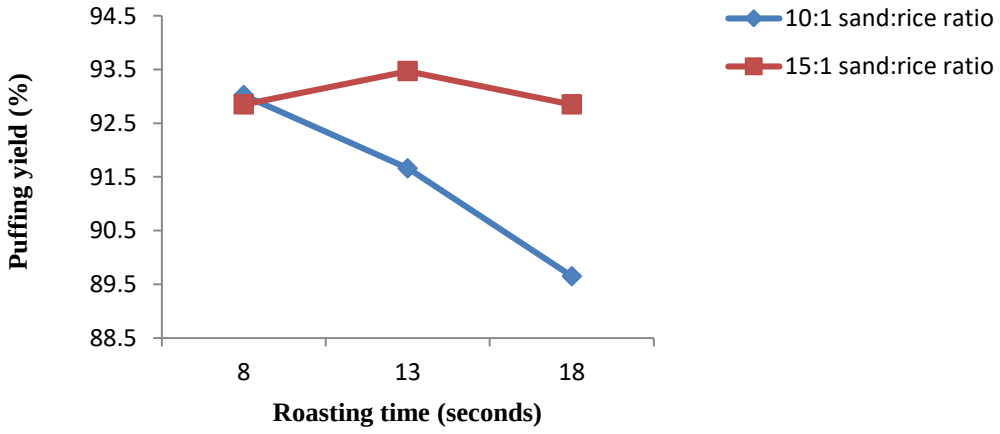


At 15% salt concentration

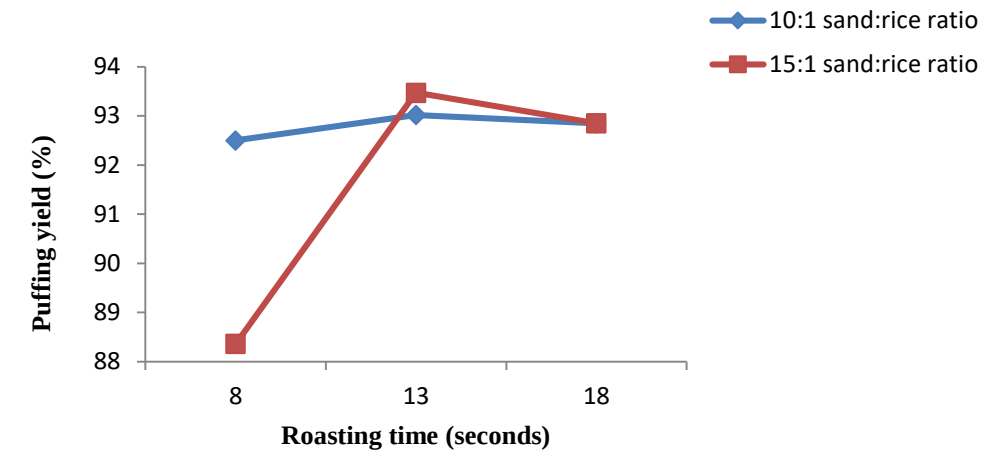
Fig. 2(a) Effect of roasting time on puffing yield of rice for 0% soy protein concentration



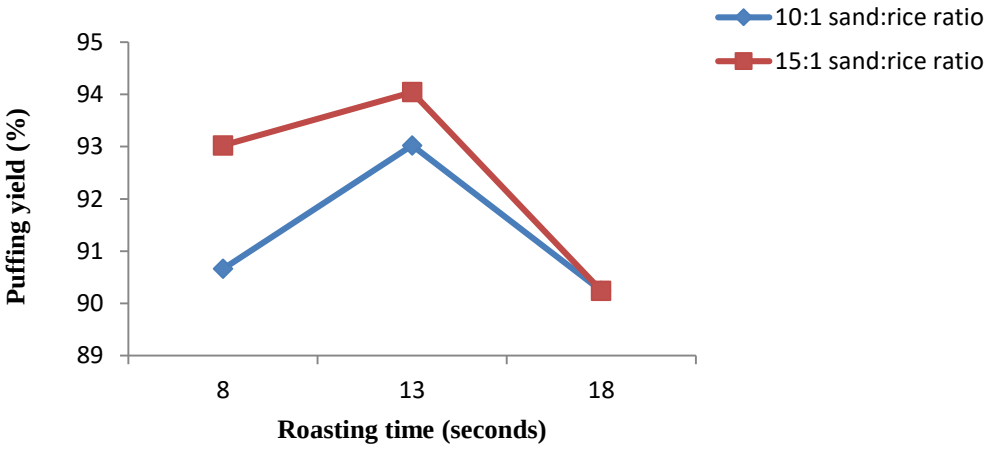
At 0% salt concentration



At 5% salt concentration

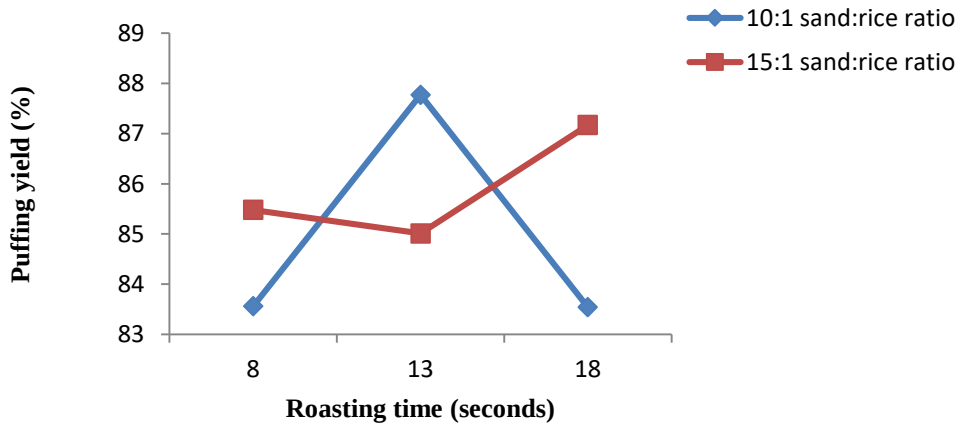


At 10% salt concentration

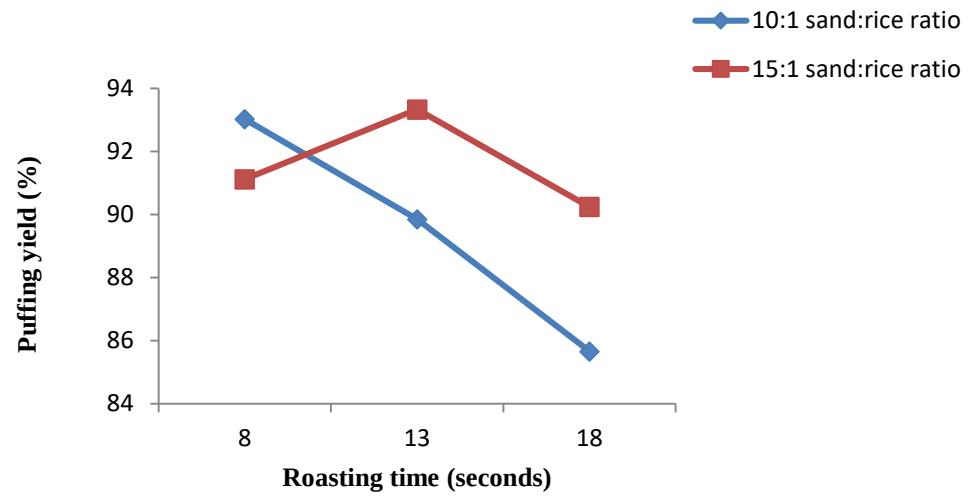


At 15% salt concentration

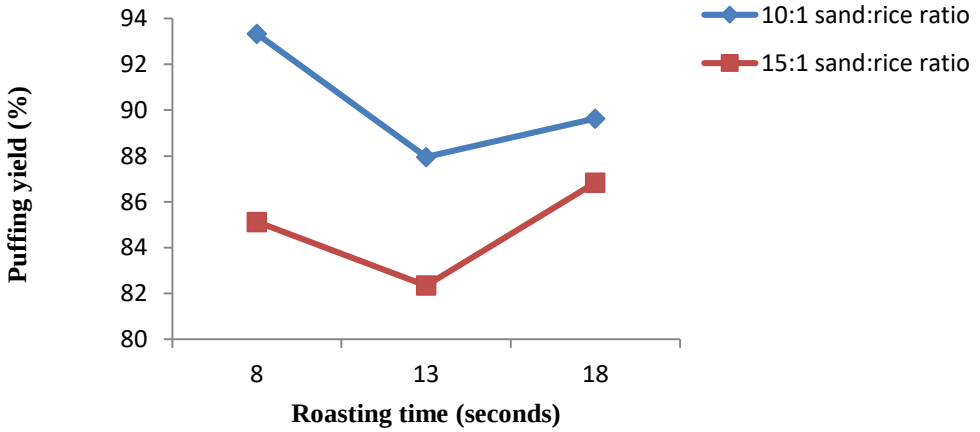
Fig. 2(b) Effect of roasting time on puffing yield of rice for 3% soy protein concentration



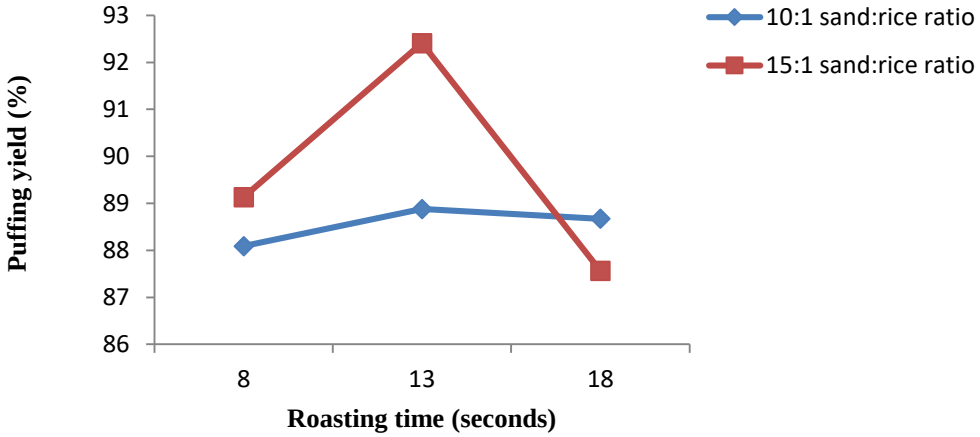
At 0% salt concentration



At 5% salt concentration

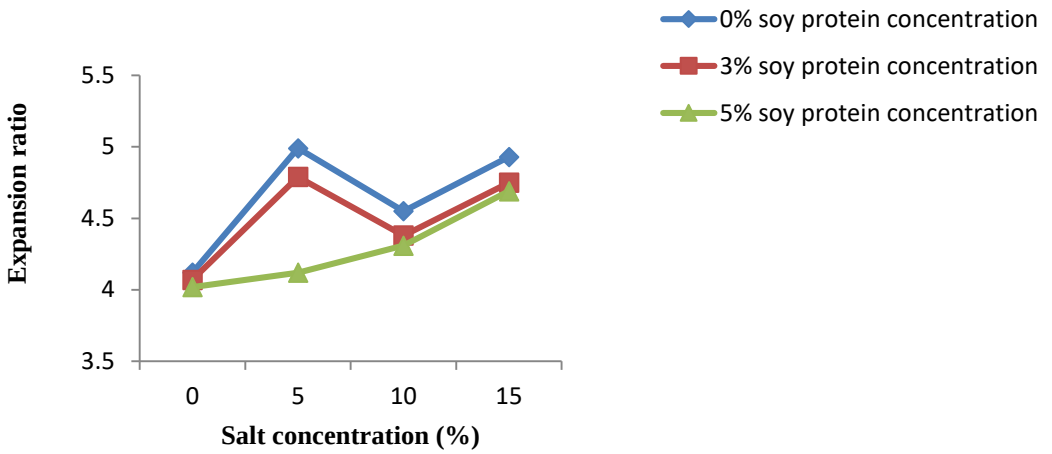


At 10% salt concentration

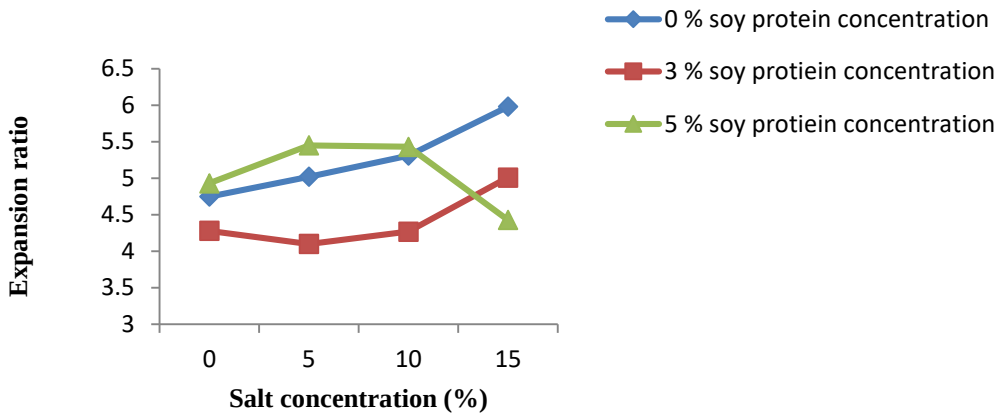


At 15% salt concentration

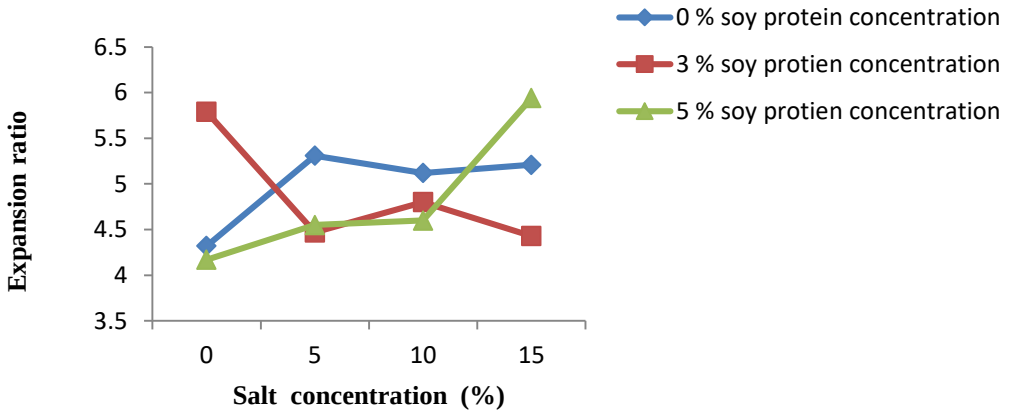
Fig. 2(c) Effect of roasting time on puffing yield of rice for 5% soy protein concentration



At 8 seconds roasting time

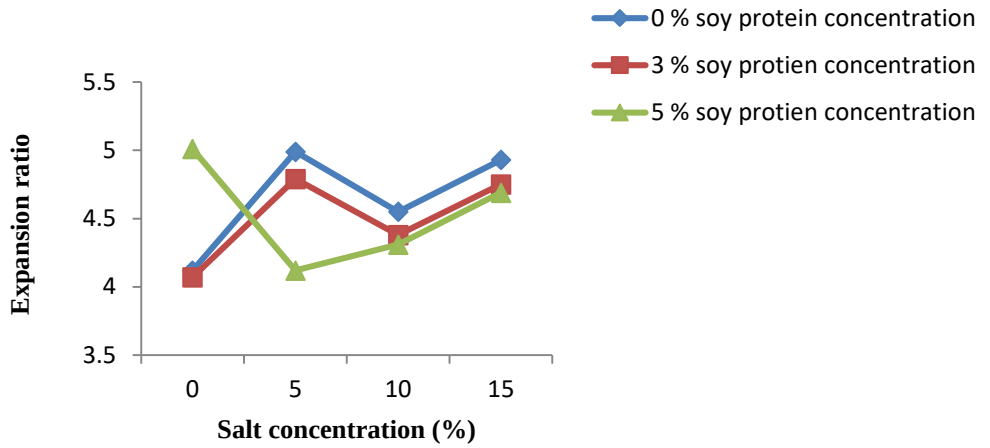


At 13 seconds roasting time

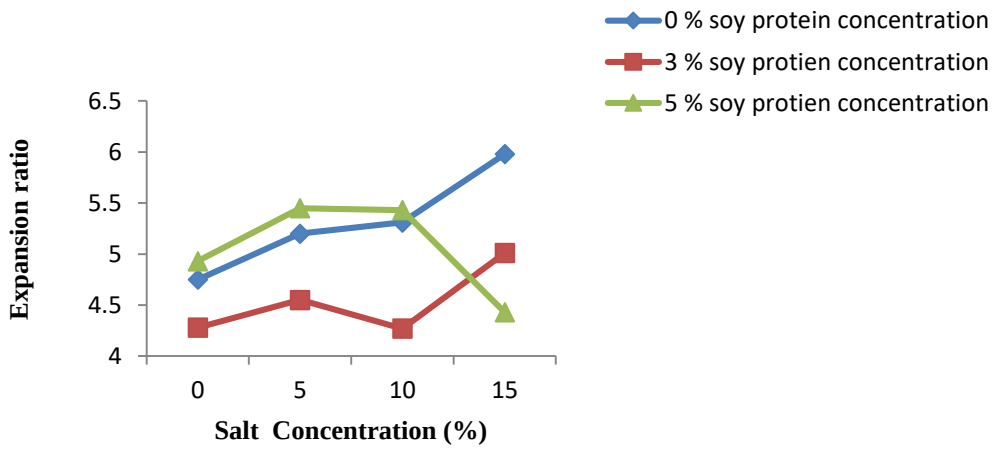


At 18 seconds roasting time

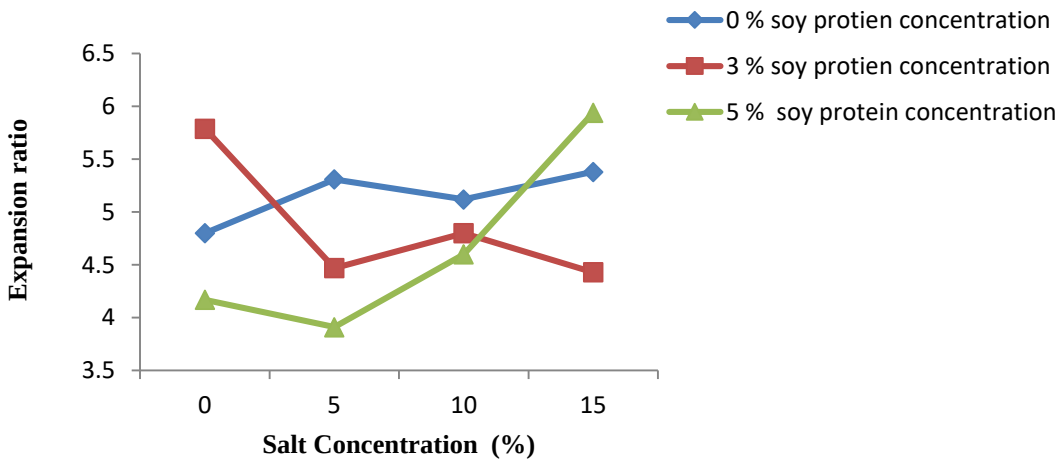
Fig. 3 (a) Effect of salt concentration on expansion ratio of rice for 10:1 sand rice ratio



At 8 seconds roasting time

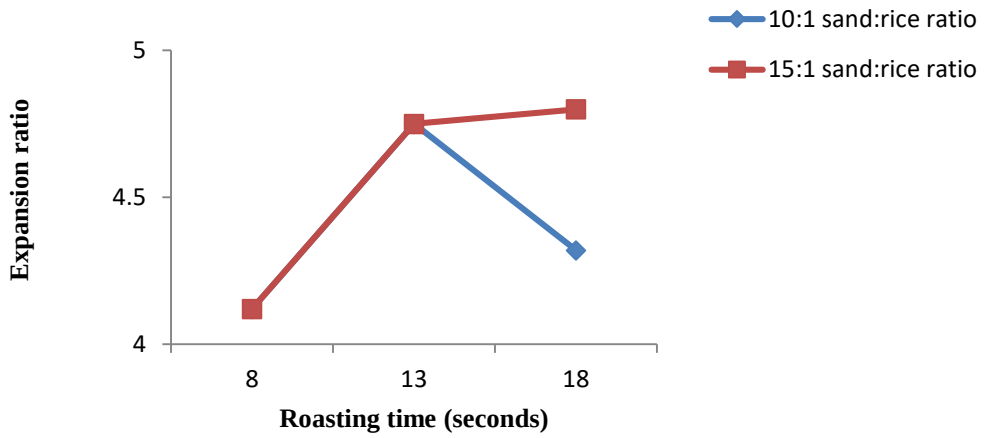


At 13 seconds roasting time

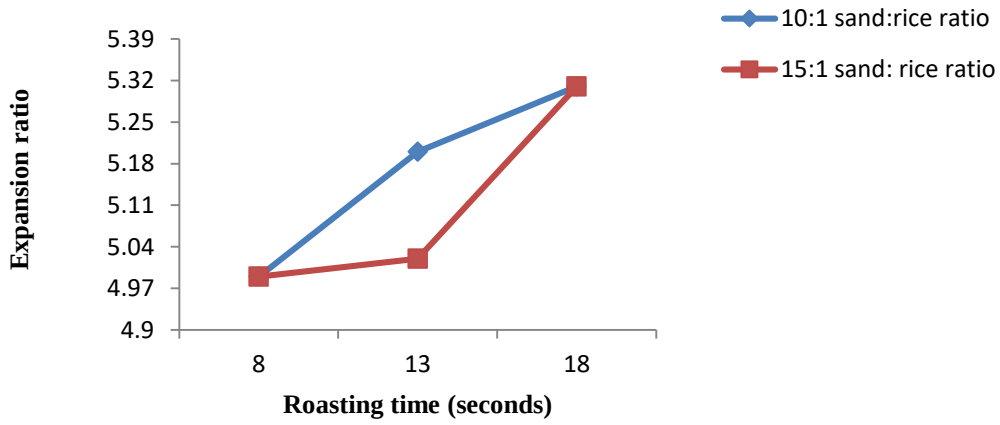


At 18 seconds roasting time

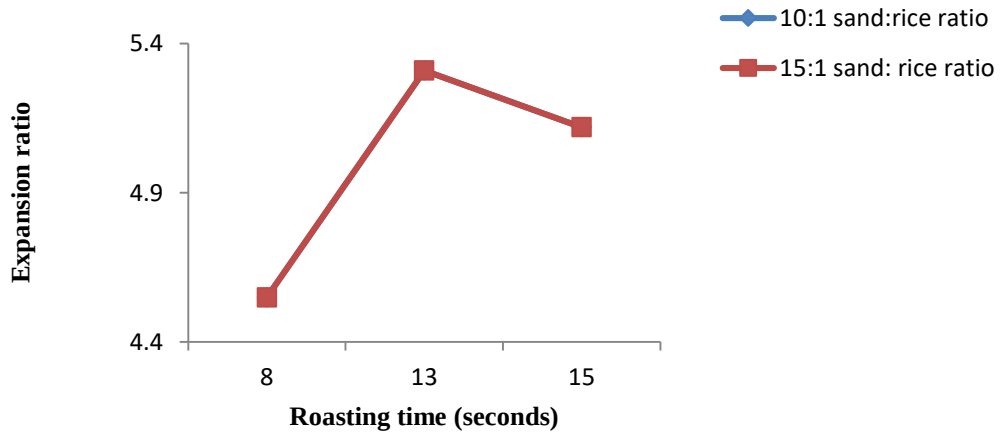
Fig. 3 (b) Effect of salt concentration on expansion ratio of rice for 15:1 sand rice ratio



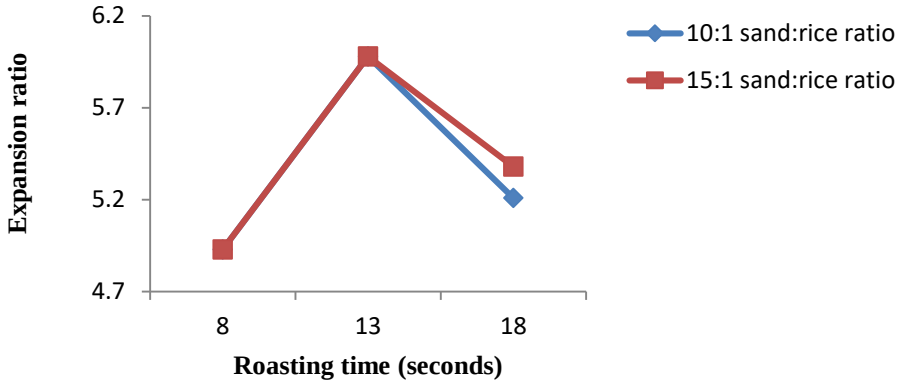
At 0% salt concentration



At 5% salt concentration

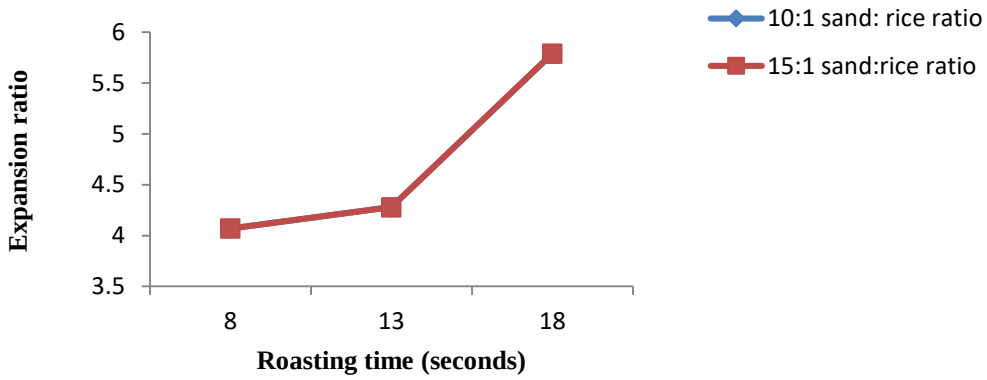


At 10% salt concentration

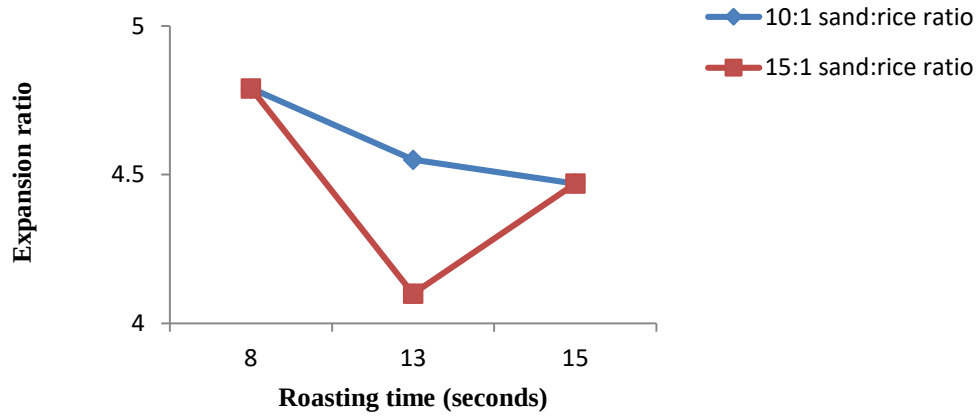


At 15% salt concentration

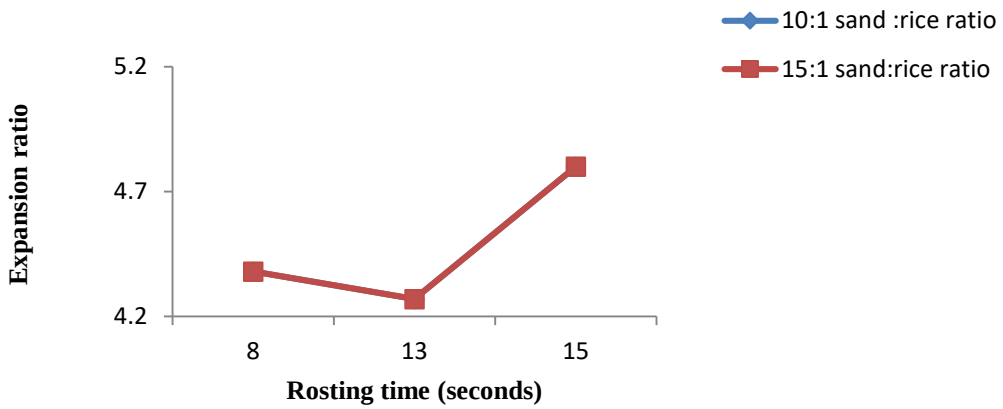
Fig.4(a) Effect of roasting time on expansion ratio of rice for 0% soy protein concentration



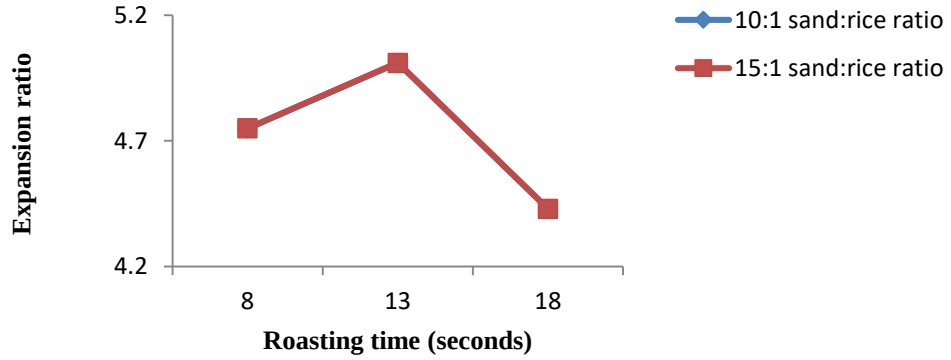
At 0% salt concentration



At 5% salt concentration

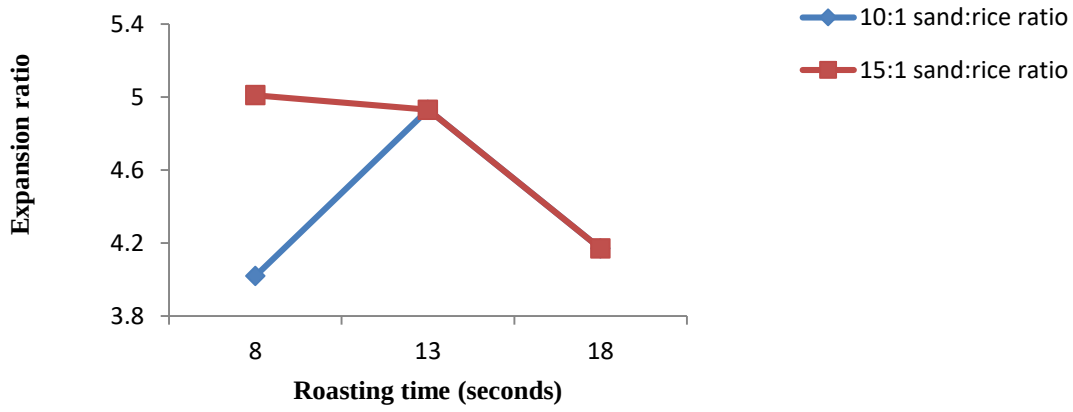


At 10% salt concentration

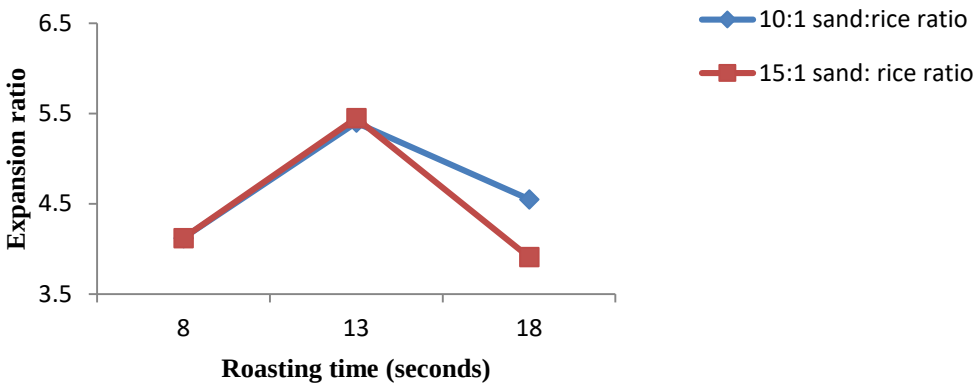


At 15% salt concentration

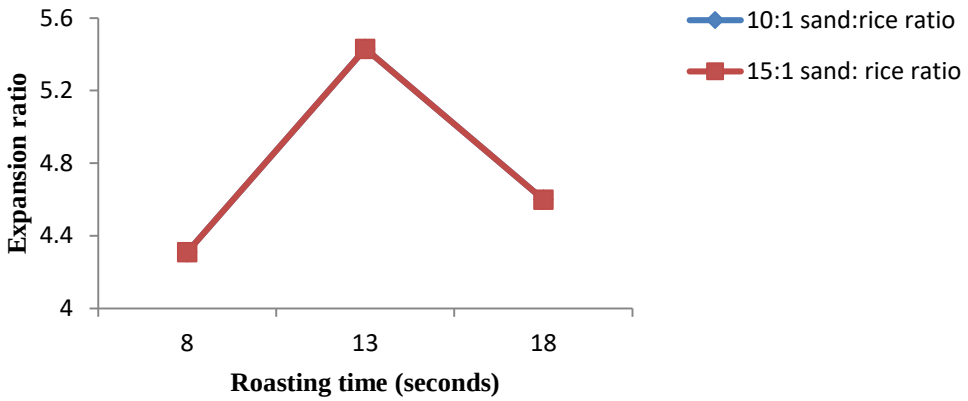
Fig.4(b) Effect of roasting time on expansion ratio of rice for 3% soy protein concentration



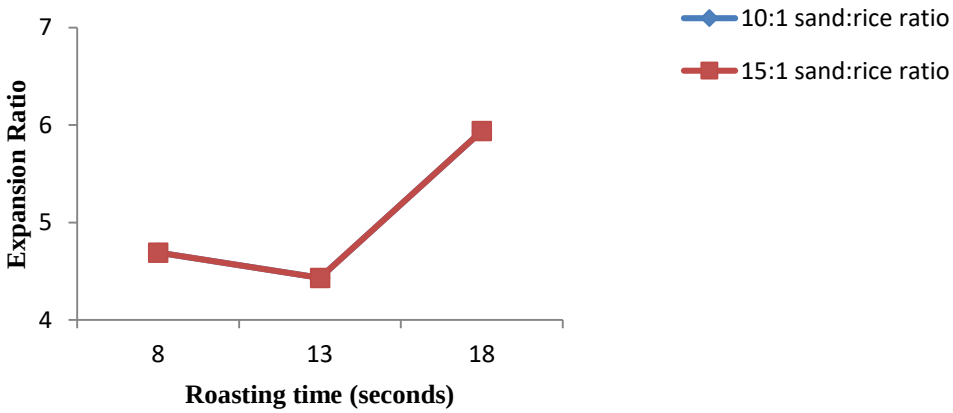
At 0% salt concentration



At 5% salt concentration



At 10% salt concentration



At 15% salt concentration

Fig.4(c) Effect of roasting time on expansion ratio of rice for 3% soy protein concentration

Table 1. Statistical analysis (correlation)

	Sand rice ratio	Roasting time	Salt concentration	Soy Protein concentration	Puffing yield	Expansion ratio
Sand rice ratio	1					
Roasting time	- 1.523E-16	1				
Salt concentration	- 1.960E-16	0	1			
Soy Protein concentration	- 7.924E-17	0	0	1		
Puffing yield	0.040	- 0.039	0.320	- 0.721	1	
Expansion ratio	- 0.002	0.273	0.317	- 0.216	0.232	1

The results of statistical analysis made with the help of t-test for paired two samples and correlation are given in Table 1. From that it can be seen that, a low degree of positive correlation exists between sand rice ratio and puffing yield, whereas a low degree of negative correlation exists between sand rice ratio and expansion ratio. A low degree of negative correlation exits between roasting time and puffing yield, whereas a low degree of positive correlation exists between roasting time and expansion ratio. A low degree of positive correlation exits between salt concentration and puffing yield, whereas a low degree of positive correlation exists between salt concentration and volume expansion ratio. A high degree of negative correlation exits between soy protein concentration and puffing yield, whereas a low degree of negative correlation exists between soy protein concentration and volume expansion ratio.

IV. CONCLUSIONS

1. Sand rice ratio and roasting time interferes in improving the puffing yield of rice.
2. The coating with the soy protein didn't help in improving the puffing quality of rice in terms of expansion ratio and puffing yield.
3. The highest expansion ratio and nearly highest puffing yield of rice can be obtained at 15% salt concentration, 0% soy protein concentration, 15:1 sand rice ratio and 13 seconds of roasting time.

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