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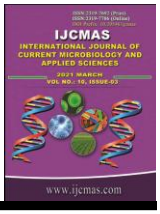

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Finger Millet Pearling Efficiency as Affected by Hydrothermal Treatment

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ABSTRACT

Keywords

Finger millet, Hydrothermal treatment, Pearling efficiency, Optimization

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Finger millet is an important millet owing to its excellent storage properties and the nutritive value. So dehulling or pearling of finger millet is necessary to remove its outer layer to improve its flour quality. Pearling of this millet is quite difficult as its seed coat is bound tightly to the endosperm of the grain. Hydrothermal treatment can help to loosen the bonding and enhancing the pearling efficiency. Hence, studies were undertaken to see the effect of hydrothermal treatment parameters on pearling efficiency and also its optimization. Responses studied were the pearling efficiency and porosity. Optimum conditions estimated for steeping time, steaming time and drying (m.c.) were observed to be 8 h, 30 min and 10% respectively. The studies indicated that hydrothermal treatment could increase the pearling efficiency up to 87.8%.

Introduction

Millets, the staple food in an Indian diet, supply carbohydrates that constitute major calorie requirement even in diabetic diet. Small millets as a group include several coarse cereals namely finger millet, foxtail millet, kodo millet, porso millet and barnyard millet grown throughout the length and breadth of the country. Among them finger millet (*Eleusine coracana*) is common. In India, it is commonly known as ragi, mandua and nagli and is widely grown in Karnataka, Tamil Nadu, Andhra Pradesh, and Maharashtra and in the hilly regions of Uttar Pradesh, Uttarakhand and Himanchal Pradesh. Finger millet is a crucial for the diets of pregnant and lactating mothers, and children as well for the economy of marginal farmers. Its grains are rich in protein, vitamins, minerals, fiber content and energy as compared to other cereals (Vadivoo et al., 1998).

In India, finger millet ranks 3rd after sorghum and pearl millet. The area under finger is around 2 million per hectare which is 7.5 % of the total area under millet cultivation but its contribution (2.5 to 2.6 million tonnes) to the total millet production is around 13% (Seetharam, 1997). Finger millet has excellent storage properties and the nutritive value, which is higher than that of rice and equal to that of wheat. Ragi is also good for diabetics because of slow release of sugars in the body. Fibre content in Ragi is also helps person to tackle constipation, high blood cholesterol and intestinal cancer. It is also good for pregnant women, and is considered as nutritive food for adult of different age (Grewal, 2005). The millet contains 6-8% protein, 1- 17% fats, 65-75% starch, 18-20% dietary fibre and 2-2.5 % minerals.

The millet kernels contain soft and fragile endosperm covered by rigidly attached seed coat and gets pulverized along with the seed coat whenever efforts were made for its dehulling similar to other cereals and millets. In view of this, the millet has never been dehulled and it is invariably pulverized along with the seed coat and the whole meal is used for food preparation. The seed coat is normally of brick red to dark coloured and contains poly-phenols and pigment which polymerize and turns dark and unattractive on cooking. Besides, the seed coat imparts characteristics odour and fibrous texture to its foods which affect their sensory qualities (Ushakumari, 2009). Due to its health benefits, finger millet is gaining interest of consumers. In recent years the consumption of finger millet along with other millets has been increased particularly in the urban sector due to awareness about the inherent nutritional and medicinal properties of millets (Patel and Verma, 2015). The finger millet grain is essentially covered with an outer thin pericarp known as glume which needs to be removed from the kernel prior to further processing as it is non-edible tissue (Patel and Verma, 2015). As millet grains are hard seed coat grains, their processing starts with the task of removal of husk (Jaybhaye *et al.*, 2014). Hence, the research work was necessary to decorticate or dehulling the millet, which could be available to consumers like other grains. Hydrothernmal treatment or parboiling of finger millet involves soaking, steaming and drying of milet. Parboiling is one of the efficient methods to reduce the breakage during milling of paddy (Bhattacharya. 1969). The aim of present study was to optimize the hydrothermal parameters on pearling efficiency of finger millet and investigate the effect of hydrothermal parameters on water uptake and porosity of finger millet grain.

Materials and Methods

Procurement of Raw material

The study was conducted on finger millet which was procured from local market, Haldwani. The initial moisture content of finger millet was found to be 13% (d.b.). Grains were cleaned to remove foreign particles and were separated using a cleaner. Cleaned samples were kept in air tight desiccators to avoid moisture exchange and insect infestation from the surroundings.

Preparation of Hydrothermally processed finger millet

The millet was steeped in excess distilled water under ambient temperature for 8, 10, 12 h to facilitate the grains to attain their equilibrium moisture content (Shobana and Malleshi, 2007; Usha and Malleshi, 2011).The steeped millet after removing excess water steamed in autoclave for 25, 30 and 35 minutes at atmospheric pressure.The steamed millet was spread in the trays and exposed to the 65°C temperature in hot air

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oven until the moisture content dropped to 10, 13 and 16%. The dried millet was further used for checking pearling efficiency and porosity.

Initial moisture content

Hot air oven method (IS 4333-II, 1967) was employed for direct determination of moisture content. Appropriate quantity of grain sample was grinded in a hammer mill to yield a sample of ground material for drying having a size passing through 1 mm Sieve. The sample weight (10 g) of ground grain was taken and recorded as initial weight of sample (M_1) and transferred to previously dried dish.

The Sample was placed in the oven, maintained at 130 ^{0} C and left for 2 h. After this period, dish was taken out of the oven, covered with its lid and put into desiccators containing activated silica gel. When the dish cooled down to room temperature, it was weighted and weight recorded as M_2. Moisture content of the sample was calculated using the equation.

$$M.C. = (M1 - M2)/M1 \times 100$$

Porosity

Measuring cylinder was filled with tolune and then measured amount of grain was poured into the measuring cylinder. The rise in volume of tolune was measured. Weight of grain poured per unit rise of tolune was true density. Bulk density of grain was determined by filling the measuring cylinder of 500 ml. with grain was obtained by subtracting the weight of empty cylinder from the weight of cylinder when filled with grain. The ratio of weight of contents to the volume gave the bulk density of grains. Bulk density of grains equal to net weight of grain per unit volume of measuring cylinder.

The porosity of the grain sample was computed from the bulk density and true density values using the following expression (Mohsenin, 1996).

$$€ = (1- \rho_b / \rho_t) \times 100$$

Pearling efficiency

Pearling efficiency was computed by following equation (Sahay K.M., 2001);

$$E_{pearling} = (1- n_2 / n_1) \times 100$$

Where,
$E_{pearling}$= pearling efficiency in %
n_1= amount of grain before hulling, g
n_2= amount of hulled grain after milling, g

Experimental design

Steeping time, steaming time and drying (m.c.) were selected as independent parameters. The levels for these parameters were selected on review of literature and preliminary trials.

The experiments were planned using Response Surface Methodology with Box-Behnken Design. The adequacy of the model was tested using coefficient of determination (R^2) and F-value. The model was used to interpret the effects of variables, namely steeping period, steaming period, and drying (%) on responses viz. Pearling efficiency, water uptake, porosity. If model was found adequate, the best fit equation were developed for showing the effect of independent variables on those responses and to select the range of variables for an acceptable product. Optimization of variable process conditions was done using software Design-Expert 9.0.

Results and Discussion

The experiments results of effects of processing variables on pearling efficiency, water uptake and porosity are shown in Table 2.

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Effect of steeping time, steaming time and drying moisture content on pearling efficiency

Pearling efficiency of hydrothermal treated sample ranged from 82 to 87.8% over entire experimental conditions. Maximum pearling efficiency (87.8%) was observed for hydrothermal treatment condition of steeping time 8 hours, steaming time 35 min and drying (moisture content) percent 13%. Milling characteristics of the hydrothermally treated millet were influenced by the moisture content of the grain. The improvement in pearling efficiency could be due to the hardness imparted to kernel because of gelatinization of starch. That took during the hydrothermal treatment of grain. It was observed that due to swelling of starch the cracks, incomplete grain filling, and chalkiness were completely healed. Such phenomenon improves the milling qualities of finger millet. These results are in accordance with (Kushwaha *et al.,* 2018) (Table 1).

The significance of independent variable viz. Steeping, steaming and drying on milling was tested using ANOVA. There is a significant effect of hydrothermal treatment on pearling efficiency. The linear and interactive terms were found to be significant at 1% level of significance, whereas quadratic term was significant at 10 % level of significance (Table 2). Full second order model equation fitted to the pearling efficiency and various experimental conditions using multiple regression analysis. The coefficient of determination (R^2) for the regression model for this parameter was 83.24 % which implies that the model could account for 83.24 % data. Model was significant at 5 % level of significance ($P<0.05$) as it is shown in (Table 2). Therefore, second order model was fit in describing pearling efficiency as:

$$Y = 85.14- 1.49\ X_1 + 0.0.28\ X_2 -1.30\ X_3 +0.27\ X_1\ X_2 + 0.015\ X_1\ X_3 -0.29\ X_2X_3 - 0.093X_1^2 +0.13\ X_2^2 + 0.82\ X_3^2$$

Effect of steeping time, steaming time, and drying percent on porosity

Porosity of hydrothermal treated sample ranged from 35.5 to 43.7% over entire experimental conditions. Maximum porosity (43.7 %) was observed for hydrothermal treatment condition of steeping time 8 h, steaming time 30 min and drying (moisture content) percent 10 %. Minimum porosity (35.5 %) was observed for hydrothermal treatment condition of steeping time 10 h, steaming time 30 min and drying (moisture content) percent 13 %. As shown in figure 1 that porosity was decreasing with increasing in drying (m.c).

Table.1 Independent variables for hydrothermal treatment of finger millet

Variables	**Range**	**Levels**
Independent		
Steeping	3	8,10,12 h
Steaming	3	25,30,35 minutes
Drying(m.c.)	3	10,13,16%

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Table.2 Experimental data for effect of hydrothermal treatment on finger millet

		Variables		**Responses**	
Exp Run	**Steeping (h)**	**Steaming (min)**	**Drying (%)**	**Milling efficiency (%)**	**Porosity (%)**
1	10	30	13	86.1	36.5*
2	10	30	13	86	35.5*
3	10	25	16	86.6	39.5
4	8	30	16	85.7	40.1
5	12	35	13	84.1	40.4
6	8	35	13	87.8**	40.3
7	10	25	10	87.6	43.5
8	10	35	10	87.74	41.6
9	8	30	10	87.76	43.7**
10	10	30	13	85.2	36.5*
11	8	25	13	86.8	40.4
12	12	30	10	86	38.1
13	12	30	16	84	40.1
14	10	35	16	84	40.9
15	10	30	13	85.4	37.5*
16	10	30	13	84.3	34.4*
17	12	25	13	82*	39.1

*minimum value, **maximum value

Table.3 ANOVA for pearling efficiency

Source	**DF**	**SS**	**MS**	**F-Value**
Model	9	35.60	3.96	3.73**
Linear	3	32.03	32.03	30.22***
Quadratic	3	2.514	2.514	2.759*
Interactive	3	21.08	21.08	19.596***
Error	7	7.42	1.01	
TOTAL	16	43.02		

***, **,* Significant at 1, 5 and 10% level of significance respectively.

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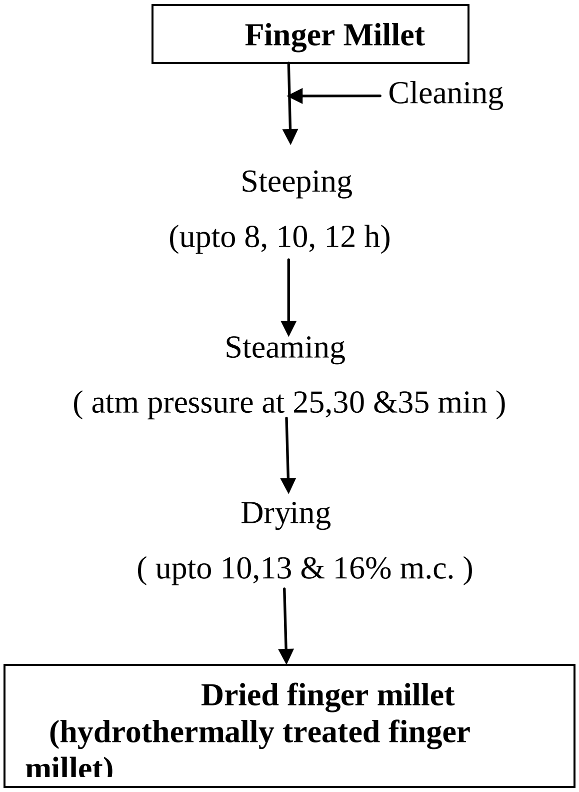
Table.4 ANOVA for porosity

Source	**DF**	**SS**	**MS**	**F-Value**
Model	9	120.25	13.6	11.14***
Linear	3	10.80	10.80	9.281***
Quadratic	3	88.62	88.62	73.89***
Interactive	3	11.05	11.05	9.22***
Error	7	8.39	1.20	
Total	16	128.64		

***, **,* Significant at 1, 5 and 10% level of significance respectively.

Fig.1 Flow chart for the preparation of hydrothermally treated finger millet



The decrease in porosity may be due to the sealing of the air vents and voids present in the endosperm and also between the endosperm and seed coat. Normally, cereals have compact endosperm but the compactness depends upon the ratio of the hard to soft endosperm (Usha *et al.*, 2011). In case of hydrothermally treated millet the voids were filled up by expanded or gelatinized starchy material, drying condition of the gelatinized material, induced porosity to some extent. As expected, higher the porosity of the grain, lesser will be the hardness and such grain become highly susceptible to breakage during milling. It can be shown from (Table 3 and 4), that model was significant ($p<0.01$).

Full second order model, Equation was fitted to the porosity and various experimental condition using multiple regression analysis. The coefficient of determination (R^2) for the regression model for this parameter was 96.66 % which implies that the model could account for 96.66% data. Model was highly significant at 1 % level of significance with F value of 22.50. Therefore, second order model was found to be adequate in describing porosity as:

$$Y = 35.46 - 0.85 X_1 + 0.088 X_2 -.0.79 X_3 +0.35 X_1 X_2 + 1.40 X_1 X_3 + 0.82 X_2X_3 + 1.86X_1^2 + 2.73 X_2^2 + 3.81 X_3^2$$

In conclusions, this study showed that that steeping time, steaming time and drying affects the hardness of finger millet, hence influenced its pearling efficiency. During hydrothermal treatment moisture content of finger millet increased from 13 to 34.7%. Steeping time and drying at optimum moisture content significantly affected the pearling efficiency of hydrothermally treated finger millet. Hence, it could be recommended that hydrothermal treatment of finger millet with steeping period 8h, steaming time 30min and drying (m. c.) upto 10% could be done.

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