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Effect of Roasting on Texture, Colour and Acceptability of Pearl Millet (*Pennisetum glaucum*) for Making *Sattu*

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Abstract: In order to study the effect of roasting on some important physical properties viz. geometric mean diameter, colour, textural properties (hardness, toughness, average rupture force) and sensory attributes of pearl millet for making *sattu*, it was roasted using three time (45, 60 and 75 sec) and temperature (160°, 180° and 200°C) combinations. In general, geometric mean diameter, hardness, toughness and average rupture force increased with increase in roasting temperature. Roasting brought a significant change in colour of pearl millet grain and its roasted flour samples. h^0 and C^* of flour increased with increase in time at the same roasting temperature except at 180°C for 45 sec time. The lower hardness of pearl millet roasted at 180 °C for 60 sec as compared to higher temperature and highest mean sensory scores for colour and appearance (6.28), roasted odour (6.58) and overall quality (6.58) for pearl millet flour prepared from the grain roasted at 180 °C for 60 sec, make this temperature and time combination best for roasting of it for making *sattu*. The 10% level of pearl millet flour with bengal gram (90%) was found the most accepted *sattu* formulation with mean sensory score (7.01). Regression equations developed for hardness, toughness, average rupture force, hue and chroma showed that temperature had significant effect on these parameters as compared to roasting time.

Key words: Colour, hardness, pearl millet (*Pennisetum glaucum*), roasting, *sattu* and textural properties

INTRODUCTION

Sattu is one of most popular traditional food of northern India. It is preferred item in the breakfast in some of the State particularly in Bihar and Uttar Pradesh. *Sattu*, in drink form, is considered as one of the best food in breakfast during the summer season due to its cool effect as believed by the population and good digestibility. *Sattu* is basically a product, prepared from roasted cereals, or legumes or, combination of cereal and legumes with added flavouring agents (Mridula *et al*., 2004). Roasting which is a simple and most commonly practiced household and village level technology, pre-cooks the ingredients used in food grains and oilseed based mixes and increased shelf life and acceptability of the products (Gopaldas *et al*., 1975). Roasting improves the flavour, texture and nutritive value of the grains (Siegal and Fawcett, 1976) and also eliminates most of anti-nutritional or toxic factors present in legumes, either partially or wholly (Liener, 1973).

Amongst various legumes, bengal gram is the preferred one for making *sattu*, particularly in Bihar and eastern part of Uttar Pradesh (Mridula *et al*., 2004) but no legume or cereal alone can provide balanced amount of nutrients. However, mixing of legume with cereal can improve the digestibility of the product. Supplementing various types of millets with chickpea has shown good improvement in

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the protein efficiency ratio (Casey and Lorenz, 1977). Addition of cereal and millets to *sattu* to the acceptable limit will not only improve the protein quality but also reduce the cost. Earlier *sattu* was considered as poor man's food but nowadays the popularity of bengal gram *sattu* amongst the diabetics is increasing day by day due to its low glycemic index. As the glycemic response of pearl millet (Shukla *et al*., 1991) is also low, pearl millet and bengal gram based *sattu* can also get popularity amongst the masses at lower cost than pure bengal gram based *sattu*. Studies (Vimala *et al*., 1990; Dahiya and Kapoor, 1995) have been carried out to develop weaning mixes based on pearl millet and Bengal gram but information on optimum roasting temperature and time and their effect on quality attributes of pearl millet and its flour is not cited in the literature. As roasting is one of the important unit operation in *sattu* making, that effect the textural, colour properties and flavour and aroma of the product i.e., *sattu*, it is important to know the effect of roasting conditions on quality of pearl millet for making *sattu*. Therefore, the present study was undertaken with the objective to study the effect of roasting temperature and time combination on quality attributes of pearl millet for making *sattu* in combination with bengal gram.

MATERIALS AND METHODS

Pearl millet (variety FBC-16), which is commonly known as bajra in India, was used for the study. In order to see the effect of roasting on quality of pearl millet for making *sattu* with bengal gram, it was incorporated in *sattu* using the method (Fig. 1). Raw pearl millet with geometric mean diameter (GMD) -2.28 mm and moisture content of 9.58% (w.b.) was dipped in water in a wire mesh basket, twice for washing followed by tempering for 2 h. The moisture content of the tempered samples was in the range of 15.85-16.02% (w.b.) ($p>0.05$). The washed and tempered samples were roasted in hot sand bath using sand grain ratio 8:1, at three different temperatures (160°, 180°, 200° C) and time (45, 60, 75 sec) combinations. The roasted samples were tempered for 4 hours, packed in LDPE bags (62.5 μ) and kept in desiccator for determination of moisture, colour and textural properties. The roasted samples were subjected to CIAE (Central Institute of Agricultural Engineering, Bhopal, India) developed cleaner cum grader to remove the sand particles if any before grinding for making flour. The ground samples were evaluated for colour and different sensory attributes. Bengal gram and pearl millet based *sattu* was prepared from pearl millet flour, prepared from pearl millet roasted at 180 °C for

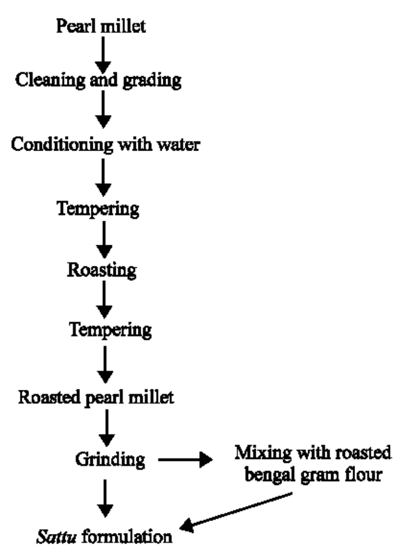

Fig. 1: Method for preparation of pearl millet incorporated *sattu*

60 sec. Different formulations with roasted Bengal gram were prepared using pearl millet at 10, 20, 30 and 40% level. Roasted Bengal gram was prepared as per the standardized process (Mridula *et al*., 2004). Statistica 7.1 was used for statistical analysis of the results of the study.

Geometric Mean Diameter

Geometric mean diameter is the geometric mean of the spatial dimensions of raw and roasted grain, were measured using Vernier Caliper with least count of 0.02 mm (Mohsenin, 1970). The spatial dimensions namely length (L, longest dimension), breadth (B, second longest dimension), thickness (T, third longest dimension) were measured for 10 representative seeds under each roasting condition. Geometric mean of the spatial dimensions was calculated as: Equivalent diameter = $(L \times B \times T)^{1/3}$

Textural Properties

The textural properties of raw and roasted pearl millet grain such as hardness, toughness and average rupture force were measured using Texture Analyzer (TA) TA-HD*i*. Stable Micro systems (U.K.). The TA setting were: mode- measure force in compression, option-return to start, pre test speed- 3 mm/s, test speed - 1 mm sec^{-1}, post test speed - 10 mm sec^{-1}, distance- 1 mm, trigger force - 20 g, stainless steel cylinder probe -5 mm diameter (P/5) and 50 kg load cell. Textural properties were measured for 10 representative seeds of each replication under each roasting condition. During the test, the graph was drawn between force and distance as the result of the force resisted by the grain sample against the probe of texture analyzer with the help of software (Texture Expert Exeed ™, MS Windows). The maximum force experienced by the probe is considered as hardness and the area under this maximum force on the graph is considered as toughness of the grain. The average force experienced by the probe throughout the test is considered as average rupture force of the grain.

Colour Determination

Colour (L*, a*, b* values) of the samples was determined by using Handy Colorimeter; Model No. NR-3000, NIPPON Denshoku, Japan. L* is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates (a*) and (b*) represents redness (+ a) to greenness (- a) and yellowness (+ b) to blueness (-b), respectively. h^0 (hue angle) is the attribute of colour by means of which the colour is perceived. C* (chroma) is the attribute of colour used to indicate the degree of departure of the colour from gray of the same lightness. h^0 and C* are computed by using the following formula.

$$h^0 = \tan^{-1}(b^*/a^*)$$
$$C^* = a^2 + b^2$$

where:

b* = b* values,

a* = a* values

Sensory Evaluation

Roasted pearl millet flour incorporated *sattu* with bengal gram were evaluated for different sensory attributes by a panel of nine trained judges. Sensory attributes like colour and appearance, body (textural property of *sattu* drink), roasted odour, flavour and taste and overall acceptability for all samples were assessed using nine-point hedonic scale (IS: 6273, 1971). Hedonic scale was in the following sequence- like extremely -9, like very much - 8, like moderately -7, like slightly - 6, neither like nor dislike - 5, dislike slightly 4, dislike moderately, - 3, dislike very much - 2, dislike extremely -1 (Larmond, 1977).

RESULT AND DISCUSSION

Roasting is an important unit operation in processing of grain for making *sattu* due to its significant effect on the odour in the final product *sattu*, which is the most desired quality of *sattu*. As the sale of the product is basically depend on the roasted odour in *sattu*, the optimum roasting temperature and time combination is of great importance. It is observed from Fig. 2 that moisture content of roasted grain decreased with increase in both roasting temperature as well as time ($R^2 = 0.99$). The increase in Geometric Mean Diameter (GMD) in linear fashion may be attributed to start of puffing of grain at higher temperature and time combination (Fig. 3).

Textural properties of the roasted pearl millet are very important because energy requirement for grinding may be in proportion to the hardness and average rupture force of the grain. From the Fig. 4, in general, hardness of pearl millet grain increased with increase in roasting temperature and time. The reason for the increase in hardness at increased temperature and time may be attributed to decrease in moisture content of the grain during the roasting process as also reported in other studies (Srivastav *et al*., 1994). Hardness of pearl millet decreased when roasted at 160°C for 45 sec time as compared to raw grain hardness, which was 30.38 N, but when roasting time increased, hardness also increased. This trend was also observed at other temperatures i.e., 180° and 200°C. The formation of a continuous protein matrix, which physically traps the starch granules, leads to difficulty in separating starch from protein and makes the grain harder (Stenvert and Kingswood, 1977; Moss *et al*., 1980). This may also be one of the reasons for increased hardness of grain. Hardness was also increased with increase in the roasting temperature for the same roasting time. The hardness of pearl millet at 200 °C

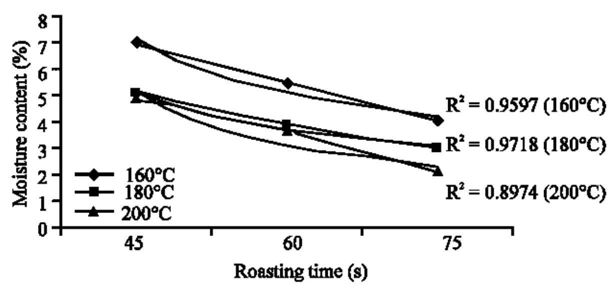

Fig. .2: Moisture content of roasted bajra grain

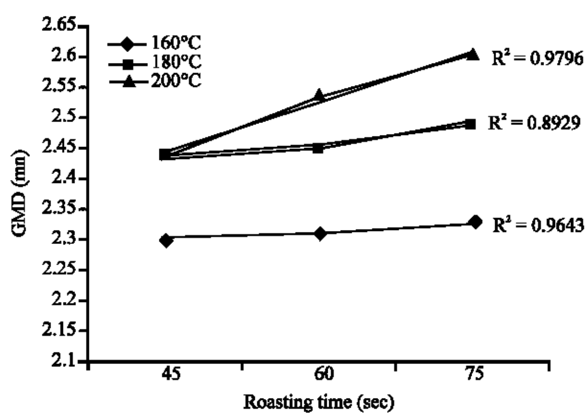

Fig. 3: Effect of roasting temperature and time on geometric mean diameter of bajra grain

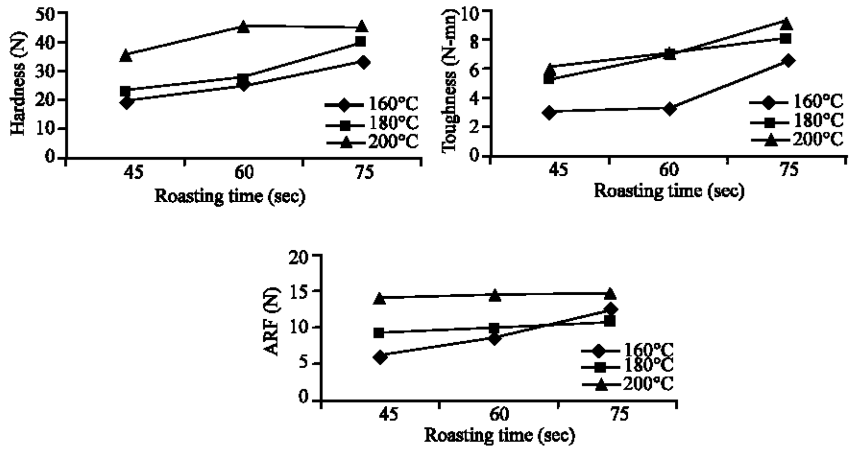

Fig. 4: Effect of roasting temperature (160, 180 and 200° C) and time (45, 60 and 75 sec) on hardness, toughness and ARF of pearl millet grain

for 60 sec, although not significant but lowered as compared to 75 sec roasting time than at 160° and 180 °C. This may be due to the fact that surface gelatinization of starch took place initially and fissures developed on the grain upon further heating, resulted in the reduced hardness. The effect of temperature and time of roasting on grain hardness, toughness and average rupture force is presented in non-linear multiple regression equations. Both the independent variable i.e., temperature and time were considered for computation of coefficient of determination. After deleting the non-significant variable (time or temperature as the case may be), the regression equation can be written as:

$$H = 218.408 + (-)\,2.758\,T + 0.008\,T^2$$

Coefficient of determination = 0.72

$$\ln T_s = -14.009 + 0.163\,T + (-)0.0004\,T^2$$

Coefficient of determination = 0.49

$$ARF = 116.31 + (-)\,1.32\,T + 0.004\,T^2$$

Coefficient of determination = 0.404

where:
H = Hardness,
T_s = Toughness,
ARF = Average rupture force,
T = Temperature.

The colour of the *sattu* is very important from consumer points of view because it is the colour, which appeal first to a person to purchase or consume any food. Roasting, in general, affected the colour of pearl millet grain (Fig. 5). L* values of pearl millet grain at 160 °C decreased with increased roasting time while at 180° and 200°C, L* values slightly decreased at 60 sec as compared to 45 sec and further increased at 75 sec time. The variation in L* values at different time and temperature combinations may be due to degree of puffing of pearl millet grain. At the same temperature when

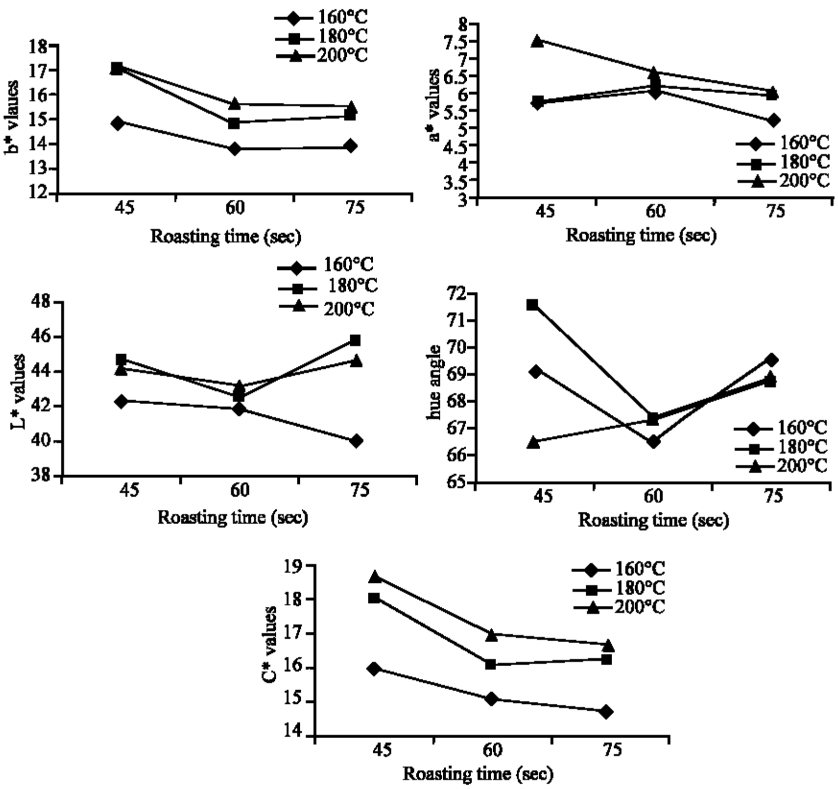

Fig. 5: Effect of roasting on colour (L*, a* and b* values, h^0 and C* (chroma) of pearl millet roasted at 160, 180 and 200° C temperature and 45, 60 and 75 sec time

roasting time was increased, no significant changes were observed in a-values except at 200 °C. The decrease in a*-value at 200°C may be due to slight puffing of some of grains, which increased the L* values i.e., whiteness and decreased the redness i.e., a*-values. Overall Colour changes during heating takes place due to Maillard reaction (Ibanoglu, 2002). When the roasted pearl millet was milled into flour, h^0 (hue) and C* (chroma) showed a different pattern because of the colour of the endosperm. In the seed form, colour basically represents the colour of the seed coat while in ground form; it is the mixed effect of the colour of all component of the grain. L* values for pearl millet flour, prepared from grain roasted at different time and temperature were not significant but effect of roasting on a* and b* values for pearl millet flour (Table 1) brought a significant change in h^0 (hue) and C* (chroma) of pearl millet flour, which has also affected the acceptability of the product. The effect of temperature and time of roasting on h^0 and C* for roasted pearl millet grain and its flour is presented in non-linear multiple regression equations and after deleting the non-significant variable (time or temperature as the case may be), the regression equation can be written as:

$$\ln h^0 (g) = 14.257 + 7.732\, t + 7.762\, t^2$$

Coefficient of determination = 0.51

$$\ln C^*(g) = 0.75 + 0.029\, T + (-)0.00007\, T^2 + (-)0.025\, t + 0.0002\, t^2$$

Coefficient of determination = 0.87

Table 1: Effect of roasting temperature and time on colour (L*, a*, b*, h^0 and Chroma (C*) of pearl millet flour

Temperature (°C)	Time (sec)	L* value	a* value	b* value	h^0	C*
160	45	62.54	5.44	9.91	61.24	11.30
	60	62.58	5.19	9.58	61.55	10.90
	75	62.65	5.06	10.63	64.55	11.77
180	45	64.61	4.78	11.99	68.26	12.91
	60	64.35	5.20	11.35	65.39	12.48
	75	64.00	5.25	12.18	66.68	13.26
200	45	63.73	4.97	11.08	65.84	12.14
	60	63.69	5.11	12.16	67.21	13.19
	75	62.94	5.39	13.22	67.82	14.28

Table 2: Effect of roasting on mean sensory scores for important sensory attributes of pearl millet flour

Roasting temperature and time (°C sec^{-1})	Colour and appearance	Roasted odour	Overall acceptability
160/45	5.66±0.22	5.68±0.51	6.04±0.33
160/60	5.89±0.28	6.02±0.49	5.58±0.43
160/75	6.03±0.23	6.44±0.45	6.15±0.35
180/45	6.06±0.24	6.02±0.51	6.12±0.39
180/60	6.28±0.23	6.58±0.43	6.58±0.31
180/75	6.22±0.26	6.14±0.60	6.02±0.38
200/45	5.67±0.35	5.89±0.42	5.79±0.40
200/60	6.25±0.25	6.23±0.55	6.07±0.36
200/75	6.21±0.23	6.13±0.52	6.13±0.26

Table 3: Mean sensory scores for different attributes of bengal gram and pearl millet based *sattu* with bengal gram

Proportion of bengal gram : pearl millet	Colour and appearance	Body	Roasted odour	Flavour and taste	Overall acceptability
90:10	6.86±0.35	6.53±0.34	6.92±0.17	7.17±0.46	7.01±0.14
80:20	5.89±0.49	6.22±0.38	6.31±0.23	6.03±0.53	5.94±0.28
70:30	5.28±0.46	5.81±0.62	6.05±0.09	5.58±0.57	5.67±0.24
60:40	4.76±0.42	5.69±0.60	5.83±0.24	5.56±0.60	5.39±0.31
100:0 (control)	7.73±0.36	7.44±0.51	7.13±0.21	7.92±0.55	7.35±0.21

$$\ln h^0 (f) = 1.491 + 0.031\ T + (-)0.00008\ T^2$$

Coefficient of determination = 0.63

$$\ln C^*(f) = -1.976 + 0.050\ T + (-)0.00013\ T^2$$

Coefficient of determination = 0.75

where:
g = Grain,
f = Flour,
T = Temperature,
t = Time

Mean sensory scores of roasted pearl millet flour for making *sattu* are given in Table 2. The mean scores for all the attributes and overall acceptability were more than 5, indicated that the samples of pearl millet flour prepared from grain roasted at different roasting conditions were accepted by the panelist with highest score for roasted odour (6.58) and overall quality (6.58) of the samples prepared from the grain roasted at 180 °C for 60 sec, hence this sample was used for making bengal gram and pearl millet based *sattu*. The acceptability of pearl millet flour for making *sattu* (Table 2) and pearl millet flour incorporated *sattu* drink with bengal gram (Table 3) for different sensory attributes was significantly different for all the attributes.

CONCLUSIONS

Roasting of pearl millet grain at different roasting conditions affected the GMD and textural properties of pearl millet and colour of pearl millet and its flour. In general, hardness of pearl millet grain increased with increase in roasting temperature from 160 to 200 °C for 45 to 75 sec time. The lower hardness of pearl millet, roasted at 180 °C for 60 sec as compared to higher temperature and highest mean sensory scores for colour and appearance (6.28), roasted odour (6.58) and overall quality (6.58) for the pearl millet flour prepared from the grain roasted at 180 °C for 60 sec, make this temperature and time combination best for roasting of pearl millet for making *sattu*. The 10% level of pearl millet flour with Bengal gram (90%) was found the most accepted *sattu* formulation. The regression equations developed for hardness, toughness and average rupture force revealed that temperature of roasting had significant effect on these quality attributes as compared to time. Whereas, regression equations for colour showed that both roasting temperature and time had effect on hue and chroma in case of roasted grain but it was only temperature in case of flour.

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