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Effect of Roasting on Texture, Colour and Acceptability of Soybean for Making *Sattu*

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Abstract: Effect of roasting on important physical properties and sensory acceptability of soybean for making *sattu* formulations was studied at three temperature (180, 200 and 220°C) and time (45, 60 and 75 sec) combinations. In general, GMD of soybean increased with increase in roasting temperature and time except for 75 sec. Hardness, toughness and average rupture force decreased with increase in roasting temperature and time except at 200 and 220°C for 75 sec time. L* value of roasted soybean decreased at increased temperatures while a* values increased with increased roasting temperature and time that affected hue and chroma of soybean. The lower hardness of soybean roasted at 200°C for 60 sec as compared to higher temperature and highest mean sensory scores for different attributes for soybean flour prepared from the soybean roasted at 200°C for 60 sec, make this temperature and time combination best for roasting of soybean for incorporating in *sattu* formulations. Roasted soybean flour can be incorporated up to 20% level but the best sensory acceptability of *sattu* formulation was observed with 10% soy flour level with 50% barley and 40% Bengal gram.

Key words: Colour, roasting, *sattu*, sensory evaluation, soybean, texture

INTRODUCTION

Sattu, is a ready-to-eat traditional snack food of northern India and most popular in Bihar and Uttar Pradesh. It is prepared from flour of roasted cereals only, or legumes only or, combination of cereal and legumes with added flavouring agents (Mridula *et al*., 2004a). It is a convenient food product, containing digestible dietary constituents of vital importance. Roasting which is a simple and more commonly used household and village level technology, pre-cooks the ingredients used in food grains and oilseed based mixes and increases 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 eliminates most of anti-nutritional or toxic effects of legumes, partially or wholly (Liener, 1973).

Amongst various cereals and legumes, barley and bengal gram are the most liked grain for making *sattu* (Mridula *et al*., 2004b). Bengal gram *sattu* is commercially produced in Bihar and eastern Uttar Pradesh, which is the most liked form of *sattu* but in other parts of Uttar Pradesh, barley and bengal gram based *sattu* is preferred by the population. Earlier *sattu* was considered as food of the poor but now a days, it is gaining popularity amongst all because of its protein value and suitability of this product for diabetics due to lower glycemic index of Bengal gram and barley (Shukla *et al*., 1991). Anonymous (2000) developed an acceptable quality product from roasted flour mixture using wheat, bengal gram, defatted soyflour, groundnut and jaggery called *Amirtham*. Proportions used for preparing this product were 50% wheat, 25% bengal gram, 8.25% defatted soy flour and 16.66% groundnut.

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Soybean, being less expensive, but rich source of good quality 40% protein and 20% fat, has been recognized as a vital ingredient for protein enrichment for ready to eat food product (Kulkarni, 1994). Several workers have explored the possibilities of using soy flour with cereal flour to prepare a variety of food products of Indian taste such as snacks, baby foods, chapatti, beverages and bakery products (Rathod and Williams 1970; Tsen *et al.*, 1973; Sushma *et al.*, 1979; Okeiyi and Futrell, 1983; Chauhan and Bains, 1985; Singh and Singh, 1989; Chauhan and Santosh Kumari, 1990; Vimala *et al.*, 1990; Deshpande *et al.*, 2004; Mridula and Wanjari, 2006) but information on optimum roasting temperature and time combination for soybean for incorporating in *sattu* is not cited in the literature. As *sattu* is getting popular amongst diabetics, incorporation of soybean in *sattu* in acceptable proportion will not only enhance the protein value of the product but also provide benefits of health promoting phytochemicals at an affordable price. The present study was conducted with the objective to standardized roasting temperature and time combination for soybean for making *sattu* formulations based on barley and bengal gram.

MATERIALS AND METHODS

Soybean with Geometric Mean Diameter (GMD) of 5.249 mm was used for the study. In order to see the effect of roasting on quality of soybean for making *sattu* with barley and bengal gram, *sattu* was prepared using the method shown in Fig. 1. Raw soybean with moisture content of 11.09% (d.b.) was dipped in water in a wire mesh basket, twice for washing followed by tempering for 3 h. The moisture content of the tempered soybean sample was 14.22% (d.b.). The tempered samples were roasted in sand using sand grain ratio 10:1 at three different temperatures (180, 200 and 220°C) and time (45, 60 and 75 sec) combinations. The roasted samples were tempered for 4 h and packed in LDPE bags (50 μ) and kept in desiccator. The quality parameters viz., moisture, GMD, colour (L*, a* and b* values) and textural properties were determined after 24 h of roasting. These roasted samples were dehulled in mini dhal mill (capacity 100 kg h^{-1}) at 6 mm dehuller clearance.

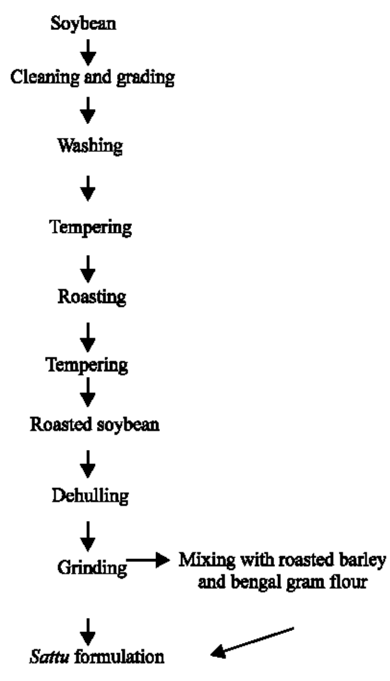

Fig. 1: Method for preparation of soybean fortified *sattu*

Dehulled and cleaned soybean dhal was ground for making roasted soybean flour. The ground samples were evaluated for different sensory attributes to find out the best accepted soybean flour, prepared from soybean roasted at different temperature and time combinations. Different *sattu* formulations with barley, bengal gram and soybean were prepared using soybean flour at 5, 10, 15 and 20% level. Thus the proportion of barley, bengal gram and soybean in different formulations was 50:50:0 (control), 50:45:5, 50:40:10, 50:35:15, 50:30:20, respectively. Roasted barley and bengal gram was prepared as per the standardized process (Mridula *et al*., 2004b).

Geometric Mean Diameter

GMD of raw and roasted sample were measured using Vernier Caliper with least count of 0.02 mm. Geometric mean of the spatial dimensions (length, breadth and thickness) was calculated as:equivalent diameter = $(L \times B \times T)^{1/3}$.

Moisture content of samples was determined by using oven method (105°C) (AOAC, 1990).

Textural Properties

Textural properties of raw and roasted soybean such as hardness, toughness and average rupture force were measured using Texture Analyzer (TA) TA-HDi. Stable Micro systems. The TA setting were: Mode-measure force in compression, option-return to start, pre test speed-3 mm sec^{-1}, test speed-1 mm sec^{-1}, post test speed-10 mm sec^{-1}, distance-3 mm, stainless steel cylinder probe-5 mm diameter and 50 kg load cell. Textural properties were measured for 10 representative grains 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 the 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* and b* values) of the samples was determined by using Handy Colorimeter NR-3000. 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. Hue angle (h°) is the attribute of colour by means of which the colour is perceived. Chroma (C*) is the attribute of colour used to indicate the degree of departure of the colour from gray of the same lightness. h° and C* are computed by using the following formula.

$$h^{\circ} = \tan^{-1}(b/a)$$

$$C^* = a^2+b^2 \quad \text{where } a = a^*,\ b = b^*$$

Sensory Evaluation

Roasted soybean flour (in flour form only) and soybean incorporated *sattu* with barley and bengal gram were evaluated in drink form, for different sensory attributes by a panel of nine scientist of the Institute. The *sattu* drink was prepared with 16 g formulation in 100 mL water with salt, cumin seed powder and white pepper. Sensory attributes like colour and appearance, body (sensory texture of *sattu* drink), roasted odour, flavour and taste and overall acceptability for all samples were assessed using nine point hedonic scale (IS, 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 and dislike extremely-1 (Larmond, 1977).

Statistical Analysis

Analysis of variance and polynomial regression for the data of the study were computed using Statistica 7.1.

DISCUSSION

Roasting has a significant impact on the overall quality of grain and the final product i.e., *sattu*. The roasting odour, a most important quality of *sattu* is basically depends on the roasting temperature and time combination. Hence, roasting temperature and time combination is of great importance in grain processing for making *sattu*. It is observed that moisture content of roasted soybean decreased with increase in both roasting temperature as well as time, which is obvious and expected. In general, GMD of soybean increased with increase in roasting temperature and time except for 75 sec. The GMD of soybean roasted at 180°C for 45 sec, the lowest temperature and time combination was 5.23 mm as against 5.34 mm of grain roasted at 220°C for 75 sec. The increase in GMD is attributed to start of puffing of grain at high temperature and time combination. The recovery of de-hulled fraction of roasted soybean was in the range of 79.05 to 81.28%. The roasting temperature affected the recovery of dehulled soybean ($p<0.001$), may be due to higher powdering in case of grain roasted at 200 and 220°C.

Textural properties of the roasted soybean are very important because energy requirement for dehulling and grinding may be in proportion to the grain hardness. Various studies indicated the affect of grain hardness on particle size of milled grain and energy consumption in milling (Symes 1969; Moss *et al*., 1980; Tran *et al*., 1981). Grain hardness is affected by size, direction of applied force, moisture content (Zoerb and Hall, 1960; Bilanski, 1966), chemical composition (Bennett, 1950) and heat treatment (Abdelrahman and Hoseney, 1984). From the Fig. 2, it is observed that in general, hardness of soybean decreased with increase in roasting temperature and time of roasting except at 200 and 220°C for 75 sec time. The reason for the increase in hardness at 200 and 220°C for 75 sec, temperature and time combination may be due to drastic reduction in moisture content of the soybean grain that made the grain harder as also observed in case of bengal gram (Srivastav *et al*., 1994). The similar trend was observed in toughness and average rupture force of roasted soybean (Table 1 and Fig. 2). The effect of temperature and time of roasting on grain hardness, toughness and average rupture force is presented in non-linear polynomial regression equations. Both the independent variable i.e., temperature and time were considered for computation of coefficient of determination (Multiple R). The regression equation can be written as:

$$H = 2593.154 - 19.402\ T + 0.045\ T^2 - 13.177\ t + 0.099\ t^2 \quad (1)$$

Multiple R = 0.93

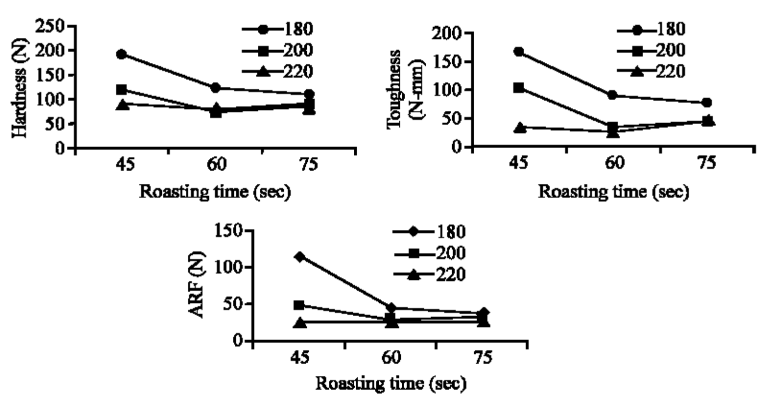

Fig. 2: Effect of roasting on hardness, toughness and Average Rupture Force (ARF) of soybean roasted at 180, 200 and 220°C temperature for 45, 60 and 75 sec time

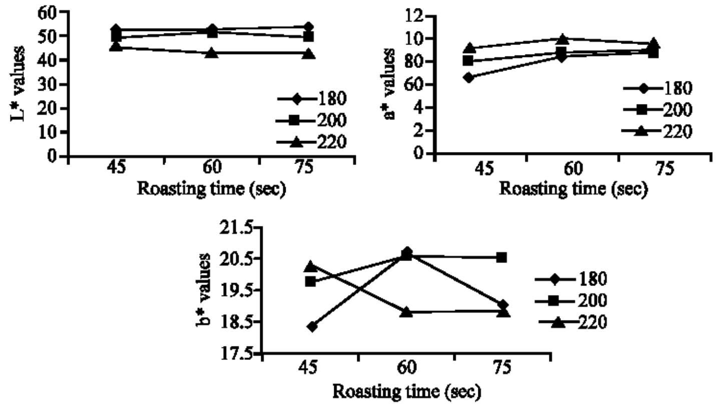

Fig. 3: Effect of roasting on colour (L*, a* and b* values) of soybean roasted at 180, 200, 220°C temperature for 45, 60 and 75 sec time

Table 1: Analysis of variance for textural properties and colour of roasted soybean

Characteristics	Source of variation	df	SS	MS	f-ratio
Textural properties					
Hardness	Temperature	2	52905	26453	134.57***
	Time	2	32338	16169	82.25***
Toughness	Temperature	2	84621.6	42310.8	65.68***
	Time	2	44720.1	22360.1	34.71***
Average rupture force	Temperature	2	26803.9	13402.0	99.23***
	Time	2	17607.2	8803.6	65.18***
Colour (L*, a* and b* values)					
L* value	Temperature	2	383.26	191.63	172.22***
	Time	2	0.59	0.29	0.26^{ns}
a* value	Temperature	2	12.87	6.43	35.99***
	Time	2	8.19	4.09	22.91***
b* values	Temperature	2	5.02	2.51	7.43**
	Time	2	1.77	0.88	2.62^{ns}

***p<0.001; **p<0.01; ^{ns} = non-significant

$$Ts = 2307.104-15.586\,T+0.034\,T^2-15.937\,t+0.12\,t^2 \qquad (2)$$
$$\text{Multiple } R = 0.87$$

$$ARF = 1439.83-10.288\,T+0.023\,T^2-8.344\,t+0.061\,t^2 \qquad (3)$$
$$\text{Multiple } R = 0.92$$

Where, H = hardness; Ts = toughness; ARF = average rupture force; T = temperature; t = time

The colour of the food product is the first attribute that affects the decision of consumer for purchasing or consuming any food. Roasting, in general, affected the colour of soybean grain. In general, L* value of roasted soybean decreased while a* values increased with increased roasting temperature that resulted in the darkening of the grain at higher temperatures and poor acceptability of that sample during sensory evaluation. Whereas, increase in roasting time at 180 and 200°C did not brought significant changes in L*, a* and b* values but at 220°C, L* values slightly decreased with increased roasting time (Table 1 and Fig. 3). The effect of temperature and time of roasting on hue angle (h°) and chroma (C*) for roasted soybean is presented in non-linear polynomial regression equations and after deleting the non-significant variable (time or temperature as the case may be), the regression equation can be written as:

$$h^\circ = -57.4385+1.5956\,T-0.0043\,T^2 \quad (4)$$
$$\text{Multiple } R = 0.92$$

$$C^* = -52.5473+0.6311\,T+0.3419\,t \quad (5)$$
$$\text{Multiple } R = 0.87$$

The roasting temperature and time affected the sensory quality of soybean flour (Table 3). The mean sensory scores for all the attributes for roasted soybean flour, prepared from the grain roasted at 180 and 200°C for different time combination and 220°C for 45 sec were more than the minimum acceptable score of 5 (Table 2). The results thus indicated that these samples of roasted soybean flour were accepted by the panelist with highest sensory scores for roasted odour and overall

Table 2: Effect of roasting on mean sensory scores for different attributes of soybean flour*

Roasting temperature (°C)	Time (sec)	Colour and appearance	Roasted odour	Overall quality
180	45	6.86	6.39	6.39
	60	7.18	6.21	6.43
	75	7.29	6.79	6.68
200	45	6.89	6.93	6.46
	60	7.14	7.21	7.21
	75	6.89	6.89	7.04
220	45	5.71	6.21	6.21
	60	4.79	5.21	5.64
	75	4.89	5.29	5.57

*Evaluated in powder form

Table 3: Analysis of variance for different sensory attributes of roasted soybean flour for making *sattu*

Attributes	Source of variation	df	SS	MSS	f-ratio
Colour and appearance	Judges	6	0.192	0.032	0.48^{ns}
	Products	8	56.657	7.082	105.63***
Roasted odour	Judges	6	0.762	0.127	1.88^{ns}
	Products	8	27.929	3.491	51.75***
Overall quality	Judges	6	0.665	0.111	1.17^{ns}
	Products	8	17.107	2.138	22.65***

***$p<0.001$; ^{ns} = non significant

Table 4: Mean sensory scores for different attributes of soybean incorporated *sattu* formulations*

Proportion of barley: bengal gram: soybean	Colour and appearance	Body	Roasted odour	Flavour and tast	Overall ecceptability
50:50:0	7.79	7.71	8.14	8.04	8.01
50:45:5	7.64	7.75	8.21	7.86	7.71
50:40:10	7.83	7.69	8.11	7.82	7.82
50:35:15	7.21	7.20	8.19	6.20	6.14
50:30:20	7.21	7.21	7.89	5.21	6.04

*Evaluated in drink form

Table 5: Analysis of variance for different sensory attributes for soybean incorporated *sattu*

Attributes	Source of variation	df	SS	MSS	f-ratio
Colour and appearance	Judges	6	0.613	0.102	1.35^{ns}
	Formulation	4	2.582	0.646	8.50***
Roasted odour	Judges	6	0.186	0.031	0.58^{ns}
	Formulation	4	0.446	0.112	2.09^{ns}
Body*	Judges	6	0.367	0.061	0.91^{ns}
	Formulation	4	2.145	0.536	7.99***
Flavour and taste	Judges	6	0.371	0.062	1.09^{ns}
	Formulation	4	43.989	10.997	193.97***
Overall acceptability	Judges	6	0.362	0.060	0.99^{ns}
	Formulation	4	26.318	6.58	107.50***

*Sensory feeling of texture of *sattu* drink; ***$p<0.001$; ^{ns}: non significant quality (7.21) for the samples prepared from the soybean roasted at 200°C for 60 sec, hence this sample was used for making barley, bengal gram and soybean based *sattu* formulations. The mean sensory scores of different *sattu* formulations for flavour and taste and overall acceptability were in the range of 8.04 (for control) to 5.21 (20% soy flour) and 8.01 to 6.04, respectively (Table 4). Although, the incorporation of soybean affected the sensory quality of *sattu* formulations (Table 5) but the sensory scores for flavour and taste and overall acceptability for *sattu* formulation up to 10% soy flour levels were comparable with the control sample drink form.

CONCLUSIONS

Roasting of soybean at different temperature and time combination affected the physical properties of soybean and sensory acceptability of soybean flour for making *sattu*. In general, hardness of soybean decreased with increase in roasting temperature from 180 to 220°C. The lower hardness of soybean roasted at 200°C for 60 sec as compared to higher temperature and highest mean sensory scores for colour and appearance (7.14), roasted odour (7.21) and overall quality (7.21) for soybean flour, prepared from the soybean roasted at 200°C for 60 sec, make this temperature and time combination best for roasting of soybean for incorporating in *sattu* formulations. The study showed that soybean can be incorporated up to 20% level but the best sensory acceptability of *sattu* formulation was observed with 10% soy flour level with 50% barley and 40% bengal gram.

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