Milling Quality of Soybean Cultivars as a Function of Premilling Heat Treatment and Grain Characteristics

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Ten varieties of soybean given two drying treatments, i.e., oven drying and dry heat roasting, were evaluated for their milling characteristics. Of 10 varieties, the cultivars PK-472, Alankar, and PK-564 yielded more than 80% dehulled splits (commonly known as dal), minimum undehulled grain percentage, and minimum milling losses and, therefore, were grouped as easy to mill varieties. The varieties PK-308 and T-49 yielded less milling percentage, maximum undehulled grain percentage, and milling losses and so were grouped as difficult to mill varieties. The rest were considered to be intermediate. The dry heat roasting method of drying yielded significantly ($P < 0.05$) higher milling percentage and lower undehulled grain percentage and milling losses over the oven-drying method. Physical characteristics of grain such as hull thickness, grain hardness, and split hardness were negatively correlated, and chemical characteristics such as protein, fat, and gum content were positively correlated with milling percentage.

INTRODUCTION

The soybean is an excellent source of nutrients and has great potential for the people of developing countries such as India who mostly rely upon vegetable sources for their protein requirements. For almost all kinds of processed products, dehulled cotyledons, commonly known as "dal", are preferred. Furthermore, to control lipoxygenase activity, it is essential that injury to cotyledons be minimized during dehulling. In most of the dehulling systems cotyledon yield ranged from 65 to 85% depending on the type of pulse (Kurien, 1984). In addition, the extent of mechanical damage to cotyledons separated is also relatively high depending on the variety of the particular pulse.

Information on the milling behavior of different soybean cultivars is not available. Therefore, the aim of the present study was to evaluate different soybean cultivars for their milling characteristics using different drying methods before milling. Some of the physicochemical characteristics were also analyzed to determine their correlation with yield, if any.

MATERIALS AND METHODS

The seeds of 10 varieties of soybean listed in Chart I were procured from the Department of Plant Breeding, G. B. Pant University of Agriculture and Technology, Pantnagar.

Physical Characteristics. Hull thickness was measured by using a screw gauge, and the means of 10 values have been reported. Thousand kernel weight was measured by counting 1000 kernels and then taking their weight. Grain and split hardnesses were measured (10 replications) by using a KIYA grain hardness tester and are reported as the force in kilograms per kernel. Cotyledon and hull percentages were obtained by manual dehulling so as to find the exact proportion of hulls and cotyledons.

Chemical Characteristics. Proximate composition including moisture, protein, fat, and total ash was determined by using standard methods of the AOAC (1976) and carbohydrate by difference. Calcium was determined according to the procedure described by Ranganna (1986) and crude fiber according to the AACC (1976) procedure. Gums and mucilage were determined according to the procedure described by Ryugu and Labaritch (1978).

Milling. Before milling, the seeds of each variety were tempered at 25 °C for 3 h in a closed container and then divided into two lots. One lot was dried in an oven at 65 °C for 3 h, and the other was dry heat roasted at 160 °C for 15 min. The drying and roasting operations were so adjusted (by preliminary trials) to obtain final moisture contents of 10–10.5%. The level of moisture was selected on the basis of findings of Saxena (1985). The dehulling was done in a laboratory-type SATAKE dal mill after the seeds had cooled to room temperature. Sample size (60 g), speed of roller (400 rpm), and residence time (8 s) were optimized to obtain maximum dehulling efficiency (preliminary trials). The cotyledons, broken powder, and husk were separated using standard sieves (No. 6). The unhusked grains were separated manually. The milled fractions from each sample were weighed and converted into percentage. The hulling efficiency was calculated by using the standard Kuprits (1967) formula modified by Saxena (1975)

Chart I. Soybean Varieties Used in This Study

Shilajeet	Kalitur	Ankur
PK-472	Alankar	T-49
PK-308	PK-564	Bragg
PK-429		

$$E = \left(1 - \frac{M_{uh}}{M_t}\right)\left(1 - \frac{M_b}{M_t}\right) \times 100$$

where E is the hulling efficiency, M_{uh} is the mass of undehulled grain after hulling, M_b is the mass of brokens and powder after hulling, and M_t is the total mass of grains before hulling, which does not contain hulled grains.

A mixture of fine powder and brokens was considered as milling loss.

The data thus obtained were analyzed statistically using the CRD technique as described by Snedecar and Cochran (1968), using these factors with the following parameters: replications, 2; soybean varieties, 10; methods of drying, 2.

RESULTS AND DISCUSSION

Physical Characteristics of Soybean Varieties. The results presented in Table I clearly indicate that the physical characteristics of soybean varied from variety to variety. The hull thickness of the grain varied from 0.067 to 0.118 mm. The 1000 kernel weight varied from 84.5 to 139.4 g. The grains of all varieties were harder than splits. Variety T-49 was hardest and variety PK-429 least among all the varieties. The average grain hardness varied from 10.2 to 18.1 kg/kernel. In the case of splits the hardness

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Table I. Varietal Differences in the Physical Characteristics of Soybean

	physical characteristics								
							size of the grain		
variety	hull thickness, mm	1000 kernel wt, g (db)	grain hardness, kg/kernel	split hardness, kg/split	cotyledon, %	hulls + germ, %	length, mm	width, mm	thickness, mm
Shilajeet	0.115	139.4	16.2	14.2	90.0	9.8	7.02	6.04	5.13
PK-472	0.109	101.8	16.9	14.3	90.0	9.9	6.36	5.60	4.72
PK-308	0.067	101.8	11.2	10.3	90.3	9.7	6.24	5.63	4.87
PK-429	0.111	111.7	10.2	9.3	89.4	10.5	6.76	5.84	4.94
Kalitur	0.074	84.5	12.6	11.8	89.4	10.4	5.68	4.91	4.26
Alankar	0.097	116.4	11.0	10.3	90.8	9.2	6.37	5.99	5.17
PK-564	0.068	114.9	16.1	14.6	91.0	8.9	6.37	5.57	4.71
Ankur	0.116	128.7	15.5	14.4	90.5	9.4	6.95	6.00	4.97
T-49	0.118	93.4	18.1	15.8	90.2	9.6	7.14	5.29	4.52
Bragg	0.071	117.0	17.3	15.4	90.6	9.3	6.88	6.23	5.25

[a] All values are the average of 10 replications.

Table II. Varietal Differences in Chemical Characteristics (db) of Soybean[a]

variety	moisture, %	protein, % $N_2 \times 6.25$	fat, %	total ash, %	carbohydrate, %	calcium, mg/100 g	crude fiber, %	total gum, mg/g
Shilajeet	9.8	44.6	25.2	4.6	25.6	341	4.5	4.8
PK-472	13.2	41.3	20.2	5.1	33.3	318	3.8	5.4
PK-308	9.9	43.7	20.4	6.0	29.9	350	4.3	3.4
PK-429	9.0	44.2	20.4	4.7	30.7	343	4.2	6.3
Kalitur	10.2	47.3	27.0	4.5	21.2	295	4.3	4.1
Alankar	10.2	42.9	25.8	6.0	25.3	321	5.1	3.2
PK-564	9.7	46.0	22.3	4.8	26.9	307	4.8	2.6
Ankur	9.5	43.5	24.9	6.0	25.6	325	4.0	3.4
T-49	8.4	42.0	17.6	4.5	35.9	351	5.1	4.1
Bragg	9.3	47.7	25.8	5.4	21.1	348	3.9	3.9

[a] All values are the average of two determinations.

Table III. Effect of Variety and Drying Method on Milling Characteristics of Soybean

	milling characteristics					
	cotyledon yield, %		undehulled grain, %		milling loss, %	
variety	oven drying	dry roasting	oven drying	dry roasting	oven drying	dry roasting
Shilajeet	72.4	79.1	7.9	5.3	10.70	8.74
PK-472	80.8	84.1	1.8	8.93	8.93	7.60
PK-308	61.2	66.4	18.2	15.1	10.28	10.52
PK-429	76.8	78.4	3.3	2.9	9.35	8.25
Kalitur	76.9	79.3	4.2	2.7	8.60	7.53
Alankar	80.2	80.9	1.0	0.9	9.84	9.13
PK-564	80.4	81.0	0.8	0.5	10.25	9.90
Ankur	73.4	78.1	6.8	3.3	11.24	10.13
T-49	52.6	71.5	27.3	7.9	12.63	11.25
Bragg	77.1	77.9	2.4	2.6	11.71	10.77
mean of 10 observations						
SEM	0.12		0.06		0.012	
CD at 5%	0.23		0.13		0.024	

Table IV. Correlation Matrix of Milling Percentage and Physicochemical Characteristics of Soybean

		correlation matrix										
		1	2	3	4	5	6	7	8	9	10	11
milling, %	1	1.000										
protein, %	2	0.113	1.000									
fat, %	3	0.493	0.596	1.000								
ash, %	4	−0.071	−0.070	0.231	1.000							
calcium, %	5	−0.667	−0.023	−0.667	0.189	1.000						
crude fiber, %	6	−0.289	−0.118	−0.124	−0.161	−0.021	1.000					
gum content, mg/g	7	0.135	−0.267	−0.318	−0.504	0.231	−0.441	1.000				
hull thickness, mm	8	−0.057	−0.611	−0.274	−0.176	0.220	0.032	0.532	1.000			
1000 kernel wt, g	9	0.337	0.034	0.355	0.288	0.185	−0.142	−0.016	0.315	1.000		
grain hardness, kg/kernel	10	−0.061	0.074	−0.124	−0.274	0.071	−0.040	−0.110	0.202	0.158	1.000	
split hardness, kg/split	11	−0.051	0.156	−0.035	−0.228	0.023	−0.021	−0.207	0.154	0.180	0.990	1.000

varied from 9.3 to 15.8 kg/split. The cotyledons and hull content varied from 89.4 to 91.0% and from 8.9 to 10.5%, respectively.

Chemical Characteristics of Different Varieties. From Table II it can be seen that variety Bragg exhibited highest protein (47.7%) and variety PK-472 lowest (41.3%). The fat content ranged from 17.6 to 27.0%. The lowest ash content was exhibited by variety T-49 but with the highest calcium content (351 mg/100 g), which indicated that calcium content is not necessarily higher with high ash content. The crude fiber content was also highest in T-49 (5.1%) and lowest in PK-472 (3.8%).

However, total gum content was highest in variety PK-429 (6.3 mg/g) and lowest in PK-564 (2.6 mg/g).

Effect of Variety and Method of Drying on Milling Characteristics. From the results presented in Table III it can be seen that milling percentage (cotyledon yield) was higher in the case of samples dried using dry roasting as compared to oven drying for almost all of the varieties taken under study. Variety T-49 accounted for minimum yield (52.6%) by the oven drying method, whereas variety PK-308 gave the minimum yield (66.4%) after dry roasting. Variety PK-472 yielded the highest milling percentage by both drying methods (80.8 and 84.1%). On the basis of milling percentages, PK-308 and T-49 were grouped as difficult to mill varieties, PK-472, Alankar, and PK-564, which yielded more than 80%, were classified as easy to mill varieties, and the remaining five varieties were considered to have intermediate milling characteristics. The statistical analysis indicated that the differences in the yields of finished products due to variety were significant ($P < 0.05$).

Undehulled Grain Percentage. It can be revealed from Table III that the percentage of undehulled grains was significantly lower ($P < 0.05$) in samples that were dry heat roasted as compared to oven-dried samples in all of the varieties. The minimum undehulled grain percentage was recorded for those varieties classified as easy to mill and the highest for those grouped as hard to mill. These differences in the undehulled grain percentage due to variety were statistically significant ($P < 0.05$).

Table III clearly indicates that the milling losses were significantly higher in soybean seeds dried by the oven-drying method than in dry-roasted samples in all of the varieties except PK-308, where the effect was reversed. Variety Kalitur yielded minimum milling losses (8.6% in oven-dried samples and 7.53% in dry-roasted samples), and variety T-49 yielded maximum milling losses (12.63% in oven-dried sample and 10–25% in dry-roasted sample). The milling losses depend on the brokens and powder produced by scoring and on the grain characteristics of each variety. The varietal effect on the milling losses was significant at a 5% level of significance.

From the results presented in Table IV it can be seen that the grain characteristics such as protein percent, fat percent, gum content, and 1000 kernel weight were positively correlated, whereas hull thickness, ash content, calcium content, crude fiber content, and grain and split hardnesses were negatively correlated with milling percentage.

In view of the above findings it can be concluded that varieties PK-472, Alankar, and PK-564, which yielded high milling percentages, are easy to mill varieties, whereas T-49 and PK-308, which yielded lower milling percentages, are hard to mill varieties; the other varieties are considered to be intermediate in milling characteristics. The dry-roasting method yielded significantly higher milling percentages and lower milling losses over the oven-drying method. The physicochemical characteristics such as protein content, fat content, gum content, and 1000 kernel weight were positively correlated with the milling percentage.

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