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A Mechanical Method for Small Scale Dehulling of Sunflower Seeds

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ABSTRACT

Sunflower is an introduced crop in India. Difficulty in dehulling the seeds at the household level and lack of awareness about its food value are the main reasons for the kernels not being used in the diets of people who grow them. Different types of treatments to dehull the seeds such as, wet dehulling, manual and mechanical methods were screened. The removability of hull was poor in all wet dehulling pretreatments that were studied. Sunflower seeds that were dehulled by mechanical method was found most acceptable method among other methods used. The calculated cost of the dehulled sunflower seeds was estimated to be Rs. 80/kg ($1.27). Three varieties namely, KBSH 44, KBSH 41 and Confectionery-1 were employed. Physical characteristics of the seed such as, seed size, weight of 100 seeds, volume, bulk density, hulls and kernel recovery by mechanical and manual methods was measured. All the genotypes exhibited significant differences in their physical characteristics.

Key words: *Sunflower, dehulling, physical characteristics, sunflower kernels*

INTRODUCTION

Sunflower is the second most important oilseed crop in the world after soybean. The current area under sunflower in India is 1.88 million hectares with a production of 1.23 million tonnes and productivity of 659 kg/ha. Sunflower seeds are one of the major oilseeds containing 35-50% oil and 17-25% protein. Sunflower seed consists of a pericarp or hull and kernel with two cotyledons and an embryo[1]. This seed is coated with dry brittle hull. High fibre, low protein and high wax content are the major constraints in obtaining better yield of oil and high quality protein. Sunflower seed contains about 19.8 g of protein, 52.1 g of lipid, 17.9 g of carbohydrate, 1 g of crude fibre, 3.7 g of minerals, 280 mg of calcium, 5 mg of Iron and it yields 620 k cal of energy per 100 g of seeds[2]. Sunflower kernel contains higher levels of vitamin E, phenolic acids, choline, arginine and lignins compared with some other nuts[3]. It can be used as a raw material for preparing confectionery and other value added products rich in nutrients. It can also be used as a successful ingredient in confectionery food products. In India sunflower seeds are not very popular as dehulling of sunflower seed is not carried out. Small scale dehulling is needed in several contexts such as, laboratory studies, product development and individual farm level consumption.

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Certain quantity of hull remains in a dehulled kernel. In India almost all the sunflower produced is for oil extraction. Dehulling the seeds at the household level and lack of awareness about its food value are the main reasons for the kernels not being used in the diets of people in India especially in people who grow them. When a new crop is introduced into an area where a local food crop is grown it can aggravate nutritional insecurity because the communities lack the tradition of converting the new crop into a food even though it may be highly nutritious. Shifts in cropping patterns must always be associated with serious efforts at developing low cost appropriate technologies which will enable the farming community to benefit from new crops not only to enjoy the cash but also the nutritional returns. Hence, dehulling of seeds is important. In this paper some results of our work on the dehulling of sunflower seeds with pretreatments and mechanical dehulling are presented with the objective to develop technology for the production of dehulled sunflower kernels at farm level and to estimate the recovery of kernels from different dehulling methods.

MATERIAL AND METHODS

Procurement of the sample

Three sunflower seed genotypes were included in this study. The different genotypes used for the study were, KBSH 44 (striped hull oilseed), KBSH 41 (black-hull oilseed) and Confectionery-1 (striped non oilseed). The samples were procured from All India Coordinate Research Project on Sunflower, UAS, GKVK, Bengaluru.

Physical characteristics of sunflower seed genotypes

The parameter studied under physical characteristics includes seed length, breadth, length/breadth ratio, hundred seed weight and bulk density. Measurements were worked in triplicates.

Seed length and width

The seed length and width was measured by using Vernier calliper.

100 Seed weight

Seeds were counted and weighed in electronic balance (readability 0.0001g). The mean hundred seed weight was expressed in grams.

Bulk density

The volume of 100g of each sample was determined by gently pouring the grain into a 250 ml graduated cylinder. The volume was recorded in ml for bulk density. The values for bulk density were expressed as g/ml.

Hull per cent

Sample of 100 seed from each genotype was dehulled manually and hull percentage was calculated by using the formula:

$$\text{Hull (\%)} = \frac{\text{Weight of husk}}{\text{Weight of seeds}} \times 100$$

Dehulling of sunflower seeds

Sunflower seed dehulling was done separating the kernel (true seed) from the hull (pericarp).

Manual dehulling of sunflower seeds

Hull percentage and kernel percentage were determined by manul dehulling from a sample of 10g and were expressed as dry basis percentage.

Wet dehulling of sunflower seeds

The following variables were investigated and their influence on the efficacy of decortications recorded:

a) Type and concentration of the chemical

b) Temperature and time of contact between the seeds and chemical solution

The chemical solutions used were those of NaOH, $CaCl_2$ and NaCl with water. Uses of these chemicals have been reported earlier by researcher[4]. The range of concentration of these solutions varied from 1 to 5 per cent. The clean seeds were immersed in the dehulling solution, then decorticated manually and the kernels were oven dried.

Mechanical dehulling of sunflower seeds

Sunflower seeds were cleaned, graded and dehulled by agitating in mixer fitted with disc type blade (figure 1, 2 & 3). The seeds were allowed to agitate in slow speed for 30 seconds. The dehulled product was winnowed for the separation of kernels, hull and unhulled seeds. The resulting product was classified into hull, whole kernels and rest (undehulled seeds, partially dehulled seeds, broken kernels and fines, *i.e.* material smaller than 2 mm)[5]. The yield of dehulled seeds was 60 per cent in the first pass. Recycling the unhulled seeds was therefore necessary. By repeated passing we found that breakage of the kernels as well as pulverization of both husk and kernel occurred, resulting in the formation of fines. The fine material is undesirable as it is lost with the hulls. Further, the kernels were graded into different fractions such as whole kernel and broken kernels. Fines and husks were considered as wastage. The samples were worked in triplicates.

Per cent kernel recovery

Per cent kernel recovery was computed by using following formula

$$\text{Per cent kernel recovery} = \frac{\{100 - [\text{Weight of hull in g - wastage}]\}}{\text{Weight of whole seeds}} \times 100$$

Cost of production: Cost of production of dehulled sunflower seeds and its products were calculated by taking into consideration, apportioned cost of equipment, ingredients, fuel, electricity, labour expenses and packaging cost.

RESULTS AND DISCUSSION

Physical characteristics sunflower seeds

The physical characteristics of different genotypes of sunflower seeds were estimated. Seed characteristics include seed size, volume, bulk density, weight of 100 seeds. The results are presented in the Table 1. All the genotypes exhibited significant difference in their physical characteristics. The seed size i.e., the length by breadth ratio was found to be significantly different among the genotypes. The average seed size ranged from 2.31mm to 1.98mm. The genotype confectionery-1 had the highest seed size (2.31) followed by KBSH 44 (2.18mm) and least seed size was recorded for KBSH 41 (1.98). The average seed size reported by Gupta and Das[6] was 1.86mm. The seed size of varieties in the present study fall between 1.98 (KBSH 41) to 2.31mm (Confectioneery-1). However the seed size reported by Santalla and Mascheroni[7] was 2.30mm. The difference in 100 seed weight was found to be significant. Values ranged from 9.01gm to 5.39gm and Confectionery-1 (9.01gm) had highest seed weight followed by KBSH 41 (6.13). The least seed weight was found in the genotype KBSH 44 (5.39gm). The mean 100 seed weight reported by Ologunde[8] ranged between 3.23g to 6.52g. The varieties in present study fall within this range except for the confectionery seeds. However Denis and Vear[9] reported the 100 seed weight ranged between 1.96g to 6.6g. The seeds of most oil seeds cultivars of sunflower weigh 40 to 60g per 1000 seeds[10]. The non oilseed types weigh more than 100g per 100 seeds[11]. The average seed volume of sunflower ranged from 14ml to 35 ml. Confectionery-1 had the higher volume (35ml) followed by KBSH 41 (16ml) and least seed volume were recorded in the genotype KBSH 44 (14ml). The results exhibited significant differences between the genotypes. The bulk density was found to be significantly different among the genotypes. The seeds of the two genotypes KBSH 44 and KBSH 41 showed higher bulk density (0.38gm/ml), compared to confectionery-1 (0.25gm/ml). The bulk density of sunflower reported by Perez[12] was 359 kg/m3. In the present study the values ranged between 0.25 (g/ml) to 0.38 (g/ml) and 0.43 to 0.65 (g/ml) for seeds and kernels respectively. It may be noted that sunflower kernels of confectionery type were lighter than the rest. The lightness of the confectionery-1 type seed can be attributed to larger air spaces between the kernel and hull when compared to other two varieties. Tranchino[13] found that seed of cultivars with a low density are easier to dehull due to a larger air space between the kernel and the hull, compared to seed of cultivars with a higher density.

Proportion of kernels and hulls of sunflower seeds

Proportions of kernels and hulls of the selected varieties of sunflower seeds are presented in Table 2. The hull percentage was found to be significantly different among the genotypes. Confectionery-1 had higher proportion of hull (37.02%) followed by KBSH 44 (31.15%), KBSH 41 (28.4%). The kernel percentage was found to be significantly different among the genotypes. The KBSH 41 had higher proportion of kernels (71.54%) compared to KBSH 44 (68.85%) and confectionery-1 (62.98%) variety of sunflower. The proportions of hulls and kernels reported by Hartman[14] ranged between 39.30 and 57.51per cent and 42.49 and 61.05 per cent respectively. In the present study slightly lower values were recorded for hull per cent in sunflower cultivars and it ranged between 28.4 and 37.02 per cent and correspondingly higher per cent kernels which ranged between 62.98 and 71.54 per cent. KBSH 41 the oilseed type sunflower cultivar recorded lower per cent of hulls (28.4%). Denis and Vear[9] reported that a high oil genotype generally has a small amount of hull. This might be due to kernels adhering very tightly to the hull (pericarp)[15,16]. Significant difference existed between the varieties for all the physical properties that were included in this study. The confectionery type sunflower had a thick and bulky seed coat this is responsible for the higher hull per cent value. Similar findings were reported by de Figueiredo[17] for confectionery sunflower variety.

Manual dehulling after pretreatments

The results of effect of pretreatments on dehulling qualities of sunflower seeds are depicted in Table 3. Dehulling of sunflower seeds is a difficult operation[18]. Several pretreatments such as, soaking in NaCl, $CaCl_2$, NaOH solutions have been reported as measures for dehulling sunflower seeds[4]. When these were evaluated in the present study it was observed that both from the point of view of removability or separation of the hull from kernels and the colour of the seed, these pretreatments were found unsatisfactory. The removability of hull was poor in all pretreatments that were studied. It was found to range between extremely difficult and moderately difficult. The colour of the dehulled seeds obtained by the manual dehulling after they were pretreated was poor except for $CaCl_2$ and NaCl treatments where only soaking was involved. Therefore, they were not evaluated further.

Mechanical dehulling

A perusal of Table 3 indicates that mechanical dehulling was found by far the best method compared to rest. Hartman[14] carried out a method of dehulling sunflower seeds which was preceded by a thermal treatment in a pilot dryer using hot air at 70ºC during 1 hr. The seeds were broken in hammer mills and the hulls removed by floatation in aqueous medium. After the separation step the kernels were dried using hot air at 40ºC. This method required laboratory equipments and water. In the present study the sunflower seeds were dehulled by agitating in mixer (using disc type blade) and winnowing. This is mechanical method and requires no aqueous medium and it could be more suitable for household level processing. Bajaj[19] carried out manual dehulling of sunflower seeds. The seeds were soaked in luke warm water for 15min to loosen the hull. The seeds were then rubbed in the hands to remove the hulls; subsequently kernels were dried to a moisture content of 4-6 per cent and kept in refrigerator. In the present study several water soaking treatments were attempted but they have proved to be unsatisfactory in terms of labour and water required. Thus the mechanical method by agitating and winnowing was found more suitable. Gupta and Das[20] have described the performance of centrifugal dehulling system for sunflower seeds. In present study the rotational agitation was employed and found to be more effective than other methods that were tried. Therefore, this mechanism may be modified and standardized for future.

Per cent kernel recovery

Recovery of kernel by mechanical and manual methods is presented in the Table 4. The hull thickness, hull content, seed morphology, moisture content and hulling condition have a major influence on the efficiency of dehulling[21,22,23,24]. Pretreatments of seeds, such as drying, size grading and heat treatments, have been shown to affect the proportion of hulls removed by industrial hulling processes[25,26,27,28]. However, genetic factors also appear involved, implying differences in hullabilities between cultivars. Selection of sunflower varieties with high oil contents has led to a reduction in seed size and percentage hull, with kernels adhering very tightly to the hull (pericarp)[15,16]. These modifications in the structure of sunflower achenes probably changed their physical and mechanical properties, making hulling generally more difficult[28,29]. A high oil genotype generally has a small amount of hull. In addition it is likely to have a poor hullability. Large seed with low oil contents have the best hullabilities[9]. However, the thickness of the hull and its degree of lignifications may be important for certain genotypes or under certain conditions. According to Popova[28] and Morrison[30] breakage of the hull occurs more easily with thick, highly lignified and therefore rigid hulls. Large seeds generally hull better than small seed[9]. In addition, Roath[15] and Dedio & Dorrel[21] have reported negative correlations between oil content and hullability.

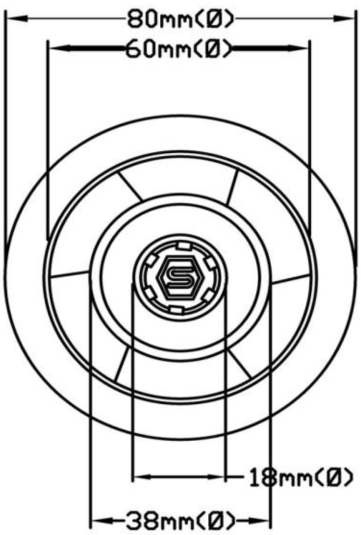
Cost of production of dehulled sunflower seeds

The calculation of the cost for the production of dehulled sunflower seeds is presented in table 5. The dehulling of sunflower seeds was carried out by agitating in mixer using disc type blade. The calculated cost of the dehulled sunflower seeds was estimated to be Rs. 80/per kg ($1.27). The cost of production of sunflower kernels at laboratory level was found to be lower (Rs. 80/kg or $1.27). If the dehulled seeds are produced at household level this cost would be even lower. Thus, inclusion of sunflower in the daily diet can be an economical way to diversify the diets. This study has demonstrated that small scale (household) dehulling of sunflower seeds can be performed. A large number of farmers are shifting to sunflower cultivation. Such a shift in cropping pattern can erode the dietary balance by diminished food choices. Small scale dehulling has applications in laboratory studies and product development research.

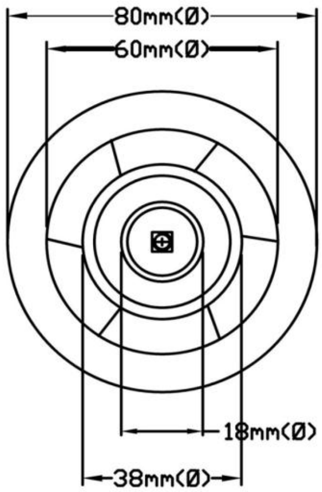
Fig. 1: Disc type blade used to dehull the sunflower seeds (Top view)

Fig. 2: Disc type blade used to dehull the sunflower seeds (Bottom view)

(A)



(B)



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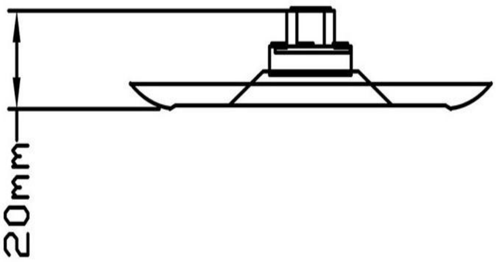

(D)

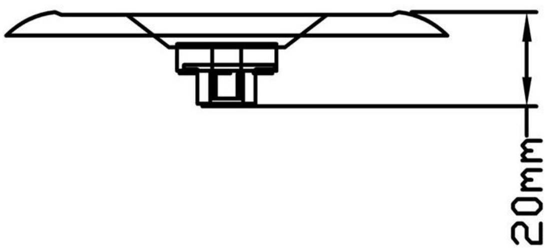

Fig. 3: Dimensions of the different sections of the blade used for dehulling of sunflower seeds. (a) Top view of the blade (b) Bottom view of the blade (c) Side view of the blade (d) Side view of the blade (inverse).
Ø: Diameter in millimeter

Table 1: Physical properties of seeds of selected varieties of sunflower

Varieties	Seed size (L/B ratio)	Weight of 100 seeds (g)	Volume (ml)	Bulk density (g/ml)
KBSH 44	2.18	5.39	14.00	0.38
KBSH 41	1.98	6.13	16.00	0.38
Confectionery-1	2.31	9.01	35.00	0.25
F-test	*	*	*	*
SEm±	0.03	0.23	0.47	0.004
CD	0.12	0.79	1.63	0.015

Significant at 5% level

Table 2: Proportions of hulls and kernels of selected varieties of sunflower

Varieties	Hull (%)	Kernel (%)
KBSH 44	31.15	68.85
KBSH 41	28.4	71.54
Confectonery-1	37.02	62.98
F-test	*	*
SEm±	0.172	0.17
CD	0.508	0.51

***Significant at 5% level**

Table 3: Effect of pretreatments on dehulling qualities of sunflower seeds

Treatment	Concentration	Removability	Color	Remarks
1. NaOH solution (boiled for 2 min and dried) 2. NaOH solution (boiled for 1 min and dried) 3. NaOH (boiled for 2 min and dried) 4. NaOH (boiled for 1 min and dried) 5. $CaCl_2$ (boiled for 1min 30 sec) 6. $CaCl_2$ (boiled for 5 min + soaked 15min and dried) 7. $CaCl_2$ (soaked for 15 min+dried) 8. NaCl (soaked for 15 min and dried) 9. $CaCl_2$ (boiled for 5 min + soaked overnight and dried) 10. Agitating in mixer (by using disc type blade)	5% 2% 5% 2% 1% 1% 2% 2% 2% -	+ + + + + + ++ ++ + +++ ++	+ ++ + ++ ++ ++ +++ ++++ ++ ++++ +	Not feasible for lab scale production Feasible for lab scale production

Removability: += Extremely difficult. ++= Moderately difficult, +++= Fairly easy, ++++= Moderately easy, +++++= Extremely easy. **Colour:** +=Extremely poor, ++=Moderately poor, +++=Fair, ++++=Moderately good, +++++=Excellent

Table 4: Recovery of sunflower kernel by mechanical and manual methods

	Mechanical method (%)	Manual method (%)
Hull	31.15	31.15
Kernel	60.0	68.85
Wastage	8.85	-
Recovery	87.14	100

Table 5: Cost of production of dehulled sunflower seeds

A. Fixed cost	Rupees
Processing equipment	5000
Managerial cost	250
Total	5250
Apportioned fixed cost *	Rs. 5.25
B. Variable cost	
Sunflower seeds (10kg)	370
Labor no. 1 (w)	100
Electricity	2.50
Packaging	2.50
Total	475
Cost of production **	Rs. 480.25
Yield of sunflower kernels per 10 kg	6 Kg
Cost per Kg of sunflower kernels	**Rs. 80 ($1.27)**

$$\text{Apportioned fixed cost} = \frac{\text{Total fixed assets (5250)}}{\text{Number of times used (1000)}} = \text{Rs. } 5.25$$

** Cost of production = Apportioned fixed cost+ Variable cost= Rs. 80 ($1.27)

CONCLUSION

Thus, this study revealed that dehulling qualities of sunflower seeds were influenced by the cultivars, oil content and physical characteristics. The removability of hull was poor in all pretreatments that were studied. Sunflower seeds were dehulled by mechanical method i.e. agitating in mixer fitted with disc type blade was found most acceptable method among other methods used.

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