The Pharma Innovation Journal 2022; 11(12): 1444-1450

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 1444-1450
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www.thepharmajournal.com
Received: 14-10-2022
Accepted: 18-11-2022

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Development and performance evaluation of field bean De-skinner

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Abstract
Deskinning of the field bean is one of the major problems which cause hindrance in commercial utilization. Presently it is done by hand which is unhygienic, tedious and time-consuming process. This causes hindrance among the consumer to purchase. The study was undertaken to develop and evaluate the performance of the field bean de-skinner. The field bean de-skinner was developed in both horizontal and rotary driving types using nylon, cloth and steel materials. The horizontal field bean de-skinner was evaluated by using both Nylon roller and cloth roller, likewise rotary type was evaluated by using both nylon and steel plates by maintaining an operating speed of 20-25 rpm and clearance between rollers/plates of about 5.4 -5.6 mm. The selected field beans were soaked for a period of 1, 2, 3 and 4 h and evaluated developed de skinner by measuring different efficiencies. De-skinning efficiency was found increasing trend with an increase in soaking time, whereas breaking efficiency and un-deskinning efficiency were found decreasing with an increase in soaking time. The rotary type field bean de skinner found higher de skinning efficiency and lower breaking and under-skinning efficiency (81, 5 and 10 per cent respectively) compared to horizontal type field bean de-skinner (72, 12 and 20 per cent respectively). The rotary type field de-skinner was found highly efficient with minimum breaking and under skinning efficiency compared to the horizontal type.

Keywords: Field bean, de-skinner, horizontal type, rotary type, soaking time, de-skinning efficiency, breaking efficiency and un-deskinning efficiency

1. Introduction
The diversification, quality enhancement and value addition in agriculture has become keywords of success in a trade at the international level. India grows the largest number of vegetables from temperate to humid tropics and from sea-level to snow-line. Vegetables combat undernourishment and are known to be the cheapest source of natural protective tools. Most of the vegetables, being short-duration crops, fit very well in the intensive cropping system and are capable of giving very high yields and very high economic returns to the farmers. Legumes are important sources of proteins, carbohydrates, dietary fibre and minerals. Only a few of the known legume species are extensively promoted and used. Field bean is a marginally known legume having the potential of reducing protein deficiency in developing and poor countries (Jhon, 2015) [11]. The young pods, unripe seeds of this plant are used as vegetables and the ripe seeds are used as pulses. The young pods and dried seeds of field beans contain 4.5 and 25 per cent protein respectively. Despite those good nutritional qualities, legume consumption is declining worldwide (D'Souza, 2013) [5].
Value addition is the process of changing the raw commodity into a quality end product, which helps to increase the ability to capture a percentage of the farm to retail price spread. Field bean is valued more for its green deskinned seeds than for pods. Field bean both in tender green and mature dry stages is consumed after cooking in India and parts of South America. Studies on nutrient composition showed that the bean is a good source of protein, carbohydrates and energy (Salimath *et al*., 1982) [20]. Soaking, cooking of pre-soaked beans and germination hold good potential for improving the nutritional value of field beans thereby increasing those utilization in food (Blanpied *et al*., 1978) [4].
In view of increasing value-added products, Deskinned field bean is widely used around the Karnataka region and some other parts of Andhra Pradesh and Maharashtra. The deskinned field bean is used in a variety of food recipes (value-added) such as upma, vada, sambar, sweets and mixtures. etc. (Hendricksen and Minson, 1985) [27] (Fig. 1). In order to improve these types of value addition, a greater number of deskinned field bean productions are important.

Field beans have a strong beany flavour and some people like to mix them with other beans or green vegetables. The immature seeds can be boiled and eaten like any shelly bean. In Asia, the mature seeds are made into tofu and fermented for Tempe. These are also used as bean sprouts. In Karnataka, the field bean is used for curry, salad, added to Upma and as a flavouring (Gowda, 2006a) [19].

Traditional processing methods alter the biochemical composition of field beans. The traditional method of deskinning such as hand pressing, pressing on the rough surface and pressing on the cloth (Fig. 2) consumes more time and labour, causes minimum production, reduces value-added products and export rate and also the addition of some additives for easy deskinning adversely affects on health and also reduces the nutritive quality of the field bean (Huxsoll and Bolin, 1989) [10]

Fig 1: Value added products of Field bean

Fig 2: Traditional method of Field bean deskinning

Deskinning of the field bean is one of the major problems which causes hindrance in commercial utilization. Now is done manually which is a very unhygienic, tedious and time-consuming process. This causes hindrance among the consumer to purchase. For reasons of expense, labour and hygiene, the catering industry aims to purchase vegetables and fruits that are already peeled and possibly also sliced, grated or shredded, that is, minimally processed. Consumers are increasingly demanding convenient, ready-to-use and ready-to-eat fruit and vegetables with a fresh-like quality and containing only natural ingredients (Lund, 1989) [13].

In view of the above, the present study was undertaken to develop and evaluate the performance of field bean de skinner.

2. Materials and Methodology

The field bean de skinner was developed in both horizontal and rotary driving types. The horizontal field bean de skinner was evaluated by using both nylon roller and cloth roller, likewise rotary type was evaluated by using both nylon and steel plates.

2.1 Nylon rollers

The 33 cm length of two sets of different diameters of knurled Nylon rollers were used for developing de skinner. The big (8.5 cm diameter) rollers were placed on the top for primary deskinning and smaller rollers (6 cm diameter) were placed at the bottom for secondary or final deskinning. (Fig. 3).

2.2 Cloth rollers

The 33 cm length and 8 cm diameter filtered cloth material rollers were used for developing and evaluating field bean de skinner (Fig. 4).

2.3 Nylon disc

The selected Nylon roller for the development of field bean de skinner had an outer diameter of 0.195 m, an inner diameter of 0.08 m and a thickness of 0.012 m with a working surface area of 0.024 m^2 (Fig. 5).

2.4 Steel disc

Likewise, Nylon disc the selected steel disc had an outer diameter of 0.195 m, an inner diameter of 0.0125 m and a thickness of 0.012 m with the working surface area of 0.0297 m^2 (Fig. 6).

Fig 3: Nylon Rollers

Fig 4: Cloth Rollers

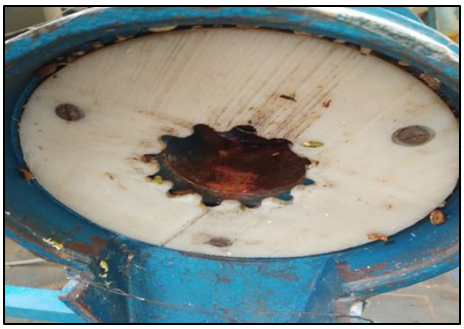

Fig 5: Nylon

Fig 6: Steel Disc

2.5 Variable frequency drive (VFD)

The variable frequency drive was used to control the speed and torque of the AC motor by varying input frequency and voltage.

2.6 Working principle of Field bean de skinner

The developed field bean de skinner consists of either horizontal type (Fig. 7) or rotary type (Fig. 5 and 6) deskinning mechanism made of rollers (cloth material roller, knurled Nylon roller) or discs (steel and nylon disc) respectively rotating in opposite direction at different speeds. A feeder feeds soaked beans uniformly to the machine. Among the rollers (or discs in case of rotary type) one was fixed while the other was adjustable to maintain the desired clearance between the rollers. The clearance was maintained at about 5.4 to 5.6 mm throughout the experiment. The rollers (or discs) were rotated at desired different speeds from the motor through the belt drive transmission. The speed was controlled with the help of VFD by varying the torque and frequency. The speed of the rotating rollers was maintained at 20-25 rpm throughout the experiment. The difference in surface speed of the rollers (or discs) develops shearing force on a grain surface resulting in the opening and breaking of the outer layer (skin) of the field bean (deskinning). In the case of the Nylon roller field bean dehusking one more set of small-sized same-length nylon rollers were fixed in the same way just below the big size Nylon rollers to improve the dehusking efficiency.

Fig 7: Developed Horizontal type Field bean Deskinner

Parameters considered during the experiment

Table 1: Parameters considered during the experiment

Sl. No.	Parameters	Levels	Values
Independent parameters			
	Number of samples	1	100
	Soaking time, h	4	1,2,3,4
	Types of rollers	2	Cloth and Nylon
	Types of discs	2	Steel and Nylon
	Clearance, mm	1	5.4-5.6
	Rotating speed, rpm	1	20-25
Dependent parameters			
	Deskinning efficiency, per cent		
	Breaking efficiency, per cent		
	Un-deskinning efficiency, per cent		

Deskinning efficiency It was calculated by using the following formula

$$\text{Deskinning efficiency (\%)} = \frac{\text{Amount of deskinned field bean (in numbers)}}{\text{The total amount of input field bean (in numbers)}} \times 100$$

Breaking efficiency It was assessed by the following formula

$$\text{Breaking Efficiency} = \frac{\text{Amount of broken grains (in numbers)}}{\text{The total amount of input field bean (in numbers)}} \times 100$$

Un-deskinning efficiency It was assessed by using the below-mentioned formula

$$\text{Un} - \text{deskinning efficiency (\%)} = \frac{\text{Amount of unskinned field bean (in numbers)}}{\text{The total amount of input field bean (in numbers)}} \times 100$$

3. Results and Discussion

The performance evaluation of developed horizontal type field bean de skinner with Nylon and cloth rollers and rotary type field bean de skinner with steel and Nylon plate were conducted at fixed motor speed and clearance under desired conditions. The collected samples were soaked for different durations such as 1, 2 3 and 4 h and the evaluations were conducted for soaked field beans. The efficiencies of all types of field bean de-skinners were computed by the above-mentioned formulae and the results were discussed below.

3.1 Deskinning efficiency

The field bean de skinning efficiency resulted higher in rotary type de skinner as compared to horizontal type de skinner. The rotary type found 81 per cent, whereas the horizontal type found 72 per cent deskinning efficiency at 4 h soaking time (Fig. 8). It was about 12.5 per cent higher than the horizontal type. From Figures 7, 8 and 9 observed that the de skinning efficiency was directly related to soaking time. It was increased with an increase in soaking time and found to a maximum at 4 h soaking time in both types of de skinner. This may be due to the maximum soaking time smoothens the outer layer of the field bean.

Particularly in horizontal type de skinner, nylon roller found higher deskinning efficiency of 72 per cent, while cloth roller found 40 per cent at 4 h soaking time (Fig. 9). It was about 80 per cent higher than the cloth roller.

Similarly, in rotary type field bean de-skinner, both types of discs namely nylon and steel discs resulted in similar de skinning efficiency with minimum difference. Nylon disc resulted from higher de-skinning efficiency of 81 per cent, whereas steel disc found 80 per cent at 4 h. soaking time (Fig. 10).

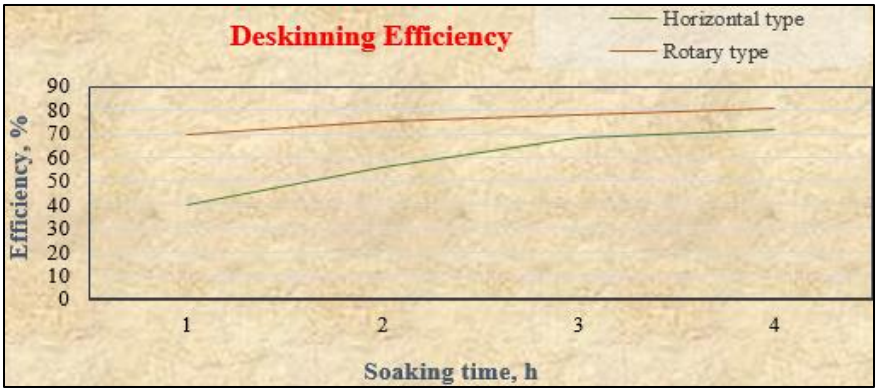

Fig 8: De-skinning efficiency between horizontal and rotary type de skinner

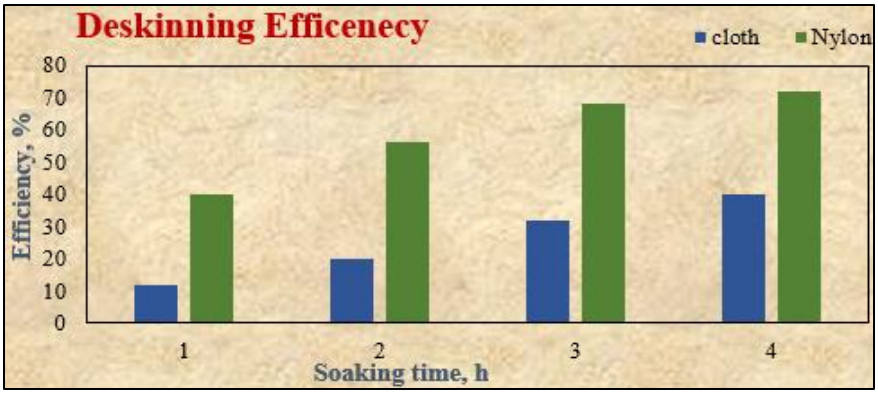

Fig 9: De-skinning efficiency of horizontal type

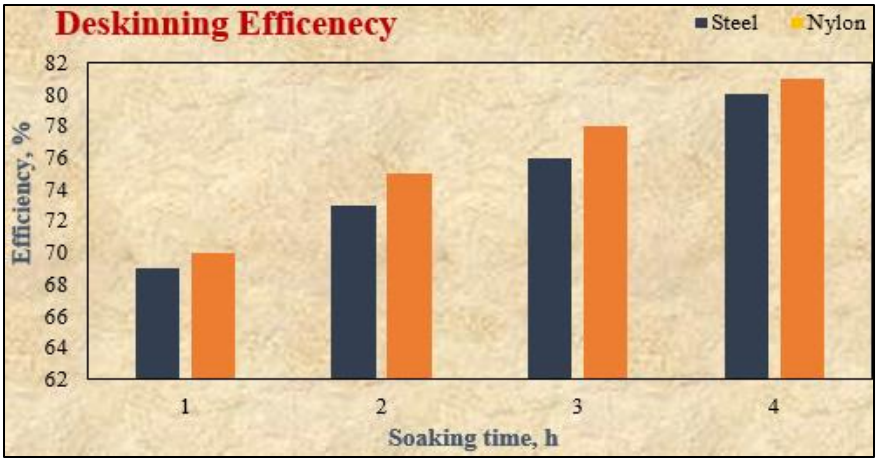

Fig 10: De-skinning efficiency of rotary type

3.2 Breaking Efficiency

The field bean braking efficiency resulted from a minimum in rotary type de skinner as compared to horizontal type de skinner. The breaking efficiency at 4 h soaking time is found as 5 per cent in rotary type and 12 per cent in horizontal type de skinner (Fig. 11). It was about 140 per cent lower than the horizontal type. Figures from 10-12 indicated that the breaking efficiency was indirectly related to soaking time. It was decreased with an increase in soaking time and found minimum at 4 h soaking time in both types of de skinner. This may be due to the maximum soaking time smoothens the outer layer of the field bean thereby reducing the breakage of the field bean during de-skinning.

In horizontal type de skinner, cloth roller found minimum breaking efficiency of 12 per cent, while nylon roller found 16 per cent at 4 h soaking time (Fig. 12). It was about 33.33 per cent minimum compared to the nylon roller. Likely in rotary type field bean de skinner, both types of discs namely nylon and steel discs resulted in similar breaking efficiency. Nylon disc resulted in minimum de-skinning efficiency of 5 per cent, whereas steel disc found 6 per cent at 4 h soaking time (Fig. 13).

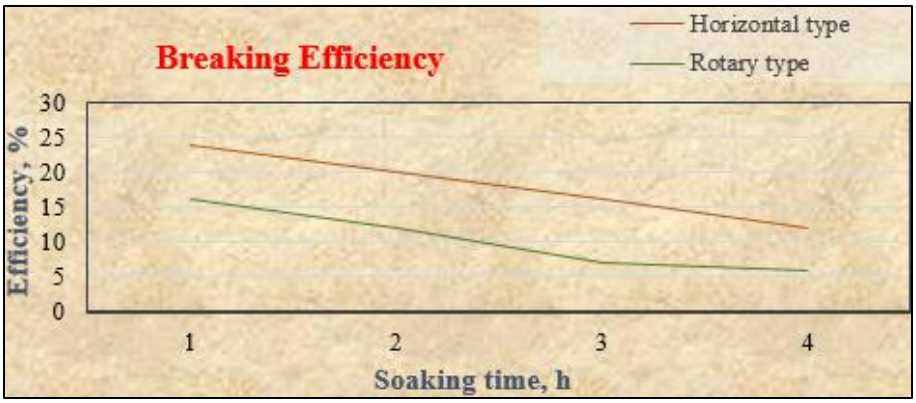

Fig 11: Breaking efficiency between horizontal type and rotary type

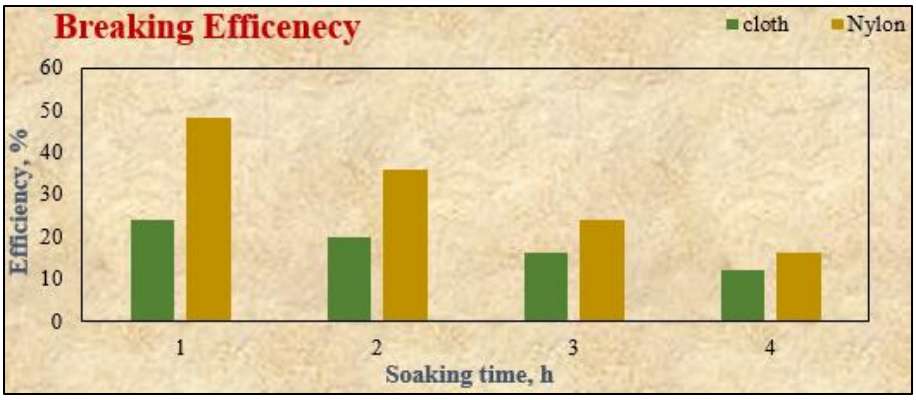

Fig 12: Breaking efficiency of horizontal type

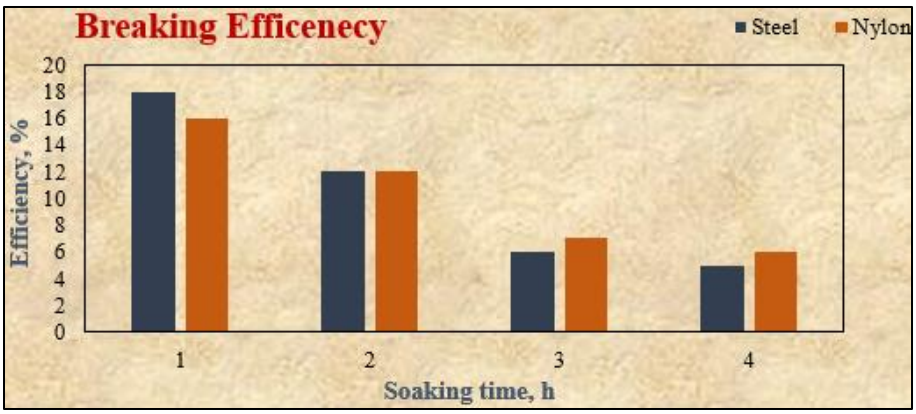

Fig 13: Breaking efficiency of vertical type

3.3 Un-deskinning Efficiency

The field bean un-deskinning efficiency resulted in a minimum for rotary type de skinner as compared to horizontal type de skinner. The rotary type found 10 per cent, whereas the horizontal type found 20 per cent un-deskinning efficiency at 4 h soaking time. It was about 100 per cent lower than the horizontal type (Fig. 14). Figures 13-15 indicated that, the un-deskinning efficiency was indirectly related to soaking time. It was decreased with an increase in soaking time and found minimum at 4 h soaking time in both types of de skinner. This

may be due to maximum soaking time loosening or smoothening of the outer layer and producing a maximum number of deskinned field beans thereby reducing the un deskinning efficiency.

Particularly in horizontal type de skinner, nylon roller found minimum breaking efficiency of 20 per cent, while cloth roller found 48 per cent at 4 h soaking time (Fig. 15). It was about 140 per cent minimum compared to cloth roller.

Similarly, in rotary type field bean de skinner, both types of discs such as nylon and steel discs resulted in similar un-deskinning efficiency. Nylon disc resulted in minimum de-skinning efficiency of 10 per cent, whereas steel disc found 11 per cent at 4 hr. soaking time (Fig. 16).

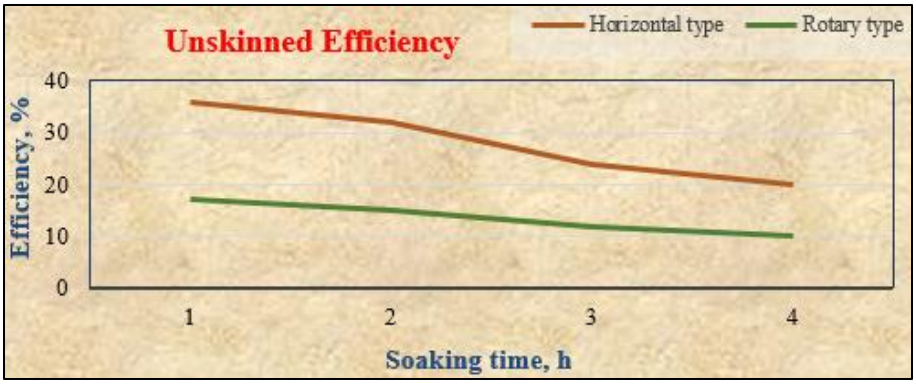

Fig 14: Un-deskinning efficiency between horizontal and rotary type

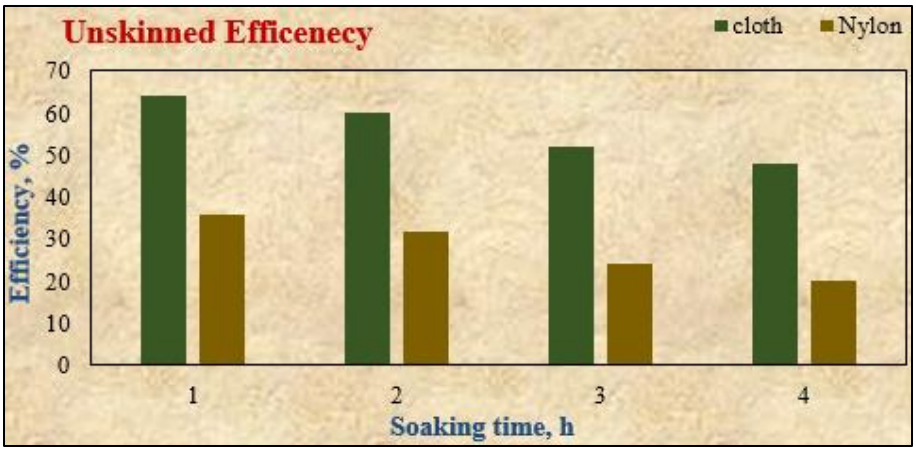

Fig 15: Un-deskinning efficiency of horizontal type

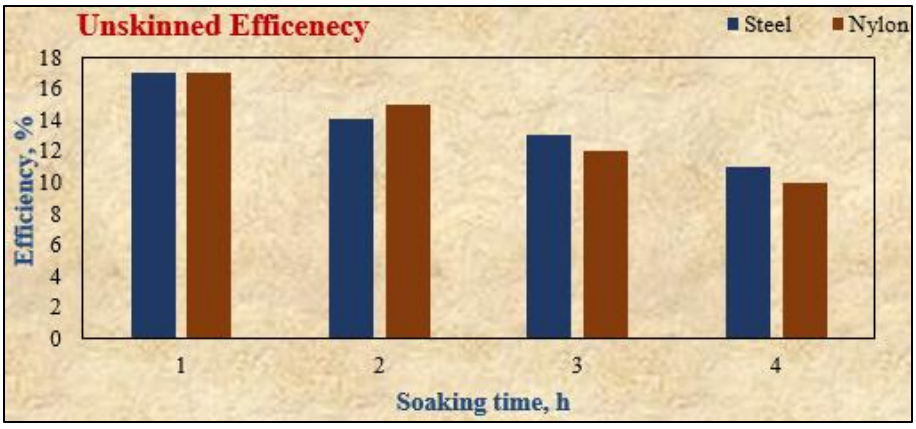

Fig 16: Un-deskinning efficiency of rotary type

4. Conclusion

The de-skinning of the field bean is a very difficult and time-consuming process. For better performance of the de skinner, the de-skinning efficiency should be maximum, un de-skinning and breaking efficiency should be minimum. The obtained results indicated that the rotary type field bean de skinner found higher de-skinning efficiency and lower un-deskinning and breaking efficiency compared to horizontal type field bean de skinner at the same soaking time. Hence, rotary type field bean de skinner was found better performed and highly efficient field bean de skinner compared to horizontal type field bean de skinner.

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