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MICROWAVE ASSISTED DEHULLING OF BLACK GRAM (VIGNAMUNGO L)

Manoj Kumar Muttaluri and Dr. R.C. Verma
CTAE College, MPUAT University, Udaipur, Rajasthan, 313001

Abstract: Pulses are the edible seeds of pod-bearing plants belonging to the family of leguminosae and are widely grown throughout the world. They are known to be the reserves of nutrients providing energy, dietary fibre, protein, minerals and vitamins required for human health. India ranks first in pulse production by contributing about 27% to the global pulse production and about 30 percent of the total consumption in the world of 72 million tonnes. Black gram (*Vignamungo L*) or urad is one of the important pulses containing 24% protein, 59.6% carbohydrate and 1.4% fat. India is the largest producer and consumer of black gram which accounts for more than 40 % of total legume seeds traded in the world.
According to estimate made by different scientists, the post-harvest losses in pulses were in the range of 25-30%. The major losses are caused at the stages of drying, milling and storage. As per estimated of 15 million tons of pulse production, 75% i.e., 11.25 million tons goes for milling, taking 15% losses into account, 1.69 million tons of produce is lost in milling alone, which if saved by adopting improved pre-treatment milling methods and machineries.
The present work was undertaken with an overall objective to study the effect of microwave application, *viz.,* energy input (power level), exposure and dosage, on the dehulling of black gram.
The dehulling time of the black gram samples decreased with increasing time and microwave power. It decreased from 29 to 22 s, 24 to 19 s and 22 to 17 s at 540, 720 and 900 W. A maximum dehulling yield observed was 85% at 900 W power levels at an exposure time of 5 minutes. The maximum dhal yield of 82% was observed at a microwave power level of 900 W at an exposure time of 5 minutes. The maximum dehulling loss was observed was 11.50% at a microwave power level of 540 W for an exposure time of 5 minutes. The optimization step was performed in order to determine the right combination of treatment process variables in order to improve the dehulling of black gram.
Keywords: Microwave, power, exposure time, dehulling time, dehulling yield, dhal yield, dehulling loss.

INTRODUCTION

Black gram (*Vignamungo L*) or urad is one of the important pulses containing 24% protein, 59.6% carbohydrate and 1.4% fat (Gopalan *et al.,* 1989). India is the largest producer and consumer of black gram which accounts for more than 40 % of total legume seeds traded in the world (CRN India, 2011). It was grown in about 31.92 lakh ha area to produce about 1.83 million tonnes in 2011-2012 (Reddy, 2013).

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Black gram dhal is a common dish in South Asia. Pulses are reported to contain anti nutrients in seed coat. Also, the seed coat is hard and imparts a bitter taste, reducing the palatability of the pulses. In order to remove the anti-nutrients and improve the palatability, it is common practice to dehull the pulses before using. Dehulling is a process of removal of hull from the cotyledon of pulses. It reduces the fibre content and improves appearance, texture, cooking quality, palatability and digestibility of grain legume (Tiwari *et al*., 2007). Dehulling of black gram has been a difficult operation due to the presence of vitreous layer of gums and mucilages, which makes bond between hull and cotyledon stronger. Pulse dehulling constitutes two major steps, *viz.,* loosening of the hull followed by its removal in suitable milling machine (Narasimha *et al.,* 2003).

Black gram is traditionally pre-treated by the dry method which involves pitting and oiling the pulses followed by conditioning by sun drying for 2 to 3 days and tempering by adding water (2-5%) and heaping overnight before dehulling. The process is labour intensive, time consuming and needs a fair amount of edible oil for processing. In addition, losses in the form of powder and broken seeds lead to less milling yields, which varies from 65% to 70% in Indian pulse mills depending upon the variety, climatic conditions and milling machinery used (Tiwari *et al.,* 2011).

It has been reported by several researchers that heat treatment significantly improves the protein quality in pulses by destruction or inactivation of the heat labile anti-nutritional factors. Soaking the grains in water before treating and milling will conditions the grains as well as loosens the hull. It helps in dehusking and splitting of kernels during milling. Microwave heating technology has also been reported in pulse processing to reduce post-harvest losses during drying, milling, cooking and storage. By drying with microwave heating technology, a significant reduction in drying time with improved quality of the produce is obtained.

Heating by microwave would disrupt the bondage between the hull and cotyledon of pulses by denaturing the protein and gums present between them. The information on the rate of microwave and infrared power application, dosage required to get the desired effect are essential in order to assess the suitability of the process

So far, no study has reported the effect of microwave on the dehulling of black gram. Keeping this in view, the present work was undertaken with the objective to study the effect of microwave application on the dehulling parameters of black gram.

Materials

Samples

Black gram of good quality will be purchased from the local market. It was cleaned well to remove the extraneous matter before conducting the experiments. Then the moisture content of the samples will be found out before starting the experiment.

Microwave oven

A domestic microwave oven (Bajaj 2800 ET-B) having the operation frequency of 2,450 MHz and maximum input power of 1,300 W was used to conduct the experiment. The rated power output from the microwave oven is 900W corresponding to 100 % power level. The oven has facility to change the power levels from 10 to 100 % at an interval of 10%.

Prototype infrared dryer

A prototype infrared dryer was used here for the experiments. It has got two chambers, one for infrared emission and the second for giving additional heated air. The first chamber is fitted with infrared emitting elements which has a maximum power output range up to 1000 W and can be controlled using variac attached to it. The temperature inside the drying chamber can be adjusted using temperature indicator and controller. The second chamber has got a blower and heater. The blower speed and heating inside the drying chamber is adjustable using air heater. The blower speed range is from 1 m/s to 12 m/s.

Emery roll polisher

A small laboratory model emery roll polisher (INDOSAW) attached with a motor was used for milling the treated samples. The rpm of the roller would be kept constant.

Methodology

Conditioning

A cleaned black gram of 100 g size was soaked into the beakers of 100 ml size and filled with normal tap water. The soaking time was 1 hour constant to each and every sample. After 1 hour of soaking time these samples was allowed to dry in hot air oven to bring down the moisture content to 11% which is a standard milling moisture content (chakraverty et al . 1981).

Microwave treatment

A sample of 100 g conditioned black gram was taken into a glass dish of 155 mm diameter and transfer on the turn table in the microwave oven. Three levels of microwave energy input, viz., 450, 750 and 900W, was applied each for 6 different exposure times ranging from 100 to 200 s at an interval of 20 s. The depth of sample in the dryer was maintained to single grain height that will be approximately 5 mm. The maximum exposure time was set through preliminary study corresponding to the beginning of the emergence of roasted smell. The microwave dosage supplying to the black gram will be calculated by relation (Yadav et al. 2013)

$$\text{Microwave dosage (J/g)} = \frac{\text{microwave power (W)} \times \text{Microwave exposure time (s)}}{\text{Initial weight of black gram (g)}}$$

Dehulling procedure

Dehulling of black gram was performed in the laboratory model emery roll polisher (Indosaw). Dehulling continued till the complete removal of husk achievement in all grains and corresponding dehullingtime was noted. After dehulling, the different fractions were collected and graded as dehulled whole and split, broken, fine brokens and powder. They were weighed separately and noted for further analysis. All samples was hulled in triplicates.

Analysis of dehulling properties of black gram

The dehulling properties of black gram was assessed in terms of dehulling time, dehulling yield, dhal yield and losses.

Dehulling time

Dehulling time was defined as the duration of dehulling of black gram for complete removal of husk from the cotyledons, i.e., 100 % dehulling of the grains.

Dehulling yield

Dehulling yield was defined as the quantity of total whole dehulled kernels and broken kernels (except fine brokens, powder and husk) that are produced in the dehulling of pulses. Head kernels were defined as the kernels retained over the sieve no. 10 (BSS mesh). Broken was defined as cotyledon retained on sieve no. 30 and pass through sieve no. 10 (BSS mesh). Fine broken was defined as the broken that passed through sieve no. 30 (BSS mesh). The dehulling yield was calculated using the relation given by (Goyal et al. 2007).

$$\text{Dehulling yield (\%)} = \frac{\text{weight of dehulled kernels (g)} + \text{weight of brokens (g)}}{\text{Initial weight of black gram (g)}} \times 100$$

Dhal yield

Dhal yield (from APQ Method 104.1, Burridge et al. 2001) was defined as the yield of dehulled whole and split kernels (dhal) as a percentage of original seed weight. It was calculated by the relationship given below by (Goyal et al. 2007).

$$\text{Dhal yield (\%)} = \frac{\text{Mass of dehulled whole and split seeds (g)}}{\text{Initial weight of black gram (g)}} \times 100$$

Dehulling loss

Dehulling loss was calculated as the weight fraction of the powder and fine broken relative to the total weight of the grain used for dehulling. It was calculated using the relationship given by (Goyal et al. 2007).

$$\text{Loss (\%)} = \frac{\text{weight of the powder obtained (g)} + \text{weight of the fine broken (g)}}{\text{initial weght of black gram}} \times 100$$

Statistical analysis:

Design-expert version 10.02 was used for designing of the experiment. In design expert under response surface the hybrid design was suggested according to the preliminary studies and the further research was under gone by using the hybrid design of the experiment. Further optimization of process parameters were done by using the same software.

Results and Discussion

Temperature:

The average surface temperature of the black gram grains subjected to microwave treatments has been recorded and presented in Table 1. The average surface temperature increased with the increase in exposure time at all power levels. It was also observed that with the increase in the microwave power the average surface temperature of the grains increased. At 540 W, as the exposure time was increased from 5 to 9 min the average surface temperature of the grains increased from 65 to 98 °C. Corresponding increase in temperature at 720 and 900 W for the same timings of treatment were 83 to 118 °C and 91 to 143 °C respectively. The average surface temperature varied approximately linearly with the exposure time at all the microwave power levels. But the rate of temperature increase per unit dosage was different at different power level.

Table 1: Effect of MW exposure on the average surface temperature

MW power (W)	MW exposure time (min)	Average surface temperature (°C)
540	5	65
	7	81
	9	98
720	5	83
	7	109
	9	118
900	5	91
	7	124
	9	143

Table 2 Effect of microwave treatment on the dehulling qualities of black gram

MW power (W)	MW exposure time (min)	Dehulling parameters			
		Dehulling time (s)	Dehulling yield (%)	Dhal yield (%)	Dehulling loss (%)
540	5	29	79	75	11.5
	7	25	81	78	7.5
	9	22	83	80	9
720	5	24	80	77	10
	7	21	83	78	8
	9	19	81	77	9
900	5	22	85	82	8
	7	19	80	78	6
	9	17	78	75	10

Dehulling time

The dehulling time of the black gram samples decreased with increasing exposure time and microwave power. It was found to decrease from 29 to 22 s, 24 to 19 s and 22 to 17 s at 540, 720 and 900 W power levels (Table 2). It might be due to the grains subjected to higher temperature which might have caused disruption of the bonds between the seed coat and the cotyledon made of gums and mucilages. Similar effect was also reported by Joyner & Yadav (2013). When the grains are dried they shrink more than the seed coat which creates the gap between the seed coat and the cotyledon. The seed coat thus loosened enabling its easy removal. The variation in dehulling time with microwave power level and exposure time is presented in Fig 1. Out of several model used to represent the process, it was found that the quadratic relationship represented the process satisfactorily. The relationship could be

$$R_1 = 21 - 3P - 2.83\,T + 0.50\,PT + P^2 + 0.5\,T^2 \qquad \ldots(1)$$

P = Power

T = Exposure time

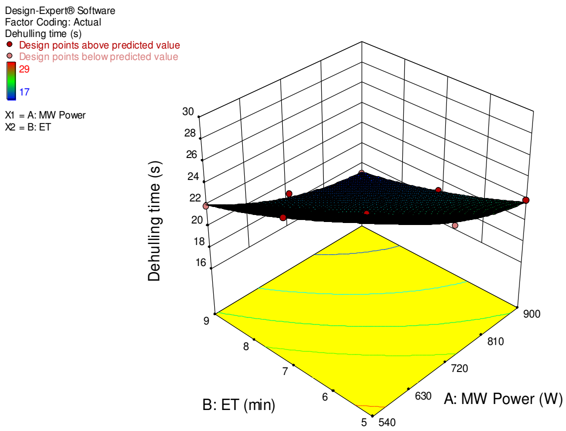

Fig.2: RSM for Dehulling time

Dehulling yield

The Dehulling yield was recorded for each microwave power levels viz., 540W, 720W and 900W for each exposure time varying from 5 to 9 min and presented in Table 2. It was found that the dehulling yield varied from 79% to 83% at 540W, 80% to 81% at 720W and 85% to 78% at 900W with increase in exposure time from 5 to 9 min. The variation in dehulling yield with microwave power level and exposure time was shown in Fig 2. It can be inferred from Fig 2 that dehulling yield increased with increase in micro wave power levels upto 720W and then decreased at the higher exposure time. It was observed that the dehulling yield increased from 79% to 85% where power levels were increased from 540 to 900W. The yield decreased in a manner of 85% to 78% for 900W at the exposure time of 9 min. A maximum dehulling yield 85% was observed at 900 watts power level and at an exposure time of 5 minutes. Out of several model used to represent the process, it was found that the quadratic relationship represented the process satisfactorily. The relationship could be

R_2= 82.55-2.75PT …(2)

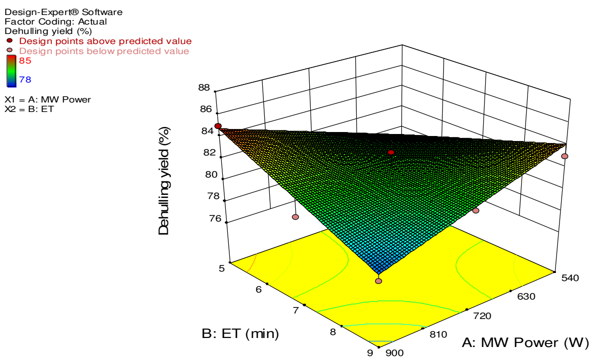

Fig.2: RSM for Dehulling yield

Dhal yield

TheDhal yield was recorded for each microwave power levels viz., 540W, 720W and 900W for each exposure time varying from 5 to 9 min and presented in Table 4.4. It was found that the dhal yield varied from 75% to 80% at 540W, 77%, 78% & 77% at 720W and 82% to 75% at 900W with increase in exposure time from 5 to 9 min. The variation of dhal yield with microwave power level and exposure time was shown in Fig 3. It can be inferred from Fig 3 that the dhal yield was increased with increase in microwave power level and exposure time up to 900W 5 min and then decreased as in the case of dehulling yield at the higher ET. The dhal yield increased from 75 to 82% as the power levels and ET increases. Out of several model used to represent the process, it was found that the quadratic relationship represented the process satisfactorily. The relationship could be

$R_3 = 77.86 - 3PT$ …(3)

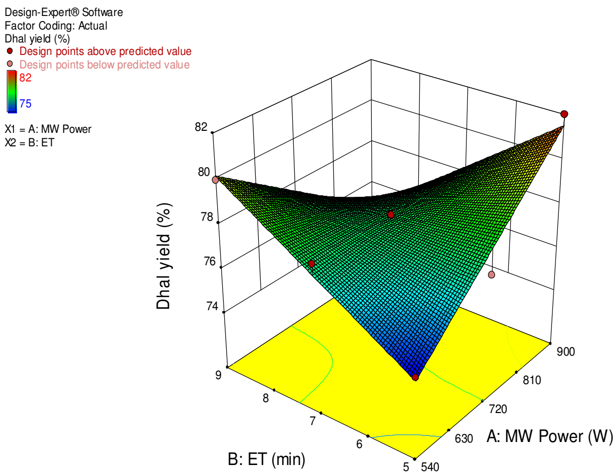

Fig.3: RSM for Dhal yield

Dehulling loss

TheDehulling loss was recorded for each microwave power levels viz., 540W, 720W and 900W for each exposure time varying from 5 to 9 min and presented in Table 4.4. It was found that the dehulling loss varied from 11.5% to 10% at 540W, 10%, 8% & 9% at 720W and 8%, 6% & 10% at 900W with increase in exposure time from 5 to 9 min. The variation of dehulling loss with micro wave power level and exposure time was shown in Fig 4. It can be inferred from Fig 4 that the dehulling losses gradually decreased with the increase in micro wave power level and exposure time. The loss increased slightly with the increase of power level and exposure time (ET) at the higher limits of levels. The losses range from a minimum of 6% to 11.50%. The maximum dehulling loss was observed was 11.50% at a microwave power level of 540 watts for an exposure time of 5 minutes. The minimum dehulling losses were observed at a maximum microwave power level of 900 watts for an exposure time of 7 minutes which was 6%.Out of several model used to represent the process, it was found that the quadratic relationship represented the process satisfactorily. The relationship could be

$$R_4 = 7.81 - 0.67P + 1.13PT + 2.16T^2 \quad \ldots(4)$$

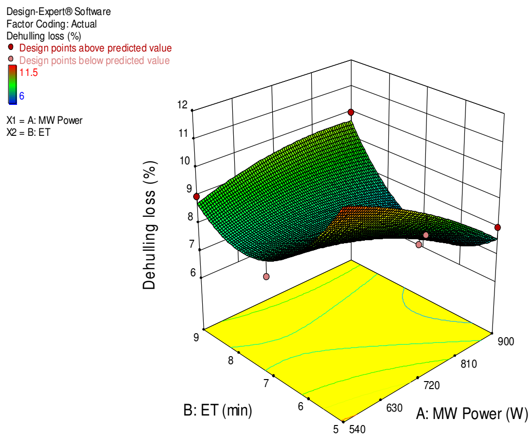

Fig.4: RSM for Dehulling loss

Summury

Increase in the microwave power and exposure time increases the surface temperature of the grains. At 540 W, as the exposure time was increased from 5 to9 min the average surface temperature of the grains increased from 65 to 98 °C. Corresponding increase in temperature at 720 and 900 W for the same timings of treatment were respectively, 83 to 118 °C and 91 to 143 °C. The dehulling time of the black gram samples decreased with increasing time and microwave power. It decreased from 29 to 22 s, 24 to 19 s and 22 to 17 s at 540, 720 and 900 watts. Dehulling yield was increased with increase in micro wave power level and exposure time, it was observed that the dehulling yield increased in the range of 79% to 85% for 540, 700 and 900 watts respectively.

A maximum dehulling yield observed was 85% at 900 watts power level and an exposure time of 5 minutes. The maximum dhal yield of 82% was observed at a microwave power level of 900 watts and an exposure time of 5 minutes. A minimum dhal yield was observed at 540 watts for an exposure time of 5 minutes which was 75%.The maximum dehulling loss was observed was 11.50% at a microwave power level of 540 watts for an exposure time of 5 minutes. The minimum dehulling losses were observed at a maximum microwave power level of 900 watts for an exposure time of 7 minutes which was 6%.

Microwave power level of 900 watts at an exposure time of 5.309 minutes give the corresponding best responses which were dehulling time 21.33s, dehulling yield 83.56%, dhal yield 81.12%, dehulling loss 7.64% with a desirability of 0.806.

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