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Preliminary treatments of Browntop and effect on performance indices, physical and geometrical properties of grain

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ABSTRACT

In the present study Browntop (BT) millet was subjected to three different treatments viz., mechanical stress, hydrothermal treatment and combined treatment (mechanical and hydrothermal) to enhance the dehulling efficiency and studied for its performance indices and its impact on physical, grain dimensions and therefore geometrical dimensions. Different treatments on grain before dehulling has shown significant improvement in the dehulling index up to 93%, coefficient of dehulling up to 96.88 %, and overall dehulling efficiency up to 96.73% compared to control. Principal axial dimensions, physical properties, and geometrical parameters of the produce were calculated to evaluate the grain vulnerability to the above treatments. Bulk Density and true density resulted in no significant difference between control and treated samples of browntop millet whereas porosity had significant difference. Principal dimensions such as length, width and thickness had not differed significantly in browntop millet. Geometric dimensions of browntop millet such as GMD, AMD, slenderness ratio, aspect ratio, sphericity, surface area and volume were evaluated and had no significant difference for control and treated samples except for volume of the grain($p<0.01$). Thus the study revealed that preliminary treatments had shown significant impact on dehulling efficiency without disrupting physical properties, grain dimensions and geometric parameters

Keywords Browntop millet, pretreatments, performance indices, geometrical properties.

1.INTRODUCTION

Millets aka *Nutri-cereals* need no introduction these days. Every single academic or formal organisation /event promotes millet as United Nations declared existing year as International Year of Millets. Though the chronicles of millet is enigmatic it’s strikingly incredible because it was negligible since decennium but making advent as super potential grain now. Once termed as skint one's grain currently enchanted as nutri-grain and treasure trove of bioactive components. This four seasons crop now proclaimed as ecological imminent guardians as they are obstinate to large number of pests and insects; effortlessly produced in dry lands, consume less water for irrigation thus inimitable in exploiting minimum natural resource and aid in boosting sustainable agricultural farming whereas other most consuming cereals like rice and wheat are side-lined in this facet.

In this perspective, to make the connection between the positive things millet processing is certain manner to continue to deploy millets. To ease the utilisation, processing of millets is the major concern and compelling necessity. It cutbacks anti nutrients and enhances absorption and bioavailability of nutrients. Basically millet processing can be broadly categorised into two streams namely essential/primary processing and secondary processing/value addition. Essential processing should give high quality output and involve steps such as cleaning, grading, and dehulling. Value addition is conversion of millets into pre-prepared form or consumable form by application of modern technologies such as flaking, extrusion, baking etc. But quality output of grain was not upto par in the essential processing stage as dehulled grain yield is nominal and economically unviable.

Dehulling is one of the most critical steps in essential processing that removes and separates inedible husk from the edible portion of the grain as minor millets husk is highly cellulosic and firmly attached to edible portion. As existing technologies are unable to yield better solutions this study was designed to standardise and optimise certain pre-treatments before dehusking/dehulling as only dehulling cannot afford manageable output (Mannuramath,2015). Application of *hydrothermal treatment* and *mechanical stress* for a short duration by means of abrasive dehuller are the pre-treatments selected to soften the husk prior to dehulling. The study focussed on optimisation of pre-treatments before dehulling and evaluated output through certain dehulling indices. Assessment of the throughput in virtue of principal axial dimensions, physical and geometrical properties was done to substantiate the treatments.

2.METHODOLOGY

Browntop (BT) was procured from local market of Madurai. It was cleaned from physical impurities,foreign particles and immature grains and used for further processing. The experiment performed in Millet Processing and Incubation Centre, PJTS Agricultural University, Rajendra nagar, Hyderabad. Total experiment was carried out in room temperature and precautions taken to maintain the grain moisture content in the range of 10°c to 12°c which was ideal for primary processing of the minor millets.

In this experiment the cleaned control sample was first dehulled in centrifugal dehuller [C] then experimental samples was subjected to three pre-treatments before centrifugal dehulling:

1. Cleaned grains subjected to abrasive dehulling [A] for a duration of 2[A_2] minutes, 4[A_4] minutes and 6[A_6] minutes to soften the husk and then dehulled in centrifugal type of dehuller [C]
2. Cleaned grain was subjected to hydrothermal treatment i.e soaked for 4 hours and dried in tray drier followed by centrifugal dehulling [HC] (Swapna et al 2020).
3. In this method a combination of above two methods were applied. Initially grains were given hydrothermal treatment followed by abrasive dehulling [HA] for a period of 2 minutes [HA_2], 4 minutes [HA_4] and 6 minutes [HA_6] followed by centrifugal dehulling.

Outcome of dehulling was evaluated based on produces of the dehulling process: initial weight of grain sample(i) and critical components such as whole kernel(k) that includes both dehulled and brokens, dehulled grain(d), undehulled grain(u), husk(h), broken grits (b) as coarse grits(cg) and fine grits (fg) were noted for calculating performance indices.

2.1 Performance indices of dehulling (Balasubramanian *et al* 2020):

(i) Dehulling index (DI): The dehulling index was calculated for the following equation.

$$DI = \lfloor (k+h) - (u+b) \rfloor * 100 \qquad (1)$$

The dehulling index range from higher value of +1 to bottom value of -1. A positive decimal value nearing one specifies completeness of dehulling whereas negative decimal value specifies inefficiency in dehulling that has more output in undehulled grain and hull rather than dehulled grain and the results were expressed in percentage (Ikebudu *et al*., 2000).

(ii) Coefficient of dehulling (CoD): This can be calculated using the following equation:

$$CoD = 100\lfloor 1 - (Yield\ of\ broken + Effectiveness\ of\ Dehulling + Yield\ of fine)\rfloor \qquad (2)$$

(iii) Overall Dehulling Efficiency (ODE): This is calculated using the following relationship

$$ODE = Husk\% + Quality\ of\ dehullingXCOD \qquad (3)$$

2.2 Physical properties of grain

Bulk density, true density and porosity was determined for all the grain samples. (Shepherd *et al* 1986). Bulk density (BD) of grains was determined by taking the weight of grain in fixed volume and calculated ratio of both and expressed in *g/ml*. And true density (TD) is determined using toluene displacement technique and values expressed as g/ml.

Porosity was calculated based on the grain bulk density and true density ratios and expressed in percentage.

$$Porosity\ (\varepsilon)\ \% = 1 - \left[\frac{Bd}{Td}\right] X100 \qquad (4)$$

2.3 Measurement of axial dimensions

The vernier callipers (least count of 0.01 mm) was used for measuring all linear dimensions namely length (L), width (W) and thickness (T) of randomly five selected grains of control and treated samples(Sreenarayanan *et al* 1988)

2.4 Geometric dimensions

2.4.1 Geometric Mean Diameter (GMD)

The geometric mean diameter also called as equivalent diameter calculated by using the method recommended by Sahay and Singh (2001).

$$\text{GMD in mm} = (LWT)^{1/3} \qquad (5)$$

2.4.2 Arithmetic mean diameter (AMD)

The arithmetic mean diameter (AMD) of grain sample was calculated by the procedures of Mpotokwane *et al* (2008) using below equation.

$$\text{AMD in mm} = \frac{L+W+T}{3} \qquad (6)$$

2.4.3 Slenderness Ratio (SR)

Determination of slenderness ratio by calculating ratio of grain length to width) (Bagheri et al., 2011).

2.4.4 Aspect ratio (AR)

The aspect ratio (%) of grain was calculated using below mentioned formula as per method of Vanramkhasti et al. (2008) as follows:

$$Aspect\ ratio\ (in\ \%)\ = \frac{W}{L} * 100 \qquad (7)$$

2.4.5 Sphericity(SP)

Sphericity is the ratio of volume of solid to the volume of circumscribed sphere that has a diameter equal to the longest diameter of the solid so that it can be circumscribe the solid sample (Mohsenin, 1986). Sphericity was obtained from equation (Sahay and Singh, 2001)

$$Sphericity(\varphi)\ = \frac{2BL^2}{2L-B} \qquad (8)$$

2.4.6 Surface area (SA) and volume (V)

Surface area (mm^2) and volume (mm^3) of the grain was calculated (Karababa & Coskuner, 2013).

$$SA = \frac{2BL^2}{2L-B} \qquad (9)$$

$$v = \frac{\pi B^2 L^2}{6(2L-B)} \qquad (10)$$

Statistical analysis was done using SPSS statistical software (version 25, SPSS Inc). Analysis of Variance (ANOVA)performed based on their mean values to determine significant difference.

3. RESULTS AND DISCUSSION

Usually, dehusker or dehuller used for dehulling process. Performance of abrasive dehuller is quick but can result in incidence of more grits and unprocessed millet grains. Centrifugal dehullers are capable and most hard-pressed machineries hence used for minor millet dehulling. This study was designed to expose grain to abrasive action followed by centrifugal dehulling. Henceforth to separate unflinched husk from edible part application of abrasion technology followed by centrifugal dehulling was opted. In addition to that adaptation of hydrothermal treatment which was being practiced for paddy was also opted as moisture drenches the grain and eases liberation of husk from the grain (Varadaraju & Ganesan, 2017).

3.1 Performance indices

The performance indices of dehulling were used to evaluate the dehulling index, coefficient of dehulling and overall dehulling efficiency of control and treated grains and its potential to give best produce. Statistical analysis revealed that there was significant difference between treated and control samples of the grain.

Initially, the dehulling index (DI) calculation was based on kernel, hull, undehulled and broken components. As the husk and kernels percentage increased simultaneously undehulled and brokens reduce and vice versa thus dehulling index was improved. In the present study control sample of BT without pretreatment produced 70.40% of dehulling index which indicated that direct centrifugal dehulling dispense 30% as wastage in the form of either broken or undehulled whereas A+C treated samples yield ranged from 79% to 88%. There was substantial rise in DI for A+C samples when compared with C sample and had significant difference ($P<0.01$).

The mechanical stress in the form of abrasion might have softened the husk and further improved yield in dehulling process. HC treated grains DI was 90% and HA treated samples throughput was in the range of 78.3% to 93.9% and deranged. This result can be attributable to combination of HT, shear (abrasion force) and impact (centrifugal dehulling) force on hard coated millet grains. The treatments had significant difference ($P<0.01$) with control.

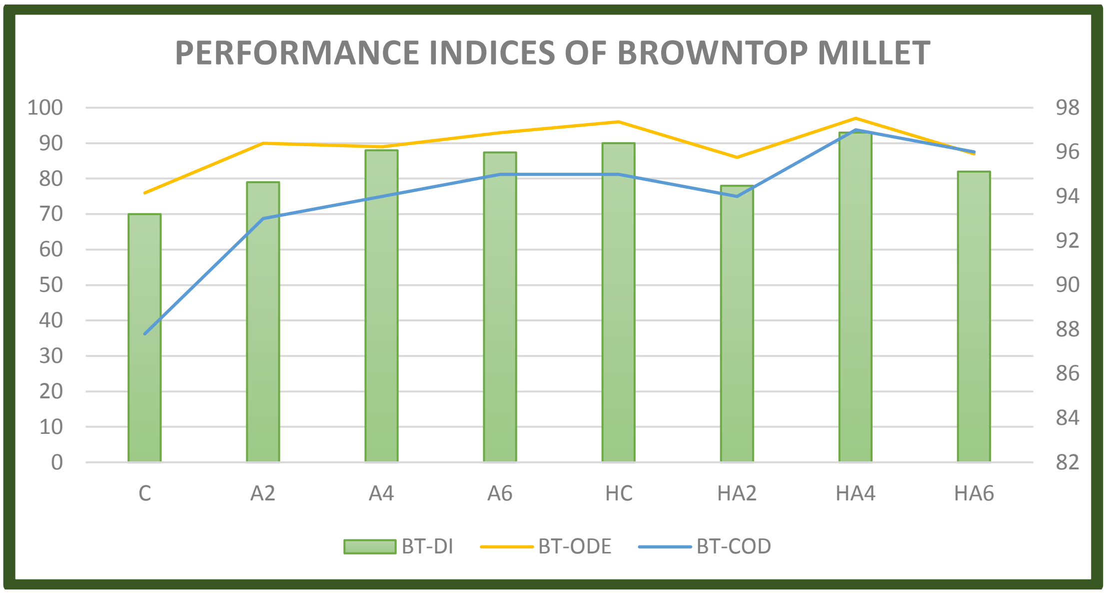

Fig. 1. Working indices of Browntop millet

Coefficient of dehulling (CoD) as second parameter to study performance index. In this indicator brokens, undehulled quantity and fine brokens taken as variables and assessed. Control sample recorded value of 88% for CoD and treated samples of BT was comparatively higher than control samples and had significant difference($P<0.01$). In the same parameter HT treated samples archived better results compared to A+C treated samples. This results proved that HT treated samples yield depleted volume of finer constituents (fine, undehulled & brokens) which improved coefficient of dehulling and the same was reported by Swapna Sahoo *et al* 2020, Balasubramanian *et al* 2020, Mamatha & Nirmala, 2015.

Overall dehulling efficiency (ODE) was low for control samples of BT when compared with treated samples and showed significant difference ($P<0.01$) between control and treated samples. BT-HA4 sample reported significantly higher values compared with other samples and results are consistent with Balasubramanian *et al* 2020.

3.2 Physical dimensions

Physical dimensions such as bulk density, true density and porosity was determined to evaluate the physical properties of grains and study the effect of treatment on grains.

Bulk density of the grain is the ratio of grain mass to the volume occupied by the grain. Bulk density of the grain varies as per the volume the grain occupies and it tends to increase or decrease based on its size not on weight/ mass of the grain. True density is the space occupied by organic solvent such as toluene. Grains left this void space and it was related to it's shape. Porosity is the extent of the void space in between the particles/grains. It is evident that solid particles especially grains tend to leave some empty space and this relationship between empty volume and entire volume is defined as porosity of the material. Porosity varies in accordance with grain shape and friction but not in line with bulk density (Bhattacharya KR, 2011).

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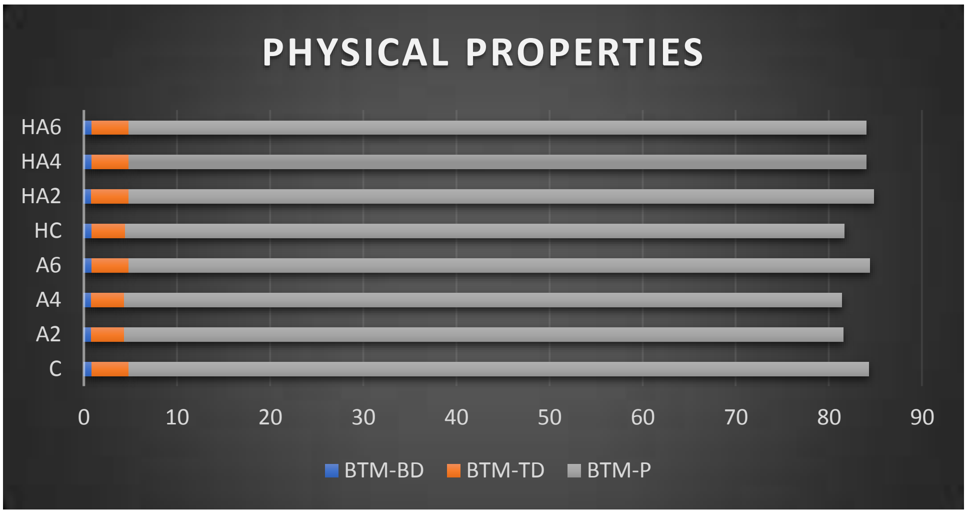

Fig. 2. Physical properties of control and treated samples of BTM

3.2.1 Bulk density

Bulk density of browntop grain values (Figure 1) ranged from 0.80±0.02 g/ml to 0.83±0.02 g/ml and values tend to reduce for A2, A4, HC, HA2 and slight increase for HA4 and HA6 when compared with control grain. As grain samples of A2, A4, and HA2 were subjected to short duration of pre-treatment, it resulted in slight alterations in shape of the grain and hence reported slight decrease in bulk density (Bhattacharya KR, 2011) and statistical analysis revealed that BD resulted in no significant difference between control and treated samples of BT.

3.2.2 True density and Porosity

True density of the grain (Figure 2) showed that pretreatments had no significant effect on BT grain and ranged from 3.50±0.41 g/ml to 4.00±0.86g/ml. The values of true density in both the grains did not registered specific trend as per treatment. Disparity in values might be due to precipitous effect on grain anatomy due to mechanical abrasion besides that hydrothermal treatment altered volume and mass of the grain (Baryeh, 2001) and as grains bulk density and true density are interdependent, it varied accordingly.

The porosity describes the void space availability and this property of grain resulted in significant difference ($p<0.01$) between control and treatments for brown top millet grain. It varied from 77.05±0.90% to 80.00±1.63% for BT grain of control and treated samples. The values of porosity was distinct and incongruous for the grain. This was due to pretreatment that caused certain blind pores or open pores on grains that resulted in varied outcome(Sahin S & Sumnu SG, 2006).

3.3 Principal axial dimensions

The mean values of principal axial dimensions were given in Table 3 i.e. length, width and thickness of control and treated samples of browntop that resulted in no significant difference. The length of browntop millet ranged from 1.82± 0.11mm to 1.93± 0.06mm. However BT-HA samples length was disrupted due to the dual treatments that grain was exposed to and length of the grain declined as the treatment duration increased. Width of the browntop grain was in the range of 1.58±0.03mm to 1.64±0.07mm. Shortest broadness was reported for BTM-A6 sample and maximum for BTM-A2 sample. Similarly minimum thickness was observed for control sample and maximum for HC sample and it ranged from 0.88±0.02mm to 1.00±0.08mm.

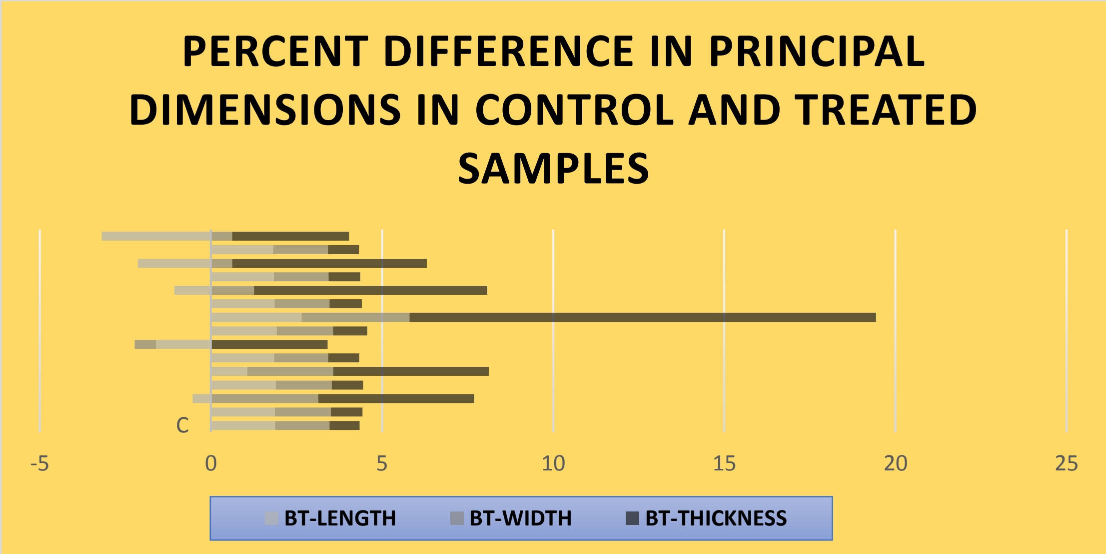

Fig. 3. Percent difference in principal dimensions in control and treated samples

3.4 Geometrical dimensions of Browntop millet

Different engineering properties of grains were calculated to evaluate the treatment effect on grain critically henceforth results can be used to assist in designing equipment of grain processing.

3.4.1 Geometric mean Diameter (GMD)

The GMD will be used in fabrication and standardization of sieves/aperture size in graders (Jain R & Bal S, 1997) and other preliminary grain processing machineries. Perhaps this data can be utilized to abridge postharvest management thereby curtailing the grain damage caused due to non-standard equipments.

The GMD of control and treated browntop millet varied from 1.38±0.05mm to 1.41±0.07mm and had no significant difference among them. At the same time GMD of treated and control samples of Barnyard had significant difference ($P<0.01$) between them. The GMD reported slight rise in hydrothermal treatments of both grains except for BT-HA6 and inconsistent values in A+C treated grains. Among principal dimensions, thickness value did not exceeded GMD value but length and width of respective grains were higher that of GMD's. Similar observations were reported by Pradhan *et al* for bottle gourd seeds and Abhishek *et al* for minor millets. This observation can be applied in determining extrapolated surfaces of grain that serve as basis in designing aspirators for discriminating semi-identical granules and removing extraneous materials from grain.

3.4.2 Arithmetic mean diameter (AMD)

The arithmetic mean diameter of both the grains was calculated based on average values of three axial dimensions of grains. Though the AMD values of treated samples were higher than control grain of Browntop millet it had no significance difference between the values. As the treatment duration intensified in Browntop millet the AMD values showed slight decreasing trend whereas A+C values showed slight soared values. As the grain subjected to dual treatment or increase in treatment time an inverse trend of the values were observed and this might be the reason for decrease in HA2 to HA6 values of AMD.

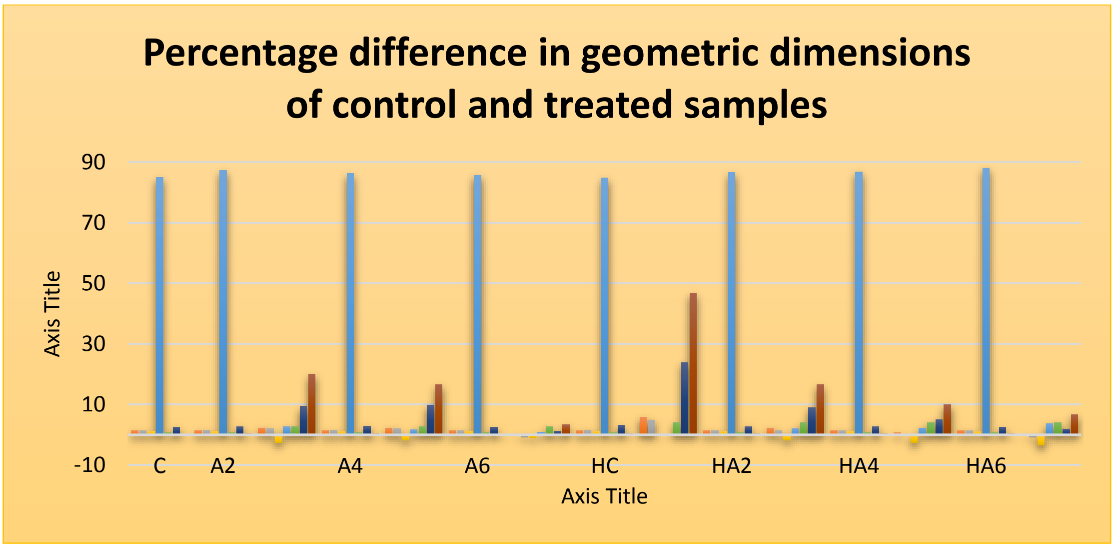

Fig. 4. Percentage difference in dimensions of browntop millet

3.4.3 Slenderness ratio

Application of slenderness ratio concept in millet grain further help in determination of grain proximity to slenderness.

As per ISO, grain shape can be determined based on length to width ratio. This classification on slenderness ratio describes if the grain L/W ratio ranges from 1.1-2.0 the grain shape is considered as bold and if its 1.0 or less then the shape is round (Omer Badi, 2013). According to the classification both control and treated grains of Browntop millet retained their bold shape and unaffected by treatments and had no significant difference between them.

3.4.4 Aspect ratio and Sphericity

Shape of the food grain is the key element used to design grain handling equipment and fundamental aspect considered in heat conduction and material exchange phenomena. Sphericity and aspect ratio are the key indicators that can disclose the shape of the food grain. The former one explain its proximity to sphere of the same volume while the latter one outline the shape of the grain. Nearer the value to percent closer its resemblance to sphere in sphericity and proportional to grain rolling ability. This shape determination of grains is crucial in designing grain handling equipment and hopper designing. Similarly lower the aspect ratio more elongated the grain is.

Aspect ratio and sphericity of Browntop millet samples ranged from 84.82±5.45% to 88.07±6.30% and 0.73±0.03 to 0.76±0.04% respectively. There was no significant difference between control and treated samples for both sphericity and aspect ratio. A+C and HT samples aspect ratio was high compared to control sample which was evident that treatment had altered principal axial dimensions with respect to width that led to grain elongation. Similarly treatments had intensified rollability of grains by increasing sphericity thus enhancing intergranular arrangement.

Similar results of increased sphericity observed in hydrothermal processed finger millet(Usha Dharmaraj *et al* 2015). As per the findings of Garnayak et al and Pradhan et al if grain sphericity value is beyond 0.70 then it can be treated as spherical and as stated above browntop millet grains could be less spherical.

3.4.5 Surface area and volume

The surface area and volume of grain was calculated for control and treated samples of both the grains. The surface area of grains information was much needed to predict the grains tendency and behavior towards vibrators and also SA crucial in designing heat transfer equipment for grain.

Surface area of browntop millet grains had no significant difference between them whereas volume of the same had indicated significant difference at a probability level of 5%. The surface area of browntop grains ranged from 2.55±0.27mm^2 to 3.16±0.43mm^2 and volume varied from 0.30±0.05mm^3 to 0.44±0.10mm^3. Highest surface area and volume noticed for HC treated sample and lowest for control sample.

Many studies reported dimensions and other engineering properties of whole grains but study on pretreated millet grains were not many but obtained results are compatible to Srivastava and Batra (1998), Balasubramanian S. and Viswanathan R(2010) that are associated with structural property of the grain.

4. CONCLUSION

Application of pretreatments in single or in combination on thick cellulosic browntop millet aided in hull/husk removal more profoundly and can be cost-effective. Studies on either abrasive or centrifugal dehulling were available but combination of abrasive & centrifugal dehulling were inaccessible hence the study was first of its kind to report and the results obtained or technologies utilized were highly adaptable. Application of abrasion, shear and hydrothermal enhanced product quality in terms of performance and innovative of its nature. Browntop millet grains dehulling output enhanced in response to pretreatments. The grains engineering properties with respect to treatment revealed that grain dimensions had no significant effect on them. Critical care should be taken in fabrication of grain handling equipment as it rendered reduced processing losses and yielded good quality produce. Hence process need to be optimized and ramped up for efficient use of technology and further studies need to be proposed to setup critical control points for upscaling technology.

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REFERENCES

1. Mamata Mannuramath, Nirmala Yenagi, 2015.Optimisation of hydrothermal treatment for little millet grains (*Panicum miliare*). *Journal of Food Science Technology*, February, DOI 10.1007/s13197-015-1798-z.
2. Swapna Sahoo, Sneha Snigdha Sarangi and Kalpana Rayaguru, 2020. Effect of pretreatment on milling characteristics of little millets. *Journal of pharmacognosy and phytochemistry*, vol 9(5): pp 554-558.
3. S. Balasubramanian, S.D. Deshpande, I.R. Bothe, 2020. Design, Development and performance evaluation of CIAE-Millet Mill. *Agricultural mechanization in Asia, Africa and Latin America*. vol.51, No.1, pp. 42-48.
4. Ikebudu, J. A., S. Sokhansanj, R. T. Tyler, B. J. Milne and N. S. Thakor, 2000. Grain conditioning for dehulling of canola. *Canadian Agricultural Engineering,* vol.42 no.1, pp. 27-32.
5. Shepherd H, Bhardwaj RK (1986) Moisture-dependent physical properties of pigeon pea. *J Agric Eng Res* 35:227–234.
6. Sreenarayanan VV, Viswanathan R, Subramanian V, 1988. Physical and thermal properties of soybean. *J Agric Eng* 25, pp. 76–82.s

7. Sahay, K. M., & Singh, K. K. (1994). Unit operations in agricultural processing. New Delhi: Vikas.
8. Mpotokwane SM, Gaditlhatlhelwe E, Sebaka A, Jideani VA(2008). Physical properties of Bambara groundnuts from Botswana. *Journal of Food Engineering*; 89:93-98.
9. Vanrnamkhasti MG, Mobli H, Jafari A, Keyhani AR, Soltanabadi MH, Rafiee S, et al. Some physical properties of rough rice (Oryza sativa L.) grain. *Journal of Cereal Science*; 47:496-501. 2008
10. Bagheri I, Dehpour MB, Payman SH, Zareiforoush H. Rupture strength of brown rice varieties as affected by moisture content and loading rate. Aust. J Crop Sci. 2011; 5:1239-1246.
11. Mohsenin N N, 1986. *Physical Properties of Plant and Animal Materials*, 2nd Edition. Gordon and Breach Science Publishers, New York.
12. Karababa E, Coşkuner E (2013) Physical properties of carob bean (Ceratonia silique L.):an industrial gum yielding crop. *Ind Crop Prod 42:440–446.*
13. Varadaraju N, Ganesan S. 2017. Effect of parboiling (thermal treatment) on dehulling and cooking qualities of little millet (*Panicum sumatrense*) and foxtail millet (*Setaria italica*). *17th International Conference on Food & Nutrition*. Las vegas, USA, 22-24.
14. Kshirod R.Bhattacharya (2013). *Rice Quality A guide to rice properties and analysis*, A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition, Amsterdam.
15. Gaines C.S., Finney P.L., Fleegoe M.L., Andrews L.C. (1998) Use of aspiration and the Single Kernel Characterization System to evaluation the puffed and shriveled condition of soft wheat grain. Cereal Chem., 75(2): 207-211.
16. Baryeh, E.A. (2001) Physical properties of bambara groundnuts. *Journal of Food Engineering*, 47 (4): 321–326.
17. Sahin S & Sumnu S G, *Physical Properties of Foods* (Springer Science & Business Media Verlag, New York) 2006.
18. Jain R & Bal S(1997). Properties of pearl millet, *J Agric Eng Res*, Vol 66(2) 85-91.
19. Rama Pradhan & Prashant Said. 2013. Physical properties of bottle gourd seeds. *Agricultural Engineering International: The CIGR e-journal*. Vol 15(01): 106-113.
20. Omer badi, 2013. Rice Quality. http://www.jica.go.jp
21. Usha Dharmaraj, MS Meera, S Yella Reddy and Nagappa G Malleshi (2015). Influence of hydrothermal processing on functional properties and grain morphology of finger millet. *J.Food Sci.Technology*., Vol 52(3): 1361-1371.
22. Garnayak, D. K., R. C. Pradhan, S. N. Naik and N. Bhatnagar, 2008. Moisture-dependent physical properties of jatropha seed (Jatropha curcas L.). Industrial Crops and Products, 27: 123-129.
23. Srivastava S, Batra Anju. Popping qualities of minor millets and their relationship with grain physical properties. Journal of Food Science and Technology. 1998; 35(3):265-267.
24. Balasubramanian S, Viswanathan R. Influence of Moisture Content on Physical Properties of Minor Millets. Journal of Food Science and Technology. 2010; 47(3):279-284.