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Impact of ingenious pre-treatments on performance indices and dimensional properties of kodo millet

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Abstract:. The present study focussed on standardisation of suitable method for kodo dehulling and evaluated the outcome percentage of dehulled kodo millet. A combination of abrasive and centrifugal type of dehulling and hydrothermal treatment followed by centrifugal dehulling was applied on whole kodo millet. Only centrifugal dehulled millet was taken as control. Dehulling index, Coefficient of dehulling, degree of dehulling and overall dehulling efficiency was more compared to control samples. Principal axial dimensions, dimensional parameters such as sphericity, aspect ratio, geometric and arithmetic mean diameter was calculated and had significant difference between control and experimental samples.

Index terms: Kodo millet, Centrifugal dehulling, abrasive dehulling, dehulling index, sphericity.

I. INTRODUCTION

The enigmatic journey of millets from ancient foods to superfoods is remarkable. Though it is nutritionally superior than other most consuming cereals, it stood in the extreme edge for almost four decades and now basking resurgence course as miracle grains because of profound efforts of various experts in the field of nutrition, agriculture, environment, technology and health care to emanate millet productivity. Major factors responsible for oversight on millets especially minor millets can be expounded primarily with three reasons: agri related, socio and economic concern.

The primary reason could be implication of innovative technologies in rice and wheat on the flip side trifling on millet technologies. The former one's are water intensive crops whereas millets are the climate resilient and can grow in dryland conditions also. In addition to that, gradual lifestyle changes made public acclimatized to convenience and refined foods which is the underlying cause for shift in eating patterns. This insalubrious tendencies made society prone to life style diseases. Simultaneously incompetency of high end secondary processing millet technologies and lack of suitable highly performing primary processing machinery made millets exterminated in urban and suburban market as it is commanded by the convenience foods. Currently scenario has changed and there was revival of millets worldwide because of its capacity to cope up with disturbed ecosystem besides fostering human health with its superior nutritional components. And millets popularly at present known as nutri-cereals has enormous potential to handle critical issues of undernutrition and metabolic disorders moreover contributing food security to the nation. Primarily, minor millets are drawing great attention because of their unique nutraceutical properties. Nevertheless there is great need to explore various technologies that can restore the plodded millet value added chain. In this connection, optimisation of the primary processing methods of millet is essential as the grain handling steps are excruciating

Hence the present study was designed on kodo millet and its physical changes when subjected to certain pretreatments. Among minor millets, kodo millet is a good source of major and micronutrients and considered as convenient grain for value addition. But the kodo grain endosperm is adhered to highly cellulosic husk making it more complicated to separate while dehulling process. Hence there is a need to treat the grain prior to dehusking/dehulling process as the traditional or ongoing dehulling process doesnot yield good output. Hence present study was designed to evaluate performance/working indices of kodo millet dehulled in centrifugal dehuller and a combination of certain dehulling techniques were used to condition/ soften the husk and produces were tested for the effect of treatments on its physical, axial and geometric dimensions.

II METHODOLOGY

Kodo millet [KM] was procured from local market of Madhurai. They were cleaned from physical impurities, foreign particles and premature grains and used for further processing. The experiment was performed in Millet Processing and Incubation Centre, PJTS Agricultural University, Rajendra nagar, Hyderabad on payment basis. Total experiment was carried out in room temperature and precautions were taken to maintain the grain moisture content in the range of 10°c to 12°c which is 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 treatments:

1. Abrasive dehulling [A] for a duration of 2[A2] minutes, 4[A4] minutes and 6[A6] minutes to soften the husk and then dehulled in centrifugal type of dehuller [C]
2. Cleaned grain was subjected to hydrothermal treatment [H] i.e soaked for 4 hours and dried in tray drier followed by centrifugal dehulling.
3. In this method above two methods were combined. Initially grains were given hydrothermal treatment and next abrasive dehulling [HA] for a period of 2 minutes[HA2], 4 minutes[HA4] and 6 minutes[HA6] 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 that includes both dehulled and brokens(k), dehulled grain(d), undehulled grain(ud), husk(h), broken grits (b) as coarse grits(cg) and fine grits (fg) and recorded for calculating working indices.

Working indices of dehulling (Balasubramanian *et al* 2020):

(i) Dehulling index [D]: The dehulling index was calculated for the following equation:
$DI = [(KM_K + KM_h)-(KM_{ud}+KM_b)]$
The dehulling index may vary from a maximum value of +1 to a minimum of -1. A value of +1 indicates that the entire original sample is completely dehulled into two fractions of grain kernel and hull with no fines and undehulled grains. A value of -1 indicates that hull removing process is incomplete with more undehulled and fine brokens{Ikebudu et al 2000}.

(ii) Coefficient of dehulling (CoD) This can be calculated using the following equation:
$$CoD = 100[1 - (\text{Yield of broken} + \text{Effectiveness of dehulling} + \text{Yield of fine})]$$

(iii) Overall Dehulling Efficiency: This is calculated using the following relationship:
$$ODE = (Mh + Qd) \times CoD$$

Measurement of principal axial dimensions

The vernier calliper (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.

Dimensional paramters

Geometric Mean Diameter

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

Geometric mean diameter in mm = $(LWT)^{1/3}$

Arithmetic mean diameter

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

$$\text{AMD in mm} = \frac{L+W+T}{3}$$

Aspect ratio

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

$$Aspect\ ratio\ \text{(in \%)} = Width\ /\ Length\ \times 100$$

Sphericity

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. Sphericity was obtained from equation (Sahay and Singh, 2001)

$$\text{Sphericity } (\varphi) = \frac{(LWT)^{1/3}}{L}$$

III Results and Discussion

Results were evaluated by taking means of the produces. As mentioned in methodology, cleaned grains were dehulled in centrifugal dehuller. There were two physical outputs namely: kernels and husk related components. Among kernel, output produces were undehulled grain, head rice, coarse and fine grits. This clearly revealed that value near to +1 indicates completeness of dehulling. As per the Table no.1 dehulling index was 0.587 for control sample which was less compared to other experimental samples and it was evident that without any pretreatment kodo grain husk was difficult to remove. Among these mean samples dehulling index was high for HA4 followed by HA2, HC and HA6 samples. This explained that treated samples gave better output compared to control sample because pretreatment such as hydrothermal treatment combined with abrasive dehulling aided in husk loosening and resulted in more dehulling index.

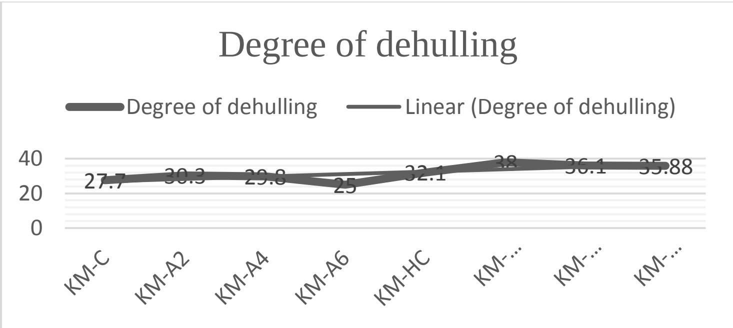
Table 1: Working indices of kodo millet

Working indices	Dehulling index	Coefficient of dehulling	Overall dehulling efficiency
KM-C	0.587±0.01	82.5±0.98	76.97±0.82
KM-A2	0.821±0.05	82.36±0.10	83.12±0.10
KM-A4	0.665±0.03	83.58±0.09	83.03±0.02
KM-A6	0.606±0.01	82.5±0.16	82.67±0.77
KM-HC	0.869±.004	90.2±1.14	87.87±0.09
KM-HA2	0.87±0.01	92.11±0.04	88.11±0.18
KM-HA4	0.93±0.02	91.53±0.09	94.06±0.16
KM-HA6	0.866±0.04	89.64±0.08	87.80±0.16

Coeffficient of dehulling which was calculated based on yield of broken, fine and undehulled. Less the value of above trio more the value of coefficient of dehulling and the above results disclosed that control sample and abrasive + centrifugal dehulled sample has less coefficient of dehulling compared to HT+A treated samples. This was evident that kodo grain yielded less brokens, fine grits and undehulled samples and more kernels that resulted in high coefficient of dehulling.

As an extension degree of dehulling in Figure 1 revealed more amount of hull removal done for HA samples rather than abrasive+centrifugal dehulled samples and control samples. Even similar results of hull removal was recorded more for raw little millet samples compared to treated samples (Swapna *et al* 2020). Similarly high values observed for overall dehulling efficiency for treated samples compared to control samples.

Fig. 1 Degree of Dehulling of grain samples.



Principal axial dimensions

The mean values of length, thickness and width of control and treated samples of kodo millet grain was given in table no.2. Length of millet grain samples was found to be in the range of 1.8 to 1.94 mm; width was 2.17 to 2.34 mm and thickness was 1.28 to 1.49 mm. Length, width and thickness of the grain are said to be principal axial dimensions. As the grain was not subjected to any pretreatment the control sample length was 1.9mm and all the hydrothermal treated samples resulted in reduction of linear measurement. This might be due to the effect of hydrothermal treatment combined with mechanical stress had reduced the extent of the grain and have greatly impacted the length of the grain. Similar results were reported by Dewendra kumar *et al* (2016) for kodo millet samples.

Table 2: Principal axial dimensions

Dimensional properties	Length (mm)	Width (mm)	Thickness (mm)
KM-C	1.90±0.04	2.17±0.08	1.43±0.03
KM-A2	1.94±0.03	2.34±0.03	1.44±0.10
KM-A4	1.92±0.03	2.21±0.04	1.49±0.19
KM-A6	1.87±0.02	2.3±0.04	1.44±0.10
KM-HC	1.85±0.08	2.21±0.07	1.36±0.10
KM-HA2	1.80±0.04	2.24±0.04	1.38±0.04
KM-HA4	1.83±0.06	2.2±0.08	1.28±0.03
KM-HA6	1.89±0.06	2.19±0.02	1.28±0.11

Similarly thickness of grain reduced for hydrothermal drastically when compared to A2, A4, A6 and control samples. This clearly described that grain thickness was influenced by dual treatment mode when compared to A+C or C sample. Contrarily width of the grain was low for control sample and more for treated samples which clearly stated that width of the grain remain unaffected during pretreatments of grains.

Dimensional Parameters

The physical properties are the preliminary steps utilized to study the grain size and shape. Hence principal dimensions stood as basic notations for calculation of grain shape. Next physical properties are mentioned in Table no.3 i.e. are sphericity, geometric mean diameter, arithmetic mean diameter and aspect ratio. Each and every parameter has different approach and specific role in practical application. Sphericity is defined as the ratio of geometric mean to the longest intercept of the grain.

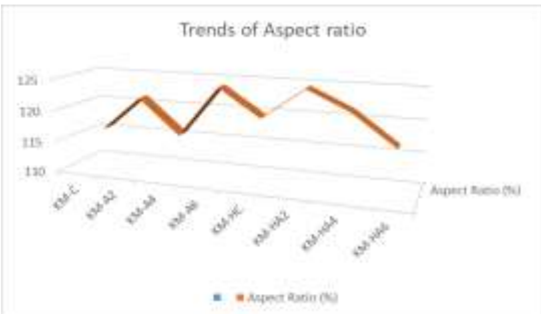
Dimensional properties	Sphericity (%)	GMD (mm)	AMD (mm)
KM-C	0.95±0.04	1.79±0.03	1.83±0.18
KM-A2	0.96±0.16	1.86±0.10	1.91±0.03
KM-A4	0.96±0.07	1.84±0.21	1.87±0.11
KM-A6	0.98±0.03	1.82±0.18	1.87±0.07
KM-HC	0.95±0.23	1.76±0.09	1.81±0.34
KM-HA2	0.98±0.12	1.76±0.30	1.81±0.15
KM-HA4	0.94±0.05	1.71±0.14	1.77±0.09
KM-HA6	0.92±0.10	1.73±0.06	1.79±0.02

Table 3 Dimensional properties

The sphericity of the grain samples was in the range of 0.98% to 0.92%. The sphericity of kodo grain samples showed linear increase when compared to control and A+C treated samples. And sphericity remained same as control sample for HC sample and increased for HA2 sample and showed decreasing trend for HA4 and HA6 sample where sphericity was reported even less than control sample. Based on these results A+C treated sample facilitated grain to slide rather than roll whereas HC sample remain unaffected; HA samples decreased and as per the findings of Wolfe and Tatepo (1972) the sphericity of materials is always below unity and that the more regular an object is , the lower the sphericity. Hence HC, HA samples maintained the object structure whereas HA sample affected the sphericity.

The GMD values were 1.71mm to 1.8 6mm and AMD values were 1.77mm to 1.91 mm. Geometric mean
Diameter (GMD) and arithmetic mean diameter (AMD) help in design of the processing equipment. Similarly aspect ratio (Figure 2) helps in predicting the shape of the particle. The GMD of the grain sample increased linearly from control to A+C samples and decreased for HC and HA samples. Similar results were observed for AMD and evident by Adil Gani *et al* 2021.

Figure 2 Aspect ratio of kodo grain samples.



The aspect ratio denotes the proximity of the grain to maintain oblong shape. The aspect ratio showed an upward trend. Aspect ratio was same for control, HA4 and HA6 samples. The aspect ratio was affected by pretreatments of grain.

CONCLUSION

The present study aimed to determine suitable dehulling method for kodo millet. The dehulling index, coefficient of dehulling and overall dehullling efficiency was high for HA4 and HA2 samples. But due to the above treatments length and thickness recorded less dimensions compared to abrasive dehulled samples whereas width remained unaffected. Similarly hydrothermal treated sample had recorded less sphericity, GMD, AMD and aspect ratio. Hence kodo millet dehulling can be coupled with hydrothermal treatment and abrasive dehulling for better output but principal axial dimensions of grain need to be monitored for better output of graded grain.

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