International Journal of Environment and Climate Change

Volume 13, Issue 1, Page 156-162, 2023; Article no.IJECC.97098
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Study on Physical Properties of Minor Millets

K. Nithyashree [a++*] and K. G. Vijayalaxmi [a#]

[a] *Department of Food Science and Nutrition, UAS, G.K.V.K, Bangalore-65, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i11663

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97098

Original Research Article

Received: 25/11/2022
Accepted: 05/02/2023
Published: 06/02/2023

ABSTRACT

Millets are important food in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. The aim of the study was to investigate the physical properties of the selected minor millets. The mean thousand seeds weight and seeds volume of millets ranged from 1.70 to 4.60 g and 2.28 to 4.40 ml per 1000 seeds respectively. Among the millets hydration capacity was highest in proso millet (1.13 g) and lowest in little millet (0.26 g) and proso millet (2.40 ml) had highest swelling capacity and lowest was in little millet (0.48 ml). Swelling index was highest in finger millet (0.81) and lowest in little millet (0.20).The specific gravity and bulk density of millets studied ranged from 0.64 to 1.88 and 0.62 to 1.55 g/ml respectively. Results showed that 'F' value indicated a significant difference to exist among the selected millets for all the physical characteristics studied (p≤0.05).The information of the present study would be useful foroptimizing milling operations, designing the storage structures and machinery, which will help to avoid the post-harvest and milling losses.

Keywords: Millets; bulk density; specific gravity.

[++] Ph.D. Scholar;
[#] Professor and Head;
**Corresponding author: E-mail: nithyashree.k.119@gmail.com;*

1. INTRODUCTION

Millets are important food in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. Millets have been used in India and Africa as a stable food for thousands of years. It was reported that people were farming millet in India about 2500 BC [1].

Millets are unique among the cereals because their rich in calcium, dietary fibre, polyphenols and protein [2]. Millet is a generic term describing a range of small seeded grains in two tribespaniceae and chlorideae of the family Poaceae (true grass). It became a staple food for humans since from 10,000 years ago already before the rise of rice and wheat [3].

Nowadays, the most cultivated species include pearl (*Pennisetum glaucum*, with synonyms of *Pennisetum americanum*, *Pennisetum typhoides, Pennisetum typhoideum*), proso (*Panicum miliaceum*), and foxtail (*Setaria italica*) millet. Less grown millet species but with meaningful local production include finger (*Eleusine coracana*), browntop (*Brachiaria ramosum*) and barnyard (Japanese) (*Echinocloa frumentacea*) [4].

Millet is a collective term referring to a number of small seeded annual grasses which is cultivated as grain crops, primarily on marginal land areas in temperate, sub-tropical and tropical regions [5]. Based on grain size millets have been classified as major millets which include sorghum and pearl millet. The several small grain millets which include finger millet (*Eleusine coracona*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), barnyard millet (*Echinochloa esculenta*), Kodo millet (*Paspalum scrobiculatum*) and little millet (*Panicum sumatrense*). Millets are considered the least important of cereals, with annual production less than 2 per cent of the world's grain [4]. However, they are of great local importance as staples and as reserve crops in marginal areas.

It is essential to study the physical properties of kernels, grains and seeds which are necessary for the design of equipment to handle, transport, process and storage. Physical appearance of the grain is also an important characteristic which determines the consumer acceptability.

Grain density is one of the important parameters which determine dehulling and milling performance. Barnyard millet was found to be relatively denser (1.80 g/ml) followed by little millet and Kodo millet (1.46 and 1.18 g/ml respectively). The densities of foxtail and little millet were recorded to range from 1.09 to 1.42 and 1.21 to 1.39 g per ml, respectively [6].

Colour of the grains is determined by the presence of pigments and is one of the important factors which contribute to product quality in terms of appearance. Variation in colour within the species is common, which is evident in almost all minor millets, both hulled and dehulled grains. Srivastava and Batra [7] reported that whole (hulled) barnyard millet was olive or olive yellow whereas, proso millet was yellowish in colour.

This study investigated the some physical and functional properties of the selected minor millets. The parameters measured were colour, thousand seed weight, thousand seed volume, hydration capacity, hydraion index, swelling capacity, swelling index, bulk density and specific gravity.

2. MATERIALS AND METHODS

Promising small millets namely finger millet (GPU-67 variety), little millet (OLM-203 variety), foxtail millet (Suryanandi variety), Proso millet (TNAU 145 variety), Kodo millet (RK-390-25 variety), barnyard millet (VL-207 variety) which were unpolished and un husked samples procured from All India Coordinated Research Project on Small Millets (AICRPSM), Gandhi Krishi Vignana Kendra, Bengaluru-65.

2.1 Dehusking of Millet

The millet samples were dehusked in rubber roll sheller without polishing to obtain brown rice.

Dehusking Efficiency % = (Weight of the millet grain (g)/ Weight of the grains fed into a machine (g)) × 100

Head Grain Yield % = (Weight of the head grains (g)/ Weight of the milled grain (g)) × 100

Broken % = (Weight of the broken (g)/ Weight of the milled grains (g)) × 100

Milling Efficiency % = Dehusking efficiency (decimal) x Head rice yield (decimal) x 100

2.2 Physical Characteristics of Millets

Physical properties namely thousand seed weight, thousand seed volume, swelling capacity, swelling index, hydration capacity, hydration index, specific gravity, colour of the grains and bulk density were studied.

2.3 Colour of the Grain

Colour measurement of the millet was determined using a Munsell soil colour chart 1952.

2.4 Thousand Seeds Weight [8]

Thousand seeds of each sample were counted randomly in triplicate and weighed in an electric balance and the weight was recorded.

2.5 Thousand Seeds Volume [9]

The thousand seeds were transferred to 100 ml measuring cylinder and 10 ml of demineralised water was added using a pipette. The seed volume was calculated as follows.

Seed Volume (ml/ 1000 seeds) = (Total Volume of 1000 Seeds – 10/ 1000)

2.6 Hydration Capacity [9]

Hydration capacity of the grains were measured by placing weighed 1000 seeds into a conical flask and soaked in water overnight. Further, soaked seeds were drained, dried and weighed. Hydration capacity was calculated as follows:

Hydration capacity = Weight of the seed after soaking - Weight of the seed before soaking

2.7 Hydration Index [9]

Hydration index was calculated as follows:

Hydration Index = (Hydration capacity/1000 seeds weight)

2.8 Swelling Capacity [9]

Swelling capacity of the grains was measured by soaking 1000 grains in known volume of water in a conical flask overnight. Further, water was drained off, grains were dried and volume was measured by using a measuring cylinder. Swelling capacity was calculated as follows.

2.9 Swelling Index [9]

Swelling index was calculated as follows:

Swelling Index = (Swelling capacity/1000 Seeds volume)

2.10 Specific Gravity [9]

Empty specific gravity bottle with stopper was weighed (W_1). Thousand grains were counted and placed in the specific gravity bottle and weighed (W_2). The seeds were removed and Toluene solution was filled up to neck of the specific gravity bottle and weighed (W_4). Further the counted seeds were added to the specific gravity bottle with toluene and weighed (W3). The Specific gravity bottle with distilled water filled up to neck was weighed (W5).

Specific Gravity = (W4 – W1/ W5 - W1) × (W2 – W1/(W4-W1) - (W3-W2))

2.11 Bulk Density

The bulk density was calculated as follows:

Bulk Density (g/ml) = (Weight of 1000 seeds/ Volume of 1000 seeds)

2.12 Statistical Analysis

The data reported in all of the tables are the averages of triplicate observations. Mean values were calculated and compared at different significance level. Pearson's correlations of the means were determined using the software OPSTAT (CCS, Haryana Agricultural University, Hisar, India). Significance of differences between treatment mean values for each trait was tested by using Duncan's multiple range tests.

3. RESULTS AND DISCUSSION

3.1 Milling Characteristics of Selected Millets

Table 1 shows the milling characteristics of selected millets. Dehusking efficiency, head rice yield and milling efficiency was highest in foxtail millet compared to other millets and lowest was observed in kodo millet. The broken yield was lowest in proso millet and highest in kodo millet.

3.2 Physical Properties

The physical parameters like colour, thousand seed weight, thousand seed volume, hydration capacity, hydration index, swelling capacity, swelling index, bulk density and specific gravity were assessed and the results are presented in Table 2 and 3.

According to Munsell soil colour chart 1952, the colour of the finger millet and kodo was yellowish red (5YR 5/6) and brownish yellow (10YR 6/8) respectively. The colour of proso (10YR 8/8) and foxtail millets (10YR 7/6) was yellow and that of little and barnyard millet (10YR 7/3) was very pale yellow were presented in Table 2.

3.3 Thousand Seeds Weight (g)

Among the millets, proso millet had the highest 1000 seeds weight (4.60 g) and lowest was recorded in little millet (1.70 g). The results of the present study were slightly lower than that reported by Nazni and Devi [10] for foxtail and barnyard millet. However, the observed values for finger millet are higher than that reported by Vidyavathi et al. [11]; Nazani and Bhuvaneshwari [12]. Similarly, 1000 grain weight of little millet in the present study was found to be lower than that reported by Thilagavathi et al. [13]; Nazani and Bhuvaneswari [12]. In general, the small millets as the name indicates were weighing less compared to conventional cereals. However, 'F'-test applied showed a significant difference in 1000 grain weight to exist among the small millets. The difference observed in the study may be due to difference in varieties and also due to agro climatic condition grown.

Table 1. Milling Characteristics of Selected Millets

Samples	Dehusking Efficiency (%)	Head Rice Yield (%)	Broken Yield (%)	Milling Efficiency (%)
Little millet	71.64	66.53	7.35	47.66
Kodo millet	67.49	59.89	8.95	40.41
Foxtail millet	83.12	75.65	7.51	62.88
Barnyard millet	70.15	63.58	6.78	44.60
Proso millet	81.21	75.08	5.65	60.97

Table 2. Colour of the Selected Millets

Samples	Colour of the Grain
Finger millet	Yellowish red 5YR (5/6)
Little millet	Very pale yellow 10 YR (7/3)
Kodo millet	Brownish yellow 10 YR (6/8)
Foxtail millet	Yellow 10YR (7/6)
Barnyard millet	Very pale yellow 10YR (7/3)
Proso millet	Yellow 10YR (8/8)

Measured by visual observation (Munsell soil colour chart, 1952)

Table 3. Physical Properties of Selected Millets

Samples	1000 Seeds Weight (g)	1000 Seeds Volume (ml)	Hydration Capacity (g)	Hydration Index	Swelling Capacity (g)	Swelling Index	Specific Gravity	Bulk Density (g/ml)
Finger millet	3.04	2.28	1.01	0.33	1.85	0.81	1.10	1.33
Little millet	1.70	2.73	0.26	0.15	0.48	0.20	1.24	0.62
Kodo millet	3.58	4.40	0.76	0.21	1.90	0.43	0.64	0.81
Foxtail millet	2.63	4.23	0.89	0.34	0.88	0.23	1.88	0.62
Barnyard millet	2.81	3.45	0.52	0.18	1.22	0.35	0.91	0.81
Proso millet	4.60	3.01	1.13	0.24	2.40	0.79	1.43	1.55
F Value	*	*	*	*	*	*	*	*
SEm ±	**0.03**	**0.03**	**0.01**	**0.04**	**0.02**	**0.01**	**0.06**	**0.01**
CD (P≤0.05)	**0.09**	**0.10**	**0.03**	**0.01**	**0.03**	**0.03**	**0.18**	**0.01**

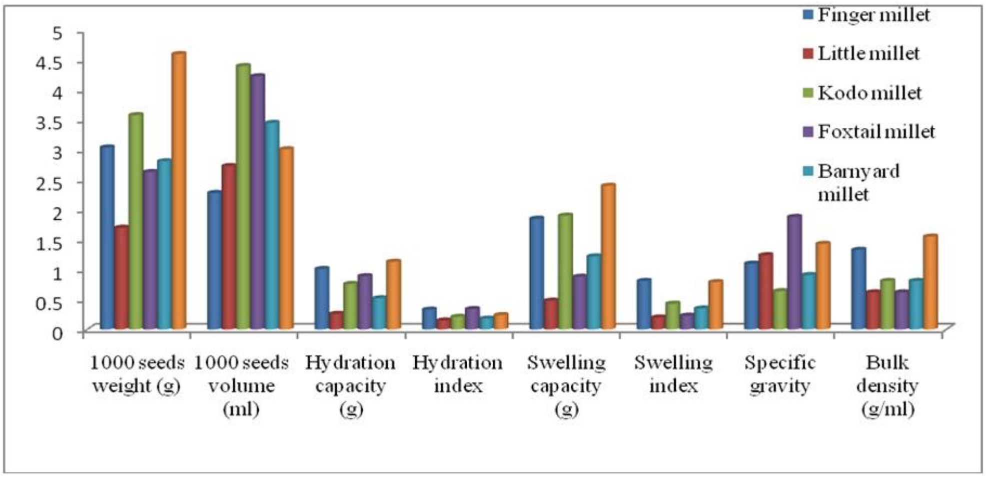

Fig. 1. Physical Properties of Selected Millets

3.4 Thousand Seeds Volume (ml)

Thousand seed volume recorded highest in kodo millet (4.40 ml) and leastin finger millet (2.28 ml). The results are slightly higher for foxtail millet and lower in barnyard millet than that reported by Nazni and Devi [10]. Veena et al. [14] also reported 1000 seeds volume of barnyard millet varieties to range from 2 to 2.5 ml. The kodo and proso millet in the present study recorded highest seeds volume compared to that reported by Thilagavathi et al. [13]. Soubhagyalaxmi [15] reported 1000 seed volume of five finger millet varieties to range from 3.30 to 3.70 ml which was higher than that recorded in the present study. The difference in 1000 seed volume may be attributed to the difference in grain size of each millet and cereal present study.

3.5 Hydration Capacity

Among the millets under study proso millet recorded highest hydration capacity (1.13g), followed by finger millet (1.01 g), foxtail (0.89 g), kodo (0.76 g), barnyard millet (0.52 g) and little millet (0.26g). The results are slightly lower than that reported by Nazni and Bhuvaneswari [12] for finger millet and little millet. The results are slightly lower than that reported by Nazni and Devi [10] for barnyard and foxtail millet. Statistically ‘F’- test indicated a significant differenceto exist among the millets under study for hydration capacity. The difference in hydration capacity among the selected millets present study may be due to varietal difference and grain size.

3.6 Hydration Index

Among the millet hydration index was highest in foxtail millet (0.34) and lowest in little millet (0.15). The results observed are inversely to that reported by Veena et al. [14]; Nazani and Bhuvaneswari [12]; Roopa et al. [16] for foxtail, barnyard and little millet. However, the recorded value for finger millet under study is slightly lower than that reported by Vidyavathi et al. [11]. Statistically significant difference was found to exist at five per cent level among the selected millets as indicated by ‘F’ value.

3.7 Swelling Capacity

Swelling capacity was highest in proso millet (2.40ml) and lowest in little millet (0.48ml). The results are slightly higher than that reported by Nazni and Devi [10]; Veena et al. [14]; Roopa et al. [16] for foxtail, little and barnyard millet. Statistical analysis showed significant difference to exist among the milletfor swelling capacity. The variations in the swelling capacity of millets under study may be due to the difference in grain size and seed volume.

3.8 Swelling Index

Swelling index was found highest in finger millet (0.81) and lowest was recorded little millet (0.20). The results are lower than that reported by Nazni and Devi [10]; Veena et al. [14]; Roopa et al. [16] for foxtail, little and barnyard millet. The swelling index of rice was lower than that reported by Raghuvanshi et al. [17]. Statistically Significant difference was found to exist among the millets with respect to swelling index.

Table 4 . Correlation between Physical Properties of Selected Millets

Parameters	1000 Seeds Weight	1000 Seeds Volume (ml)	Hydration Capacity (g)	Hydration Index	Swelling Capacity (g)	Swelling Index	Specific Gravity	Bulk Density (g/ml)
1000 seeds weight (g)	1							
1000 seeds volume (ml)	0.998**	1						
Hydration capacity (g)	0.992**	0.992**	1					
Hydration index	0.772*	0.769*	0.812*	1				
Swelling capacity (g)	0.996**	0.995**	0.999**	0.796*	1			
Swelling index	0.446	0.392	0.450	0.551	0.457	1		
Specific gravity	0.160	0.166	0.188	0.456	0.163	-0.032	1	
Bulk density (g/ml)	-0.061	-0.125	-0.071	0.094	-0.061	0.832*	-0.034	1

***. Correlation is significant at p<0.01 level, *. Correlation is significant at p<0.05 level*

3.9 Specific Gravity

Specific gravity was highest in foxtail (1.88), followed by proso (1.43), little (1.24), finger (1.10), barnyard (0.91) and kodo millet (0.64). The results are slightly higher than that reported by Vidhyavathi et al. (2001) for finger millet. However, the reported values for finger millet corroborates with the findings reported by Soubhagyalaxmi [15]. Statistical analysis showed significant difference to exist among millets for specific gravity, which may be due to the grain size and weight.

3.10 Bulk Density (g/ml)

High bulk density is a desirable property especially in preparation of infant foods [18]. Bulkdensity was found highest in proso millet (1.55g/ml), followed by finger millet (1.33 g/ml) and least was recorded in foxtail and little millet (0.62 g/ml). The results of the present study were slightly higher than that reported by Nazni and Bhuvaneswari [12] for finger and little millet. However, the observed value for finger millet is slightly higher than that reported by Soubhagyalaxmi [15]. Statistically 'F' value indicated a significant difference to exist among the millets under study for bulk density. The difference in bulk density may be attributed to the grain size and weight.

The correlation among the physical properties of millets analysed in the present study as presented in Table 4. Highly significant relationship at one per cent level was found to exist for thousand seeds weight and thousand seeds volume (r=0.998**), highly significant correlation also existed between hydration capacity and 1000 seeds weight as well as hydration capacity and 1000 seed volume (r= 0.992**). Significant correlation between thousand seeds weight and thousand seeds volume may be attributed to the dependency of both parameters on same factor i.e, seed size.

Further, significant correlation existed between hydration index and thousand seeds weight, hydration index and thousand seeds volume, hydration index and hydration capacity with the 'r' value of 0.772*, 0.769* and 0.812* respectively. Highly significant correlation also existed between swelling capacity with thousand seeds weight, thousand seeds volume and hydration capacity (r=0.996**, 0.995**, 0.999**) respectively. Non-significant negative correlation was found to exist between bulk density with thousand seed weight, thousand seed volume, hydration capacity, swelling capacity and specific gravity.

4. CONCLUSION

The investigation has showed that the physical properties of selected millets vary significantly. The wide variation in millets observed in the study may be due to difference in varieties and also due to agro climatic condition grown. This information is useful for optimizing milling operations, designing the storage structures and machinery, which will help to avoid the post-harvest and milling losses.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh RP, Qidwai S, Singh O, Reddy BR, Saharan S, Kataria SK, Tiwari H, Naresh RK, Kumar L. Millets for food and

nutritional security in the context of climate resilient agriculture: A Review. International Journal of Plant & Soil Science. 2022;939-953.

2. Devi PBR, Vijayabharathi S, Sathyabama NG, Malleshi; Priyadarsini VB. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review. Journal of Food Science and Technology; 2011.
   DOI: 10.1007/s13197-011-0584-9
3. Lu H, Zhang J, Liu K, Wu N, Li Y, Zhou K. Earlier domestication of common millet (*Panicum miliaceum*) in East Asia extended to 10,000 years ago. Proceedings of the national academy of sciences of the United States of America. 2009;(106):7367-7372.
4. Zhu F. Structure, physicochemical properties, and uses of millet starch. Food Research International. 2014;64:200-211.
5. Baker RD. Millet production guide. 1996;6A-414.
   Available: http://www.google.com
6. Mandhyan BL, Sharma SK, Tyagi HR. Study of physical properties, milling performance and cooking time of minor millets. Journal of Food Science and Technology. 1987:3280-3282.
7. Srivastava S, Batra A. Popping qualities of minor millets and their relationship with grain physical properties. Journal of Food Science and Technology. 1998;35(3):265-267.
8. Balasubramanian S, Vishwanathan R. Influence of moisture content on physical properties of minor millets. Journal of Food Science and Technology. 2010;47(3):279-284.
9. William PC, Nakoul H, Singh KB. Relationship between time and some physical characteristics in chickpeas (*Cicer arietinum*L.). Journal of Science Food Agriculture. 1983;(34):492-496.
10. Nazni P, Devi SR. Effect of processing on the characteristics changes in Barnyard and foxtail millet. Journal of Food Processing and Technology. 2016;7(3): 2-8.
11. Vidyavathi HG. M.Sc. (Agri.) Thesis (Unpub.), University of Agricultural Sciences, Bengaluru; 2001.
12. Nazni P, Bhuvaneswari J. Analysis of physico chemical and functional characteristics of finger millet (*eleusine coracana l)* and little millet (*p. Sumantranse*). International Journal of Food and Nutritional Sciences. 2015; 4(3):109-114.
13. Thilagavathi T, Kanchana S, Banumathi P, Hemalatha G, Vanniarajan C, Sundar M, Ilamaran M. Physico-chemical and functional characteristics of selected millets and pulses. Indian Journal of Science and Technology. 2015;8(7):147-155.
14. Veena B, Chimmad BV, Naik RK, Shantakumar G. Physico-chemical and nutritional studies in barnyard millet. Karnataka Journal of Agricultural Sciences. 2005;18(1):101-105.
15. Soubhagyalaxmi PH. Physico-chemical characteristics of raw malted and popped finger millet varieties. M.Sc. (Agri.) Thesis (Unpub.), University of Agricultural Sciences, Bengaluru; 2011.
16. Roopa U, Kasturiba B, Naik RAMA. Physico-chemical and functional properties of little millet genotypes. Karnataka Journal of Agricultural Sciences. 2013;26(4):539-542.
17. Raghuvanshi SR, Dutta A, Tewari G, Suri S. Qualitative characteristics of red rice and white rice procured from local marke of uttarakhand: A comparative study. Journal of Rice Research. 2015; 10(1):49-53.
18. Anwara K. Nutritional composition, processing for value addition and anticalcifying properties of selected horse gram genotypes. Ph.D. Thesis (Unpub.), University of Agricultural Sciences, Bengaluru; 2009.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97098