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Comparative Study of Starch content in Foxtail, Little, Kodo, Proso, Barnyard and Brown Top Millets processed by Traditional and Modern Grain Processing Methods

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ABSTRACT: Six minor millets *i.e.*, foxtail, little, kodo, proso, barnyard and brown top millets were processed using both traditional and modern grain processing methods and the starch content was estimated. The starch content of traditional processed minor millets ranged from 43.4±0.20% to 72.2±0.43%. The highest starch content in traditionally processed grains was in proso (72.2±0.43%) followed by foxtail (64.83±0.29%), kodo (60.54±0.28%), little (50.67±0.46%), barnyard (50.47±0.23) and brown top millet (43.44±0.20) respectively with significant difference ($p \leq 0.01$) across all the millets. Minor millets grains processed by modern methods had starch content between 45.5±0.46% to 73.4±3.69%. Among the modern processed minor millets, the highest starch was seen in proso (73.4±3.69%) followed by foxtail (66.20±0.25%), kodo (57.23±0.37%), little (52.12±0.23%), barnyard (50.97±0.16%) and brown top millet (45.51±0.46%) respectively with significant difference ($p \leq 0.01$) across all the millets. Proso millet has the highest starch content, while brown top millet has lowest starch content among both traditional and modern processing methods. Proso, kodo and foxtail millets have higher range of starch content compared to little, barnyard and brown top millets. It was observed that the starch content varied in minor millets with processing methods although not statistically significant. A trend of the starch content to be slightly high in grains processed by modern method compared to grains processed by traditional method was noticed although not statistically different. It's important to focus on minor millet specificity as the starch content varies significantly among the foxtail, little, kodo, proso, barnyard and brown top for enhanced therapeutic and health outcomes both by nutritionists and food scientists.

Keywords: Foxtail millet, Little millet, Kodo millet, Proso millet, Barnyard millet, Brown top millet, Starch, Traditional grain processing and Modern grain processing.

INTRODUCTION

Millets are small-seeded grasses, annual cereal grasses, which include several distinct botanical species which are cultivated in arid and semi-arid regions of Asia and Africa (Obilana, 2003). The potential of millets is not fully explored as compared to that of other cereals, such as wheat, maize, and rice, which are used most widely (Habiyaremye *et al*., 2017). In India, minor millets rank sixth in production after wheat, rice, maize, sorghum and bajra as reported by Devi *et al*. (2014). As per the 4th advance estimates of the Department of Agriculture and Farmers Welfare, 2021 the production of nutri cereals (millets) in India has increased from 137.11 lakh tonnes in 2018-19 to 172.60 lakh tonnes in 2019-20 respectively (DAFW Govt, 2021). Based on the size of grains, millets have been classified as major and minor/small millets (Reddy and Dipti 2020). The major millets include Sorghum (*Sorghum bicolor*) and Pearl millet (*Pennisetum glaucum*) while the minor/small millets include Finger millet (*Eleusine coracana*), Foxtail millet (*Setaria italica*), Little millet (*Panicum sumatrense*), Kodo millet (*Paspalum scrobiculatum*), Proso millet (*Panicum sumatrense*), Barnyard millet (*Echinochioa frumentacea*), and Brown top millet (*Urochloa ramose*) (Chandrasekara and Shahidi 2010). They are also known as nutri-cereals because of their high nutritional value and ability to provide key nutrients that are required for normal functioning of human body. Millets can be staple food sources, due to the presence of vitamins and minerals apart from complex carbohydrates, proteins and fats (Singh *et al.,* 2020). It is necessary to process grains in order to make them edible and digestible (Balasubramanian, 2013). Millets could be processed both by traditional processing method using (stone grinding and hand pounding) and modern processing method using (mechanical dehullers) and further can be consumed as traditional local foods (Nithiyanantham *et al*., 2019). Starch is one of the primary components of carbohydrate content of human staple diets, so its digestive properties are important. Maltose, oligosaccharides, and higher dextrin are all released into the small intestine lumen as a result of starch breakdown, which is mediated by salivary and pancreatic amylases (Reddy, 2015). It is the most abundant polysaccharide in nature, cost-effective and provides a major source of energy in human food, and is utilized extensively in various food and non-food products (Perin & Murano 2017). Amylose and amylopectin are the primary components of starch, and the amount of amylose determines the cooking quality (Bao, 2019). Most food applications require starch, which is the main constituent of millet grain (Bangar *et al*., 2021). There has been a significant amount of study on the starches of rice, wheat, maize, sorghum, barley, and oats. However, very little research on small millets has been documented especially to study the impact of processing methods of minor millet grains. With the renewed interest in consumption of minor millets, availability of processed millet grains and in many processed food forms has increased in the market. Since the information of starch content in minor millets processed by traditional grain processing methods is not available, therefore, the present investigation was done to compare the starch content of six minor millets handled by traditional and modern processing methods.

MATERIAL AND METHODS

Six minor millets namely foxtail millet, little millet, kodo millet, proso millet, barnyard millet and brown top millets in the form of whole grains were procured from the Deccan Development Society (DDS), Aswatha traders (Coimbatore) and Orillet traders (Anantapur). They were further processed using traditional methods (stone grinding and hand pounding) and modern methods (mechanical dehulling) using the facility at Millet Processing and Incubation Centre (MPIC) and Deccan Development Society (DDS) an agri based NGO. Further the dehusked and dehulled minor millet grains processed by traditional and modern methods were made into flour using NISA flour mill and analysed for starch content in six minor millets using the method described by (Yang *et al*., 2018; Gao *et al*., 2016). Chemicals, glassware and instruments were obtained from Post Graduate and Research Centre (PGRC) and Central Instrumentation Cell (CIC), Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad.

Traditional grain processing of minor millets: Traditional grain processing of six minor millets *i.e*., foxtail millet, little millet, kodo millet, proso millet, barnyard millet and brown top millet was done based on the method described by Subramanian and Jambunathan (1980) with some modifications as required for the grains. Traditional processing of six minor millet were done with the help of senior farm women from the millet growing areas of Bidekene and Pastapur villages with the support and help from DDS an NGO located at Pastapur village of Zaheerabad region, Sangareddy district, Telangana state.

The traditional method of processing minor millet grains includes sequence of steps (Fig. 1 and Plate 1) such as threshing, winnowing, mixing with soil, sun drying, cleaning, grinding, pounding and further cleaning. The minor millet grains were cleaned from foreign materials such as dust and straw and then subjected to sun drying (10-12 hrs). Little, kodo and proso were mixed with the mixture of mud and ash and kept for drying, while foxtail, barnyard and brown top were directly sun dried.The traditional indigenous method of grinding was manually done using a stone grinder consisting of two plates (upper and lower plate). The lower plate was immovable, while the upper plate was movable and operated by hand. A leather sheet was soaked in water for half an hour, followed by coating the sheet with mixture of wet mud, ash and allowed to dry moderately. Then the leather sheet was inserted above the lower plate. A handful of grains were poured from the central hole of the upper plate and subjected to a churning process to dehusk the grains. During the churning process the dehusked grains were scattered around the lower plate. The dehusked grains were collected and subjected to winnowing where the grains were thrown from a height to separate the dehulled grain from the husk followed by hand pounding.

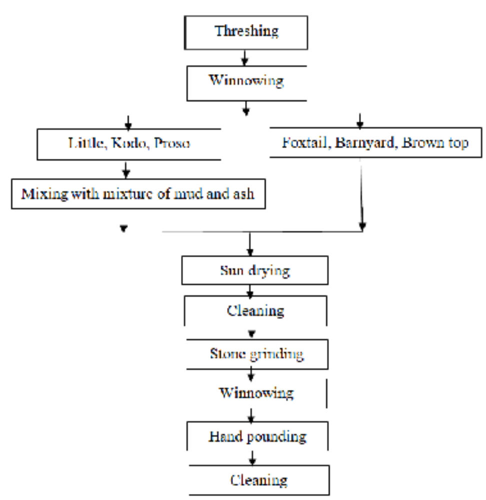


Fig. 1. Flow chart of traditional processing of minor millets.

Plate 1. Step by step traditional grain processing of minor millets.

Hand Pounding process includes pounding of the dehulled grains in a hand-operated wooden mortar and pestle, where bran from the grains was separated and then subjected to the winnowing process again which segregates the bran from the grains.

Modern grain processing of minor millet: Modern grain processing of minor millets was done based on the methods described by Durairaj *et al*. (2019) with some modifications. Modern processing of minor millet grains includes a sequence of steps *i.e.*, grading, destoning and dehulling is represented in Fig. 2 and Plate 2. Dehulling of the minor millets was done using Rice Mill Walson machinery with a minimum capacity of two kgs to a maximum capacity of ten kgs.

Grading and destoning

↓

Dehulling

Fig. 2. Flow chart of modern processing.

Destoning was the first step in the modern processing of grains where grains were passed through a conveyor belt consisting of grading frames for effective separation of millet grains from dust, straw, stones etc. It operates in a continuous mode powered by electric motor. Then the obtained minor millet grains were poured into the dehulling machinery from the top opening and allowed to dehull the grains. Dehulled grains and husk were collected from separate outlets. Obtained dehulled grains were cleaned using Dhan foundation grading machinery and stored.

Starch isolation (SI). Starch content was determined based on the method described by (Yang *et al*., 2018; Gao *et al*., 2016). The traditional and modern processed six minor millet grains were made into flour using NISA flour mill and 50g of sample flours were weighed and suspended in 0.1%(v/v) sulphuric acid (H_2SO_4) and then left overnight at room temperature. The suspension was transferred into 50ml centrifuge tubes and centrifuged at 3000rpm for 20min using Eltekrefrigerated bench centrifuge and then the supernatant was decanted. The remaining sediment was dissolved in 0.1% sodium hydroxide (NaOH) and then further centrifuged at 3000rpm for 20min to remove impurities. The obtained deposit was washed with distilled water and then centrifuged at 3000rpm for 20min. The above-mentioned steps were repeated until the colour of the supernatant was clear.

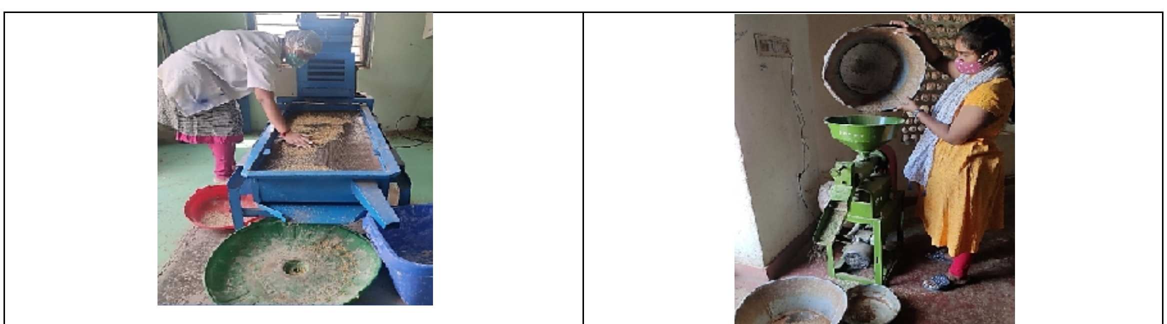


Plate 2. Modern grain processing of minor millets.

The remaining deposit was then mixed with 20ml of acetone and centrifuged at 3000rpm for 20min. The final starch pellets were dried in a fume hood and weighed. The starch percentage was calculated.

RESULTS AND DISCUSSION

Traditional processed grains. The starch content of traditional and modern processed minor millets is enumerated in Table 1, Fig. 3a. The starch values of traditional processed minor millet grains ranged from 43.4±0.20% to 72.2±0.43%. Proso millet has reported the highest starch content of 72.2±0.43% followed by foxtail millet (64.83±0.29%), kodo millet (60.54±0.28%), little millet (50.67±0.46%), barnyard millet (50.47±0.23) and least in brown top millet (43.44±0.20) with significant difference ($p \leq 0.01$) across all the minor millets. Proso millet, kodo millet and foxtail millets have shown higher range of starch content as compared to little millet, barnyard millet and brown top millets.

Modern processed grains. Fig. 3b represents the isolated starch values of modern processed grains varied from 45.51±0.46% to 73.41±3.69%. The highest starch content was found in proso millet (73.41±3.69%) followed by foxtail millet (66.20±0.25%), kodo millet (57.23±0.37%), little millet (52.12±0.23%), barnyard millet (50.97±0.16%) and least in brown top millet (45.51±0.46%) with statistically significant difference ($p \leq 0.01$) across all the minor millets. Proso millet, kodo millet and foxtail millets have shown higher range of starch content as compared to little millet, barnyard millet and brown top millets (Table 1).

Traditional grain processing v/s Modern grain processing. The starch content values among six minor millets between the processing methods varied slightly and the results revealed that the starch content was reported slightly high among all the modern processed grains when compared to all traditional processed grains. From our results although there was a trend of starch content being less in traditional processed minor millets compared to starch content in minor millets processed by modern methods the results were not statistically significant. Statistically there was no significant difference in starch content values between both the processing methods whereas statistically a significant difference ($p \leq 0.01$) was noticed among the minor millet interactions.

A comparative study of starch from decorticated small minor millets done by Kumari (1996) and revealed that the highest starch content was found in foxtail millet (69.40%), followed by kodo millet (67.52%), barnyard millet (65.70%), proso millet (64.80%) and least in little millet (62.50%) respectively. While Singh and Adedji (2017); Annor (2014) have reported the starch content in proso millet was in the range from 54.1% to 93.7% and in finger millet (52.4% to 63.4%), foxtail millet (69.1%), kodo millet (94.18%) and pearl millet (70.4%) respectively. Yanez *et al.* (1991) studied the physical and chemical properties of proso millet starches and reported that the starch content from different varieties of proso millets were in the range of 61.8% to 68.2% respectively. From the literature we couldn't get the information on the starch content of minor millets processed by traditional methods. Most of the studies on starch content of minor millets from the literature are grains processed using mechanical dehullers only. Although hour results also show a similar trend in starch content in minor millets as reported in literature there is slight variation. The starch content among the minor millets varies, it can be affected by different factors such as nature of origin, structure, type of processing methods and machinery used (Mahajan, 2021).

Wang and Wang (2004) studied the starch content of rice and reported that the starch content of different rice varieties ranged from 62.5% to 86.7% respectively at different reaction times. Moongngaram, (2013) conducted a study on starch content in starchy foods and revealed that the total starch content in different rice varieties varied from 68.57±5.65% to 74.76±2.19% respectively. Hover *et al.*, (1996) examined starch characterization of long grain brown rice and revealed that the starch yield was 64.4% in long grain brown rice and 38.3% in wild rice respectively. Snow and Dea (1981) revealed that the starch content of white rice flour was 77.4%, white rice was 82.2% and brown rice was 77.9% respectively. In the present study the starch content of minor millets *i.e.*, little millet, kodo millet barnyard millet and brown top millets processed by traditional and modern methods have comparatively lower starch content than in different rice varieties, white rice flour, brown rice and long grain brown rice too.

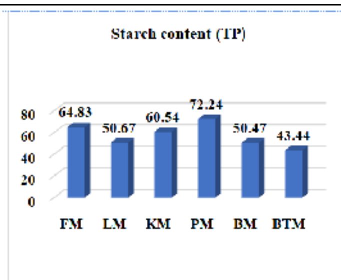
Hakim *et al*. (2012) studied the starch content of twenty wheat genotypes and reported that the starch values ranged from 60.7% to 66.6% with significant difference of ($p \leq 0.05$) statistically. Holm *et al*., (1986) studied the starch content of white wheat flour and whole grain. The highest starch content was found in white wheat flour (80.6% to 81.7%) and whole grain (67.3% to 71.1%) respectively. Verma *et al*. 2018 studied the starch content of different cereals and reported that the starch content of wheat varied from 60.34% to 66.6%, white wheat flour ranged from 83.6% to 84.1% and in whole wheat grain it ranged from 69.0% to 71.3% respectively. From the results of our work the starch content of foxtail, little, kodo, barnyard and brown top millets processed by traditional and modern methods was lower compared to starch content of whole wheat grain, white wheat flour and wheat starch as reported in the above studies.

Table 1: Mean starch content of six minor millets processed by traditional and modern grain processing methods.

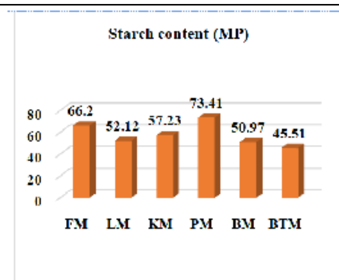
Samples	Processing		Pooled millets
	Traditional Processing	Modern Processing	
Foxtail Millet	64.8±0.29	66.2±0.25	65.5^{a}±0.79
Little Millet	50.6±0.46	52.1±0.23	51.3^{b}±0.86
Kodo Millet	60.5±0.28	57.2±0.37	58.8^{c}±1.83
Proso Millet	72.2±0.43	73.4±3.69	72.8^{d}±2.44
Barnyard Millet	50.4±0.23	50.9±0.16	50.7^{b}±0.32
Brown top Millet	43.4±0.20	45.5±0.46	44.4^{e}±0.18
Pooled processing methods	57.0±10.06	57.5±9.89	57.3±9.83
ANOVA Table			
Source of Variation	Degrees of freedom	F Value	P Value
Millets	5	540.3	0.000**
Processing	1	2.1	0.156^{NS}
Millets vs Processing	5	4.6	0.004**

Values are expressed as mean ± SD, **Significant at (p≤0.01), NS: Not Significant

NOTE: Variations in superscripts indicate (p>0.05) significance of mean differences across the minor millets.



(a)



(b)

Foxtail millet (FM), Little millet (LM), Kodo millet (KM), Proso millet (PM), Barnyard millet (BM) and Brown top millet (BTM)

Fig. 3. Mean values of minor millet starch content in traditional processed (TP) and modern processed (MP) grains.

CONCLUSION

The present study shows that there is significant difference in starch content among the six minor millets (foxtail, little, kodo, proso, barnyard, brown top millets). Starch content of each minor millets is significantly different with each other. The starch content of foxtail, kodo and proso millets are in higher range when compared to starch content of little, barnyard and brown top millets. Therefore, while consuming the minor millets it is important to select the minor millets based on physiological conditions and health goal. Also, nutritionists while giving dietary prescriptions, should recommend specific minor millets according to the needs of the individuals to enable effective results. Food technologists also can design foods based on starch content for specific functionality. Furthermore, there are variations in the starch content between the traditional and modern grain processing methods for all millets (foxtail, little, kodo, proso, barnyard, brown top millets). Modern grain processing has resulted in increased starch content in all minor millets although statistically no significant difference was found.

FUTURE SCOPE

Studies on starch content of traditional processed minor millet grains are limited and need further exploration. It's important to develop and promote appropriate grain processing technology and methods suitable for each individual minor millet grain. Further research can be done on effect of degree of milling in different minor millets which will help in developing appropriate processing tools for development of value-added products with commercial value and therapeutic potential.

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Conflict of Interest: None.

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