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# Processing kodo millet (*Paspalum scrobiculatum*) to obtain low fiber flour

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## Abstract
Millet is a generic term used for small sized grains that form heterogeneous group and referred as 'coarse cereals' similar to maize and sorghum. These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security. Kodo millet is one among the oldest traditional underutilized crop. Though, kodo millet is nutritionally superior it is least used in supplementary and complementary food because of high fiber content. Hence the present was undertaken to partition the kodo millet to get low fiber flour, which can be further used in supplementary and complementary foods. The kodo millet was partitioned by three different methods (sieving method, grinding method and traditional method) and analyzed for recovery rate, particle size and proximate composition. The recovery rate of partitioned fine flours from sieving, grinding and traditional methods was 48.00, 42.00 and 66.33 per cent respectively. The size of majority of the particles of partitioned fine flours ranged from 75 to 180 microns. The proximate composition *i.e.,* moisture, fat, protein, crude fiber, ash, available carbohydrate, total available and energy of kodo millet flour and fine flours ranged from 12.46 to 13.55 g/100g, 2.25 to 3.52 g/100g, 7.11 to 13.80 g/100g, 3.70 to 5.87 g/100g, 1.14 to 1.95 g/100g, 62.27 to 71.67 g/100g, 68.05 to 75.79 g/100g and 353 to 359 Kcal respectively. Therefore, the kodo millet fine flours becomes suitable for the children and convalescent population after partitioning as it is rich source of protein, fat and had lower crude fiber.

**Keywords:** Kodo millet, partitioning, particle size, proximate composition

## Introduction
Millet is a generic term used for small sized grains that form heterogeneous group and referred as 'coarse cereals' similar to maize and sorghum. Their agricultural importance arises from the hardiness, tolerance to extreme weather and could be grown with low inputs in low rainfall areas (Jaybhaye *et al.,* 2014) [10]. Millets are considered as crop of food security because of their sustainability in adverse agro-climatic conditions. These crops have substantive potential in broadening the genetic diversity in the food basket and ensuring improved food and nutrition security (Ushakumari *et al.,* 2004) [20]. These millets are cultivated largely in the Asian and African countries. Most exploited and widely used millets are pearl millet, finger millet, foxtail millet and little millet. Whereas, kodo millet, proso millet, barnyard millet and brown top millet are considered as underutilized minor millets (Jaybhaye *et al.*, 2014) [10].
Subsequently, millets are these days used in expanding the genetic diversity and food basket to improve the food, health and nutrition security. Previously, millets were consumed traditionally as an energy dense and healthy food by poor people of the community especially during drought and famine, thus referred as ‘poor man’s food’ or ‘poor people’s crop’ in rural India (Hegde and Chandra, 2005 and Yousaf *et al.*, 2021) [5, 21].
Kodo millet is one among the oldest traditional underutilized crop. It is grown in India, Pakistan, Philippines, Vietnam, Indonesia, Thailand and West Africa. It is majorly grown in Deccan plateau of India such as Karnataka, Gujarat, parts of Tamil Nadu; some regions of Maharashtra, Odisha, West Bengal, Rajasthan, Uttar Pradesh and Himalayas and consumed as healthy and energy food in rural parts of India. The nutritional potential of kodo millet in terms of protein (11%), fat (4.2%) and fiber (14.3%) is superior to the commonly used cereals like wheat and rice.
With the increasing awareness about nutritional and health benefits of underutilized millet, it has gained attention among nutritionists, technologists and food processors. To alleviate public health problems it becomes a viable policy to develop different foods from kodo millet to improve the nutritional status of the population and develop new deviation in food basket.

Conventionally, millet malt is used as a cereal base for low dietary bulk and calorie dense weaning foods, supplementary foods, health foods and also amylase rich foods. Usually, the millet malt particularly finger millet malt (*ragi*) is utilized for infant feeding purpose. Malting helps to appreciably increase the nutrient composition, fibre, crude fat, vitamins B, C and their availability, minerals, improve the bioavailability of nutrients, sensory attributes of the grains. This accounts for the decrease in the prevalence of protein malnutrition among children fed exclusively on millet diet. Though, kodo millet is nutritionally superior they are least used in supplementary and complementary food because of high fiber content. Hence the present was undertaken to partition the kodo millet to get low fiber flour, which can be further used in supplementary and complementary foods.

## Material and Methods

Kodo millet was procured from the local market of Dharwad, Karnataka. The millet was cleaned washed and was further used for analysis in triplicates.

### Physicochemical properties of kodo millet

#### Thousand Grain weight (g)

Three sets of 1000 intact grains were selected randomly. Weight of selected grains was recorded in triplicates using electronic weighing balance and average was calculated. The mean weight was expressed as g/1000 grains.

**Thousand Grain volume (ml):** The volume of millet grains was measured by water displacement method. Thousand randomly selected grains were dropped in measuring cylinder containing known volume of water. The rise in volume was recorded in ml. The volume of millet was calculated by subtracting the initial volume from final volume.

#### Bulk density

Bulk density was calculated from weight and volume of Kodo millet as follows;

$$\text{Bulk density (g/ml)} = \frac{\text{Weight (g)}}{\text{Volume (ml)}}$$

#### Colour of kodo millet

Kodo millets were selected randomly and were packed in transparent pouches. The samples were subjected to colour assessment in Konica Minolta spectrophotometer of model CM 2600/2500d. The colour was assessed for L* (lightness/ black to white), a* (redness/ redness to greeness) and b*(yellowness/ yellowness to blueness).

#### Hydration capacity (g/1000 grains)

Hydration capacity was measured by soaking weighed 1000 millets overnight in beaker with 100 ml of water. Next day, water was drained off and millets were dried using filter paper to remove superfluous water and weighed (Bhokre *et al.*, 2015) [6]. Hydration capacity was calculated as;

$$\underset{\text{(g/grain)}}{\text{Hydration capacity of seeds}} = \frac{\text{Weight after soaking (g) - Weight before soaking (g)}}{\text{Number of seeds (1000 grains)}}$$

#### Hydration index

Hydration index was calculated by using formula

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Weight of seeds}}$$

#### Swelling capacity (ml/ 1000 grains)

Thousand grains were counted and volume was noted by water displacement method. The grains were soaked overnight. Further, water was drained off next day and volume was noted (Bhokre *et al.*, 2015) [6]. Then, the swelling capacity was measured using formula:

$$\underset{\text{(ml/ grain)}}{\text{Swelling capacity}} = \frac{\text{Volume of seeds after soaking (ml) – Volume of seeds before soaking (ml)}}{\text{Number of seeds (1000 grains)}}$$

#### Swelling index

Swelling index was calculated using formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Volume of seeds}}$$

### Partitioning of kodo millet

The kodo millet was partitioned by three methods *viz.*, traditional method, milling and sieving method and by grinding to get fine flour with low fiber and coarse flour with high fiber content.

#### Traditional method

Hundred grams of kodo millet flour was passed through muslin cloth with constant stirring, till fine flour was collected in the container. Three trials were done. The recovery rate of fine flour was recorded.

**Partition through milling and sieving:** Hundred gram of kodo millet flour was passed through 150 BSS sieve with opening of 105 microns. The flour obtained after sieving was collected as fine flour. The weight of the flour was recorded.

**Partitioning through grinding:** About 100g of kodo millet grains were soaked overnight in water (1:1 ratio). The water was drained and the grains were washed with water. The soaked grains were ground to obtain the fine paste. The obtained paste was passed through 100 BSS sieve with opening of 150 microns. The milk obtained was collected in a tray and dried in hot air oven. The dried product (milk) was later converted into powder. The flour was weighed and noted (Devi and Sangeetha, 2013) [7].

The recovery rate of kodo millet fine flour was recorded and distribution of particle size and proximate composition was analysed.

**Particle size distribution:** Hundred grams of flour was weighed and passed through different meshes of BSS sieves from 60, 85, 100, 150, 200, 240 and 300 with sieve opening of 250, 180, 150, 105, 75, 63 and 53 microns respectively. The samples were passed from bigger sized mesh to smaller. The sample above the mesh was weighed and the reading was recorded. Percentage was calculated (Kurahatti, 2010) [11].

**Proximate analysis:** The proximate components like moisture, crude fat, crude protein, crude fiber and ash were analysed for Kodo millet flour and partitioned flours using standard AOAC procedures (Anon., 2019) [4]. Total and available carbohydrates were computed by subtracting the sum of moisture, crude fat, crude protein and ash from 100. For available carbohydrate crude fiber was also deducted from 100.

**Statistical analysis:** The data was computed for mean, standard deviation and ANOVA using SPSS 16.0.

## Results and Discussion

Table 1 shows the physicochemical properties of the kodo millet. The thousand grain weight and thousand grain volume of kodo millet grains were 3.88 g and 3.33 ml respectively. The bulk density of kodo millet was 1.16 g/ml. The functional properties of kodo millet like hydration capacity, swelling capacity, hydration index and swelling index were 4.65 g/ grain, 11.63 ml/ grain, 1.19 and 3.00 respectively. The colour values *i.e.*, 'L', 'a' and 'b' of kodo millet were 54.03, 5.39 and 15.04 respectively. Few studies conducted revealed that the weight, volume and bulk density ranged from 2.45 to 4.29 g, 1.2 to 3.99 ml and 1.07 to 1.84 /ml respectively (Thilagavathi *et al.*, 2015; Muragod *et al.*, 2019 and Patil *et al.*, 2020) [19, 13, 15]. Muragod and co-workers (2019) [13] reported that the hydration capacity (g/1000 grains), hydration capacity (%), swelling capacity (ml/1000 grains), swelling capacity (%) and swelling power (g/g) of kodo millet grains were 0.51, 24.52, 0.55, 42.30 and 9.73 respectively.

All millets apart from finger millet have harder seed coat; therefore their processing starts with removal of husk. On the other hand, owing to superior nutritional quality in general and protein profile in terms of quantity and quality, in particular, it is important to convert kodo millet into a form more suitable for growing children. Thus, kodo millet was partitioned in three different ways *i.e.*, traditional method, sieving method and grinding method to get finer portion of kodo millet which is nutritious and low in fiber. Recovery rate of partitioned fine flours from kodo millet is shown in Fig. 1. The traditional method had highest recovery of fine flour (66.33%) followed by sieving method (48%) and grinding method (42%). Different millet flours like barnyard millet, foxtail millet, pearl millet, finger millet were passed through different pore size sieve to get fine flour (Thathola and Srivasatava, 2002; Onweluzo and Nwabugwu, 2009; Lombor *et al.*, 2006 and Verma and Patel, 2013) [18, 14]. Whereas, Devi and Sangeetha, 2013 [7]; Shunmugapriya *et al.*, 2020 [17] and Akashaya *et al.*, 2020 [2] extracted millet milk from finger millet, pearl millet, kodo millet, barnyard millet and little millet for development of extruded products or for production of beverages.

The particle size distribution of partitioned fine flour is depicted in Table 2. About 50 per cent of kodo millet flour had particle size of 105 microns followed by 150 microns (26.41%) and 180 microns (8.86%). About 13 per cent of kodo millet flour had particle size of less than 75 microns. It was observed that majority of the particles in fine flours (FSM, MMP and TFF) were less than 105 microns. In FSM, 85.72 per cent of flour had passed through 150 BSS sieve (105 microns). About 70 per cent of MMP passed through 150 microns size sieve (100 BSS) and only 29.37 per cent of flour particles were of 180 to 250 microns. Majority of the particles of fine flour from traditional method (TFF) had size of 105 to 150 microns (73.53 per cent). Only 3.48 per cent flour had 53 to 75 micron size and 22.73 per cent were of 180 microns. Table 2 indicates that the partitioned flours had smaller microns thus making flour fine, nutritious and less fibrous (Itagi, 2003; Banakar, 2005 and Kurahatti, 2010) [9, 5, 11].

Table 3 shows the proximate composition of fine kodo millet flour. There was significant difference among all three partitioned kodo millet flours for moisture, fat, protein, crude fiber, ash, available carbohydrate and total carbohydrate. The moisture content of KMF was 13.38 g/100 g. The moisture content of fine flour from sieving, grinding and traditional method was 13.55, 12.46 and 12.72 g/100 g respectively. The fat content of KMF was 3.52 g/100 g. It was noted that fine flours had significantly ($p \leq 0.01$) lower fat content after partitioning *i.e.*, FSM (2.65 g%), MMP (2.70 g%) and TFF (2.25 g%). The protein content of kodo millet flour was 13.80 g/100 g. The protein content reduced by approximately 49, 44 and 41 per cent and the values were 7.11 g/100 g, 7.72 g/100 g and 8.08 g/100 g for sieving, grinding and traditional method respectively. The crude fiber content of FSM, MMP and TFF was 4.21, 3.70 and 4.12 g/100 g respectively while that of kodo millet flour was 5.87 per cent. The ash content of fine flours of sieving, grinding and traditional method *i.e.*, FSM, MMP and TFF was 1.43, 1.95, and 1.14 g/100 g respectively. The kodo millet flour had 1.24 g/100 g of ash content. The available and total carbohydrate of kodo millet flour (KMF) was 62.27 and 68.05 g/100 g respectively, while, that of partitioned fine flours was FSM (71.02 and 75.25 g%), MMP (71.46 and 75.16 g%) and TFF (71.67 and 75.79 g%) respectively. The energy of partitioned kodo millet flour ranged from 353 to 359 Kcal. Therefore, fine flours are rich in fat, protein and carbohydrate since endosperm and germ are concentrated in this portion. Similar result was witnessed in study conducted by Abdalla and co-workers (2009), wherein, after extraction of starch from pearl millet; the starch flour (fine) had lower composition of proximates. Similar results were also recorded in the study of Alfauomy *et al.* (2017) [3]. The processing techniques convert the grain into flour and separate the barn, germ and endosperm (Ramashia *et al.*, 2019) [16]. After partitioning, the endosperm and germ rich in fat, protein and carbohydrate are concentrated in fine flours.

**Table 1:** Physicochemical properties of kodo millet grains

| Physicochemical properties | Mean ± SD |
|---|---|
| Thousand grain weight (g) | 3.88 ± 0.41 |
| Thousand grain volume (ml) | 3.33 ± 0.28 |
| Bulk density (g/ml) | 1.16 ± 0.06 |
| Hydration capacity (g/ 1000 grains) | 4.65 ± 0.09 |

| | |
|---|---|
| Hydration index | 1.19 ± 0.04 |
| Swelling capacity (ml/ 1000 grains) | 11.63 ± 0.77 |
| Swelling index | 3.00 ± 0.31 |
| Colour | |
| L (lightness) | 54.03 ± 0.05 |
| a (Redness) | 5.39 ± 0.09 |
| b (Yellowness) | 15.04 ± 0.04 |

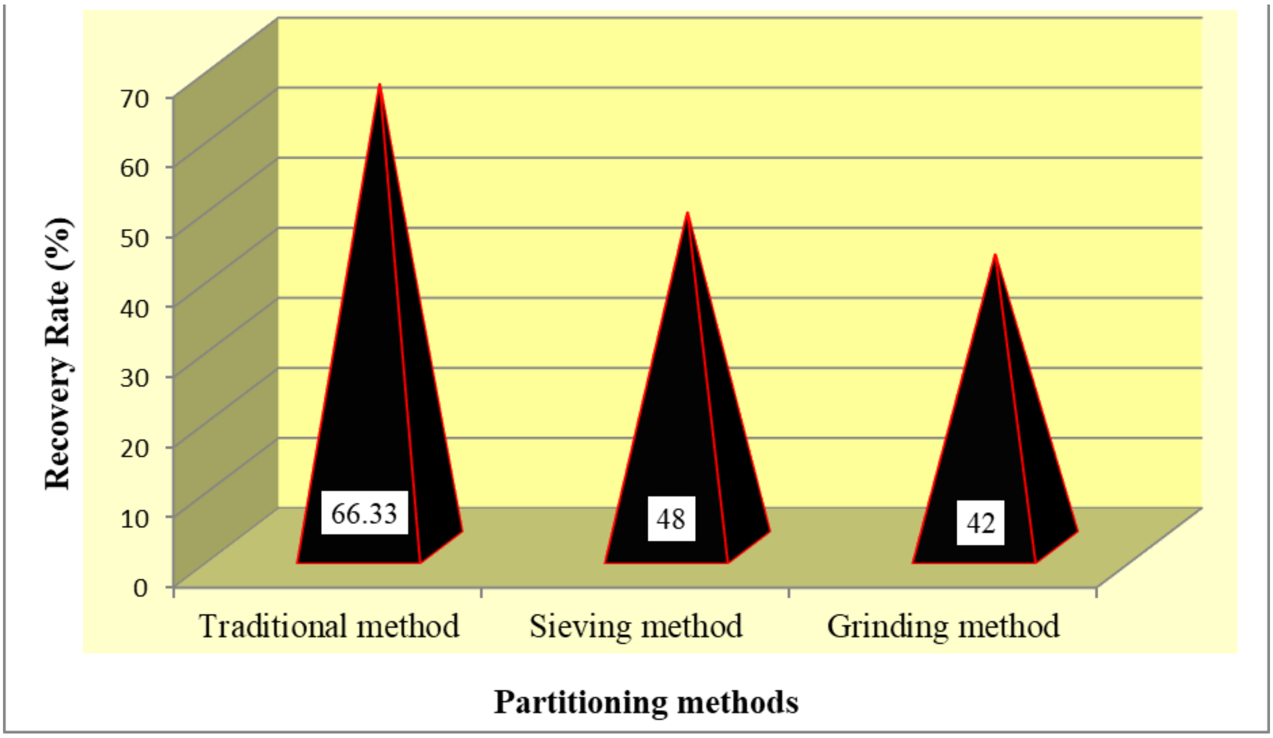


**Fig 1:** Recovery rate of fine flours from kodo millet

**Table 2:** Particle size distribution of fine flours of kodo millet

| BSS standards [sieve opening (µm)] | Flours | | | |
|---|---|---|---|---|
| | KMF | FSM | MMP | TFF |
| 300 (53) | 0.67 ± 0.02[f] | 0.50 ± 0.08[e] | 1.23 ± 0.30[f] | 0.37 ± 0.18[ef] |
| 240 (63) | 3.82 ± 0.24[d] | 1.59 ± 0.39[d] | 2.49 ± 0.37[e] | 0.76 ± 0.04[e] |
| 200 (75) | 8.75 ± 0.48[c] | 3.41 ± 036[c] | 4.76 ± 0.51[d] | 2.35 ± 0.08[d] |
| 150 (105) | 49.18 ± 0.69[a] | 85.72 ± 0.78[a] | 21.92 ± 0.62[b] | 35.27 ± 0.11[b] |
| 100 (150) | 26.41 ± 0.29[b] | 7.95 ± 0.16[b] | 40.19 ± 0.73[a] | 38.29 ± 0.58[a] |
| 85 (180) | 8.86 ± 0.26[c] | 0 | 21.18 ± 0.18[b] | 22.73 ± 0.38[c] |
| 60 (250) | 1.89 ± 0.57[e] | 0 | 8.19 ± 0.33[c] | 0 |
| Above 60 | 0 | 0 | 0 | 0 |
| F value | 5.12 | 2.26 | 3.03 | 1.26 |
| S. Em. ± | 0.23 | 0.19 | 0.25 | 0.15 |
| C. D. | 0.69** | 0.88** | 1.15** | 0.67** |

**Note:** Values are mean of three replications; Values having same superscript in a column are not significantly different, S.Em: Standard error of mean, C.D.: Critical Difference, * Significant @ 5%, **Significant @ 1%
KMF: Kodo Millet Flour, FSM: Fine flour from sieving method, MMP: Millet milk powder, TFF: Traditional method fine flour

**Table 3:** Proximate composition of fine flours of kodo millet

| Proximate composition (g/100 g) | Flour | | | | F value | S. Em. ± | C. D. |
|---|---|---|---|---|---|---|---|
| | KMF | FSM | MMP | TFF | | | |
| Moisture | 13.38±0.48[a] | 13.55±0.15[a] | 12.46±0.28[b] | 12.72±0.50[b] | 5.49 | 0.21 | 0.37* |
| Fat | 3.52 ± 0.16[a] | 2.65 ± 0.28[b] | 2.70 ± 0.20[b] | 2.25 ± 0.11[c] | 20.88 | 0.11 | 0.37** |
| Protein | 13.80±1.04[a] | 7.11±0.20[bc] | 7.72 ± 0.57[b] | 8.08 ± 0.40[b] | 70.70 | 0.36 | 1.20** |
| Crude fiber | 5.87 ± 0.18[a] | 4.21 ± 0.17[b] | 3.70 ± 0.36[c] | 4.12 ± 0.32[b] | 49.78 | 0.12 | 0.42** |
| Ash | 1.24±0.34[cd] | 1.43±0.33[bcd] | 1.95 ± 0.04[a] | 1.14 ± 0.17[d] | 5.90 | 0.13 | 0.48** |
| Available CHO | 62.27±0.95[d] | 71.02±0.34[c] | 71.46±1.15[c] | 71.67±0.88[bc] | 79.55 | 0.51 | 1.67** |
| Total CHO | 68.05±1.14[d] | 75.24±0.49[c] | 75.16±0.84[c] | 75.79±0.91[c] | 52.64 | 0.50 | 1.65** |
| Energy (Kcal) | 359 | 353 | 356 | 356 | | | |

**Note:** Values are mean of three replications, Values having same superscript in a column are not significantly different, S.Em. Standard error of mean, C.D.: Critical Difference, ** Significant @ 1%,* Significant @ 5% level
KMF: Kodo Millet Flour, FSM: Fine flour from sieving method, MMP: Millet Milk Powder, TFF: Traditional method fine flour

## Conclusion

Kodo millet was partitioned by three different methods *i.e.*, sieving, grinding and traditional method. The recovery rate of the partitioned fine flour ranged from 42 to 66.33 per cent. Majority partitioned fine flour's particle size ranged from 75 to 150 microns. It was evident that partitioned fine flours had higher crude fat, crude protein and energy and lower crude fiber content. Hence the partitioned fine flours fit into the criteria of children's and convalescent food and thus can be used for the development of health mix.

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