Madras Agric. J., 101 (4-6): 201-205, June 2014
https://doi.org/10.29321/MAJ.10.001182

Evaluation of Quality Charactertistics of Porridge from Kodo and Little Millet

P. Karuppasamy* and D. Malathi
Food Science and Nutrition, Post Harvest Technology Centre
Tamil Nadu Agricultural University Coimbatore - 641 003

Small millet based porridge was standardized by incorporating kodo and little millet flour at 50, 75 and 100 per cent levels. The optimized porridge was evaluated for its sensory attributes and was highly acceptable at 100 per cent level. The optimized small millet porridge was analyzed for its physico-chemical properties, rheological and cooking characteristics using standard procedures. The water activity of kodo (T_1) and little millet (T_2) flour was lower (0.39 and 0.45 a_w) and sedimentation value (25.00 and 18.00 ml) was higher than the control (0.61 a_w and 0.21 ml). The final viscosity and pasting temperature of T_1 and T_2 was 1363.00 and 1124.00cP, 80.34 and 80.32°C respectively. The gelatinization temperature for T_1 and T_2 was 79 °C and 76°C and the time taken was 5 mins. The protein, fibre, iron and calcium content of T_1 was 8.12 g, 8.20 g, 1.40 mg and 24.00 mg and that of T_2 was 7.30 g, 7.25 g, 8.60 mg and 16.10 mg per 100 g respectively. The microbial load was found to be within the safe limit.

Key words: Small millets, Porridge, Rapid visco analysis, Gelatinization and Physico-chemical properties.

Millets are small-seeded with different varieties such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), kodo millet (*Paspalum setaceum*), proso millet (*Penicum miliaceum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*) and barnyard millet (*Echinochloa utilis*) (Kaur *et al*., 2012).

Millet grains account for about one sixth of the total food grain production and hold an important place in the food grain economy of India. India is the largest producer of millet grains, producing about 33-37 per cent of a total of 28 million tonnes of the world produce. Finger millet constitutes about 81.00 per cent of the minor millets produced in India; and the rest by kodo millet, foxtail millet and little millet (Pradhan *et al*., 2010). The world total production of millet grains at last count was 7.63 lakh metric tons and the top producer was India with an annual production of 3.35 lakh tons (43.85 per cent) (FAO, 2012).

Millets are highly nutritious, non glutinous and non-acid forming foods. Hence, they are soothing and easy to digest. They are considered to be the least allergenic and most digestible grains available. Kodo millet and little millet are the minor millets having certain specialities, which if exploited, may yield products of superior nutritional and technological characteristics than the major cereals, but their utilization is limited. Kodo millet is found across the old world in humid habitats of tropics and subtropics. It is a minor grain crop in India. The fibre content of the whole grain is very high and has around 11.00 per cent protein, and nutritional value of the protein has been found to be slightly better than that of foxtail millet, but comparable to that of other small millets. Little millet is another reliable catch crop in view of its earliness and resistance to adverse agro-climatic conditions. This millet is rich in fibre content when compared to other small millets. (Kumar, 2010). Small millets can be used for traditional as well as novel foods. However, there is a need to look into the possibilities of alternative uses. Value addition to food has assumed critical importance in the last decade due to socio-economic and industrial factors. Hence, the present study aimed in optimizing and assessing the quality characteristics of small millet porridge.

Materials and Methods

Kodo millet and little millet grains were procured from Peraiyur Taluk, Madurai District and Jamunamarathoor, Thiruvannamalai District of Tamil Nadu. The other ingredients were purchased from the local market.

Water activity (Aw) was measured with a HygroPalm AW1 (Cole Parmer A-37910-35, Huntington, New York, USA) instrument in the AwE mode. Measuring range: 0.030 to 1.000 a_w. Accuracy: +/-0.003 a_w. Sedimentation shaker (Muhlenbau sedimentation shaker, Model: 189, Peenya Industrial Area, Bangalore).

Processing of small millet flour

The grains were cleaned to remove dust and other foreign materials and grinded in a commercial roller mill. The flour was sieved using a BS 40-mesh sieve to obtain fine flour and was stored in air tight containers.

Formulation of small millet porridge

The formulation of small millet porridge is presented in Table 1. The functional ingredient, small millet flour was used in the preparation of porridge

*Corresponding author email: samysks@gmail.com

replacing rice flour at 50, 75 and 100 per cent levels.

Method of Preparation of porridge

Table 1. Formulation of composite flour for porridge

Varieties	Level (%)	Rice flour (g)	Kodo millet flour (g)	Little millet flour (g)	Water (ml)
Rice flour (T_0)	100	100	-	-	600
	50	50	50	-	600
Kodo millet flour (T_1)	75	25	75	-	600
	100	-	100	-	600
	50	50	-	50	600
Little millet flour (T_2)	75	25	-	75	600
	100	-	-	100	600

Kodo and little millet flour was weighed separately, each at 25 g and mixed with 25 ml of water without lumps. The blend was added to 125 ml of water to make slurry and allowed to cook with continuous stirring for 5 minutes until the porridge thickens. Then the gruel was allowed to cool.

Sensory evaluation of small millet Porridge

The small millet porridge was evaluated for its sensory attributes by a panel of 10 members using a nine point hedonic scale (Watts *et al*., 1989).

Based on the sensory attributes of kodo and little millet porridge, the best proportion was selected to study the physico-chemical properties, cooking characteristics and nutritional qualities.

Water activity and sedimentation value

The optimized kodo millet, little millet and rice flour was analyzed for water activity and sedimentation value as per the standard approved methods of the American Association of Cereal Chemists (2000). The sample was placed in a plastic box and introduced into the moisture sensor, which quantifies the water activity when equilibrium is reached.

Rapid Visco Analyser (RVA)

Pasting properties were determined using a starch cell C-ETD 160/ST (Physica Smart, Starch analyzer-Anton Paar) attached to a rheometer (MCR 52, Anton Paar, GmbH, Germany) and established methodology (Jayakody *et al*., 2007). A sample (7 percent w/w) was equilibrated at 50°C for 1 min, then heated from 50 to 90°C, 100°C, 110°C at 6°C / min, held at 90°C, 100°C, 110°C for 5 min, cooled to 50°C at 6°C / min, and held at 50°C for 2 min. The speed was 960 rpm for the first 10 seconds, then 160 rpm for the remaining experiment. The pasting properties of each sample were inferred from acquired diagrams including the peak time, peak viscosity, holding strength, setback, and final viscosity.

Nutrient analysis

The small millet porridge were analysed for moisture (Ranganna, 1995). carbohydrates (Dubois *et al.,* 1956), protein (Micro kjeldahal, Nx6.25), fat (solvent extraction), ash (muffle furnace - dry ash), calcium (titration), iron (colorimetric) were determined by the AOAC (1980). Crude fibre (acid and alkali), tannin (colorimetric) were determined by the method of Sadasivam and Manickam (1996).

Microbial population

The microbial load of the optimized kodo and little millet porridge was enumerated by the method described by Istavankiss (1984). Approximately 10 g of the sample was taken in 90 ml sterile water blank and thoroughly mixed in a rotary shaker for 10 minutes. From the solution, a series of 10^{-4} dilution were obtained using serial dilution techniques. The dilution 10^{-4} was used for the estimation of total plate count. From the 10^{-4} dilution, 1.0 ml of the sample was poured into a Petri plate and rotated clockwise and anticlockwise for the uniform spreading of the sample. Appropriate medium was added and allowed to solidify. After solidification the plates were incubated at room temperature (28±2°C) for 24 to 28 hours and the colonies were counted.

Statistical analysis

Statistical determinations including the Mean ± SED is indicated. Analysis of variance (ANOVA) to distinguish the responses between the treatments were performed using Completely Randomized Design (CRD). The level at which significant differences are reported as $p \leq 0.05$.

Results and Discussion

Water activity (a_w) and sedimentation value (ml / 5 min)

The water activity and the sedimentation value of small millet flour compared with that of control is given in table 2. The water activity of T_1 and T_2 was lower than T_0 with the mean values of 0.39, 0.45 and 0.61 respectively. The sedimentation value of T_1 and T_2 was 25.00 and 18.00, which was comparatively higher than T_0 (21.00 ml).

Table 2. Mean value of water activity for flour (a_w) and sedimentation value (ml/5min)

Treatment	Water Activity of Flour (a_w)	Sedimentation Value (ml/5min)
Rice flour (T_0)	0.61 ± 7.07	21.00 ± 0.00
Kodo millet flour (T_1)	0.39 ± 0.00	25.00 ± 1.40
Little millet flour (T_2)	0.45 ± 0.00	18.00 ± 0.00

Hema *et al.,* 2008 reported that higher proportion of sedimentation value 24.25 ml was noted in the pearl millet incorporated dough than ragi (finger millet), and cholam (sorghum) in the development of bakery products. The effects of millets on starch related properties (falling number and sedimentation value) can be related to interference of fibre components of millet with the amylolytic activity in the blends (Hudson *et al.,* 1992).

Microorganisms have a limiting water activity level below which they will not grow. Water activity determines the lower limit of “available” water for microbial growth. Since bacteria, yeast and mold require a certain amount of “available” water to support growth, designing a product below a critical a_w level provides an effective means to control their growth. No microbial proliferation is observed upto

0.60 a_w.

Pasting properties

Table 3. Rapid visco analysis of optimized small millet porridge

Treatment	Peak 1	Trough 1	Break down	Final Visc	Set back	Pasting temp.
Rice flour (T_0)	5535.00	5516.00	18.72	6007.00	490.60	78.40
Kodo millet flour (T_1)	1235.00	1169.00	66.70	1363.00	194.50	80.34
Little millet flour (T_2)	1041.00	987.20	53.96	1124.00	136.40	80.32

The pasting properties of optimized small millet porridge is presented in Table 3. The pasting temperature of T_1 and T_2 was 80.34 °C and 80.32°C, which was higher than T_0 (78.40 °C). The maximum viscosity (peak viscosity) reached upon starch gelatinization in T_0 (5535.00mPa.s) was much higher than T_1 and T_2 with the values being 1235.00 and 1041.00 mPa.s respectively. As fat content increases, the amount of air en-trapped in the structure of the dispersion during mixing increases, which causes a decrease in viscosity. The holding viscosity of T_0 (5516.00) was higher than T_1 and T_2 with the values 1169.00 and 987.20, respectively. Ragaee *et al*., 2006 reported that during the holding period of the viscosity test, the samples are subjected to high temperature and mechanical shear stress, which further disrupt starch granules in the grains, resulting in amylase leaching out and alignment. The results revealed that T_0 had the maximum viscosity (peak viscosity-5535.00mPa.s) and the highest pasting stability than small millet porridge, as indicated by its low breakdown viscosity (18.72). This indicates that rice porridge may have good potential as a food ingredient for food exposed to heat treatment at high temperature and mechanical stirring.

The set back viscosity of T_1 and T_2 was 194.50 and 136.40 mPa.s, which was lower than T_0 with the value of 490.60mPa.s. The low setback value indicates low rate of starch retrogradation and syneresis. Sorghum, maize and soy composite flour mixture was characterized by little decrease in viscosity on cooling as indicated by setback viscosity value 12.00BU, a pointer towards low retrogradation property of the flour (Ragaee *et al*., 2006). The final viscosity of T_1 and T_2 was1363.00 and 1124.00, which was much lower than T_0 with the value of 6007.00mPa.s. During cooling, re-association between starch molecules, especially amylase, results in the formation of a gel structure and therefore, viscosity will increase. Nicole *et al*., 2010 stated that the presence of starch may contribute to some extent to its faster gelatinization and require long time to reach maximum viscosity; this might be due to the lower rate of absorption and swelling of starch granules.

Gelatinization of optimized small millet porridge

The data on gelatinization is given in the Table 4. The initial and final gelatinization temperature of T_0 was 68 °C and 74 °C, which was lower, when compared with that of 71°C and 79°C for T_1, 72°C and 76°C for T_2. The time taken for gelatinization was five minutes for all the samples.

Table 4. Gelatinization temperature and time taken for optimized small millet porridge

Treatment	Temperature (°C) Initial	Temperature (°C) Final	Time duration (min)
Rice flour (T_0)	68	74	5
Kodo millet flour (T_1)	71	79	5
Little millet flour (T_2)	72	76	5

Bello *et al*., (1990) observed that the presence of bran in flour yielded softer gels when preparing thick porridges. In the decorticated sorghum fractions bran was not completely removed (e.g. they are partially refined flours), while the commercial corn flour used in the corn porridge was highly refined and no bran pieces affected the texture of the porridge. Cagampang *et al*., 1985 stated that when hard grains made in to porridge, form products that are less sticky than grains with a larger proportion of floury endosperm; protein may influence this behaviour by interfering with starch gelatinization.

Starch gelatinization is the irreversible loss of the native structure of starch when sufficient moisture and energy (mechanical, thermal or chemical) break the intermolecular hydrogen bonds in the crystalline areas. During gelatinization, the starch granules absorb water, swell and amylase leaches from the granule (Rooney and Pflugfelder, 1987)

Shinoj *et al*., 2006 studied gelatinization and rheological characteristics of minor millet flour. The gelatinization temperature *viz*., Onset temperature (To), Peak temperature (Tp) and end set or conclusion temperature (Tc) were reported for finger millet, foxtail millet, little millet, proso millet, barnyard millet and kodo millet. The results indicated that foxtail millet yielded higher gelatinization range of 101.80 to 73.40°C followed by 17°C finger millet. The lower range was 12 °C for little millet. Other millet flour yielded a range around 13°C. Among the millet flour, foxtail millet flour is more structurally stable and is more resistant to gelatinization.

Russel and Juliano (1983) reported values for To, Tp and Tc in the range of 56-71, 63.10-78.40 and 71-85°C, respectively. The onset and peak temperatures of rice flour 61.10± 0.80 and 67.90±0.80 °C were determined by Chung and Lim (2004). Sopadea *et al*., 2004, studied and found that the gelatinization temperatures and enthalpy did not change with starch: sugar proportion.

Sensory evaluation of the optimized small millet porridge

The results on the sensory attributes of small millet porridge in comparison with rice porridge are presented in Table 5. The data revealed that the mean sensory scores of small millet porridge were higher than the T_0. The colour and appearance of T_0, T_1 and T_2 was 8.80, 8.70 and 8.60 respectively. The mean scores for flavour attribute was 8.8 in T_1 and 8.8 in T_2, which was higher than T_0 with score of 8.6. With regard to the texture (consistency), the mean score of T_0, T_1 and T_2 was 8.60, 8.70 and 8.70, respectively. The scores for taste of small millet porridge was

Table 5. Mean value for sensory evaluation of optimized small millet porridge

Treatment	Sensory attributes				
	Color and appearance	Flavor	Texture	Taste	Overall acceptability
Rice porridge (T_0)	8.8	8.6	8.6	8.7	8.6
Kodo millet porridge (T_1)	8.7	8.8	8.7	8.9	8.8
Little millet porridge (T_2)	8.6	8.8	8.7	8.8	8.7

higher than the control. The mean score of T_1, T_2 and T_0 was 8.9, 8.8 and 8.7, respectively. Overall acceptability of small millet porridge was higher than the control, with score values of 8.8, 8.7 and 8.6 for T_1, T_2 and T_0 respectively. Thus the sensory evaluation results revealed that the millet porridge was highly acceptable upto 100 per cent.

Nutritional qualities of the optimized small millet porridge

The proximate composition of optimized small millet porridge is presented in Table 6.

Moisture

The observed moisture content of T_1 and T_2 was lower than T_0. The moisture content was 84.99 g, 84.86 and 85.08 g for T_1, T_2 and T_0 respectively. The statistical analysis of the data revealed that a highly significant difference was observed between the treatments.

Table 6. Nutrient content of optimized small millet porridge (per 100 g)

Nutrients	Rice porridge (T_0)	Kodo millet porridge (T_1)	Little millet porridge (T_2)
Moisture (g)	85.08	84.99	84.86
Carbohydrate (g)	72.00	64.00	65.50
Fat (g)	0.03	0.04	0.12
Protein (g)	6.05	8.12	7.30
Crude fibre (g)	0.25	8.20	7.25
Ash (g)	0.06	0.14	0.21
Iron (mg)	1.10	1.40	8.60
Calcium (mg)	8.00	24.00	16.10
Tannin (mg)	3.88	15.01	15.14

Carbohydrate

The carbohydrate content of T_1 and T_2 was 64.00 and 65.50 g, respectively which were found to be lesser than T_0 which exhibited 72.00 g per 100 g.

Protein

The protein content of the small millet porridge was found to be higher than the control with the values of 8.12, 7.30 and 6.05 g per 100 g for T_1, T_2 and T_0 respectively. Among the small millet samples T_2 was found to contain the maximum protein content.

Fat

A slight difference in the fat content was observed between the samples with the corresponding values being 0.03, 0.04 and 0.12 g per 100 g of T_0, T_1 and T_2, respectively.

Ash

The ash content of small millet porridges was higher than rice porridge. The ash content of T_0, T_1 and T_2 was 0.06, 0.14 and 0.21 g per 100 g respectively.

Table 7. Microbial load for porridge

Treatment	Total plate count ($x10^4$ cfu/g)	Total yeast and mold count ($x10^4$ cfu/g)
Rice porridge (T_0)	2.66	0.66
Kodo millet porridge (T_1)	4.66	1.66
Little millet porridge (T_2)	4.00	2.66

Crude fibre

The results revealed that the crude fibre content of the small millet porridge was significantly higher

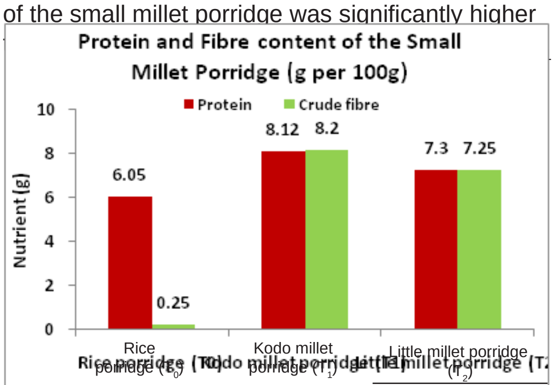

Fig. 1. Protein and fibre content of the small millet porridge (g per 100g)

and T_2 was 8.20 and 7.25 g per 100 g, respectively which was higher when compared with that of T_0 (0.25 g). Among the samples T_1 was found to contain the maximum amount of crude fibre.

Minerals

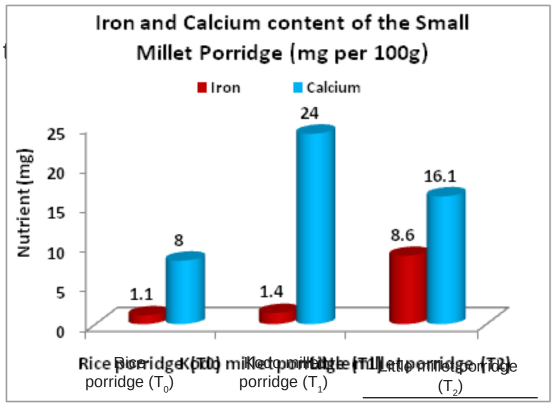

Fig. 2. Protein and calcium content of the small millet porridge (mg per 100 g)

that of control. The calcium content of T_1 and T_2 was 24.00 and 16.10mg respectively and that of T_0 was 8.00mg per 100g. Among the small millet samples T_1 was found to contain maximum calcium content.

The iron content of the optimized small millet porridge was found to be higher than the control among which T_2 was found to contain the maximum. The results showed that the iron content of T_0, T_1 and T_2 was 1.10, 1.40 and 8.60 mg per 100 g respectively.

Tannin

The tannin content of the small millet porridge was lower than the rice porridge. The tannin content of T_0, T_1 and T_2 was 3.88, 15.01 and 15.14 mg per 100 g respectively. Among the small millet porridge samples T_2 was found to contain maximum tannin content. Tannin is considered as an anti-nutrient due to the formation of precipitated complex that strongly reduces the absorption of essential dietary minerals (Greiner, 2006).

Conclusion

The study revealed that kodo and little millet porridge were highly acceptable at 100 per cent level. The optimized small millet porridge was found to contain higher protein, fibre, iron and calcium than the rice porridge. The microbial load was found to be within the safer limit.

Acknowledgement

International Development Research Centre (IDRC), Canadian International Development Agency (CIDA) and University of Guelph, Canada.

References

AACC. 2000. Approved methods of the American Association of Cereal Chemists. Method: 38-11, 44–15 A, 80–01, 38–10, 56–70, 22–15, 56-81 B, 9th ed, St. Paul. MN: American Association of Cereal Chemists. Minessota. USA.

AOAC, 1980. Official Method of Analysis, 11th edn. Association of Official Analytical Chemists, Washington, D.C.

Chung, H.J., Lim, H.S., and Lim, S.T. 2006. Effect of partial gelatinization and retrogradation on the enzymatic digestion of waxy rice starch. *J. Cereal Sci*., 43, 353-359.

Dubois, M., Gilles, K.A., Hamilton, JK., Rebers, PA. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem*., **28:** 350-356.

FAO. 2012. Economic and Social Department: The Statistical Division.

Hema, V., Malathi, D., Pushpa, G., Thangavel, K., Viswanathan, R and K. Kumar. 2009. Development and Evaluation of sorghum, finger millet and pearl millet composite bread and its effects on the management of diabetes mellitus. Ph.D., Thesis. Tamil Nadu Agric. Univ., Coimbatore.

Hudson, C.A., Chiu, M.M. and Knuckles, B.E. 1992. Development and characteristics of high fibre muffins wit oat bran, rice bran and barley fibre fractions. *Cereal Foods World.* 37:373-378.

Istavankiss. 1984. Testing methods in food microbiology. Eleservia Pub. Ltd. 95-397.

Jayakody, L., Hoover, R., Liu, Q and Donner, E. 2007. Studies on tuber starches. II. Molecular structure, composition and physicochemical properties of yam (Dioscorea sp) starches grown in Sri Lanka. *Carbohydrate Polymers.* **69:** 148-163.

Kaur, K.D., Jha, A., Sabikhi, L and A.K. Singh. 2012. Significance of coarse cereals in health and nutrition: A review. *J. Food Sci. Technol.,* 13197-011-0612-9.

Kumar, S., Rekha and Sinha, L.K. 2010. Evaluation of quality characteristics of soy based millet biscuits. *Advances in Appl. Sci. Res*., **1:** 187-196

Nicole, M., Fei, H.Y. and Claver, I.P. 2010. Characterization of ready to eat composite porridge flours made by soy-maize-sorghum-wheat extrusion cooking process. *Pakistan J. Nutrition*. **9:** 171-178.

Pradhan, A., Nag, S.K and Patil, S.K. 2010. Dietary management of finger millet control diabetes. *Curr. Sci.,* **98:** 763-765.

Rage, S and El-Sayed, M.A. 2006. Pasting properties of starch and protein in selected cereals and quality of their food products. *Food Chem.,* **95:** 9-18.

Ranganna, S. 1995. Manual analysis of fruit and vegetable products. Tata McGraw Hill Publishing, Co. Ltd., New Delhi: 891.

Rooney, L.W. and McDonough, C.M. 1987. Food Quality and consumer acceptance of pearl millet. In: Proceedings of International pearl millet workshop. J.R. Witcomber and S.R. Beckerman (eds). ICRISAT. Patancheru. India. p 43-61.

Russel, P.L and Juliano, B.O. 1983. Differential scanning calorimetry of rice starches. *Starch / starke*. **35:** 382-386.

Sadasivam, S and Manickam, A. 1996. Bio-chemical methods. 2 nd Edn, New Age International (P) Ltd. New Delhi: 63.

Shinoj, S., Viswanathan, R., Sajeev, M.S. and Moorthy, S.N. 2006. Gelatinization and rheological characteristics of minor millet flours. *Bio-systems Engg.,* **95:** 51-59.

Sopadea, P.A., Halleya, P.J and Junmingb, L.L. 2004. Gelatinization of starch in mixture of sugars. II: application of differential scanning calorimetry. *Carbohydrate polymers*. **58:** 311-321.

Watts, B.M., Jlimaki, G.L., Jeffery, L.E and Elias, L.G. 1989. Basic sensory methods for food evaluation. International Development Research Centre, Ottawa, Canada. p1-16.

Received: August 27, 2013; Accepted: September 12, 2013