Intl. J. Food. Ferment. Technol. 6(1): 49-56, June, 2016

DOI: 10.5958/2277-9396.2016.00026.X

RESEARCH PAPER

Influence of Milling Speed on Proximate Composition of Pearl Millet Flour during Storage

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Paper No. 112 Received: 9-10-2015 Accepted: 12-4-2016

Abstract

To assess the effect of milling speeds on shelf-life and proximate composition of flour, pearl millet (*Pennisetum glaucum*), one of the most extensively grown type of millet was selected. Pearl millet flour was prepared using low speed mini flour mill at 75 and 115 rpm and the results were compared with the flour prepared using commercial flour mill. The performance of flour mill was evaluated on the basis of recovery of flour, rise in temperature of flour after milling, time taken for milling, particle size distribution and different quality parameters viz., moisture, protein, crude fat, ash, fiber, carbohydrates and free fatty acids (FFA). The whole pearl millet flour was packed in high density polyethylene (HDPE), lower density polyethylene (LDPE) plastic jars and stored for 50 days at ambient conditions. The recovery of flour was the the higher (95.26%) at 75 rpm speed than at 115 rpm although the time taken was more i.e. 25 min. but the rise in temperature during milling was very less (13.45°C) as compared to the commercial mill where the temperature rose upto 36.5°C. The moisture content and FFA increased significantly ($P<0.05$), whereas the protein, fat and ash content decreased significantly ($P<0.05$) with increase in storage time. Further, the moisture content, FFA, crude protein and fat content were affected significantly ($P<0.05$) whereas, the fiber and ash contents were effected non-significant ($P<0.05$) by both the storage time and packaging material. The pearl millet flour prepared at low speed (rpm) was light brown in color as compared to higher speed (rpm) which was dark brown. Pearl millet flour prepared at 75 rpm and stored in low density polyethylene LDPE packaging material of (200 gauge) was found the best in quality among those milled at 115 rpm and 400 rpm, followed by packaging HDPE packs.

Keywords: Pearl millet, pearl millet flour, mini flour mill, physico-chemical parameters, packaging material, storage

Pearl millet (*Pennisetum glaucum*) is one of the most extensively grown types of millet. The crop is tolerant to difficult growing conditions in which other cereals fail to give substantial yields (Adekunle, 2012). It is cultivated mainly in the semi-arid and arid tropics, almost exclusively by subsistence and small-scale commercial farmers (Belton and Taylor, 2004). Pearl millet production is concentrated in the developing countries in Asia and Africa, contributing around 93% of total world production. India is the largest producer of this crop, producing about 7.3 million tons from an area of 9.3 million ha, with an average productivity of 780 kg/ha (Anon, 2012). Millet has been reported to have numerous nutritious and medicinal functions (Florence *et al.*, 2014; Obilana and Manyasa, 2002 and Yang *et al.*, 2012). A number of traditional and mechanical milling processes are used to mill pearl millet (Barenwal *et al.*, 2013; Goussault and Andrian, 1977, Rasper, 1977 and Wyss, 1977) into flour for food production. However, pearl millet undergoes quick deterioration after it has been ground into flour; as the hydrolytic and oxidative changes occur in lipids during storage (Carnovale and Quaglia, 1973 and Lai and Varriano-Marston, 1980, Yadav *et al.,* 2012; Tiwari *et al.,* 2012). Considerable information is available on the various chemical and physico-chemical characteristics of flours and their functional characteristics milled in different types of mills. It has also been reported that the temperature rise is greater in plate and stone mills as compared to other type of mills (Bhupinder *et al.,* 2012; Pichan and Punaroor, 2001). Therefore, it is likely that there would be changes in the quality of protein and lipids due to high temperature generation during milling, thereby altering the functional characteristics. Since, such reports are not available on differently milled flours, studies on these aspects are undertaken and reported in this paper.

Materials and Methods

The whole pearl millet kernels of variety PCB-164 grown in Punjab Agricultural University, Ludhiana, India, were used. The pearl millet kernel were cleaned by using pedal-cum-power operated grain cleaner to remove foreign mat er such as dust, dirt, chaff, immature and broken grains. The clean healthy grains were selected for the study.

Sample preparation

The grinding of the millet kernels were performed using variable speed mini flour mill at different speeds i.e. at 75 rpm and 115 rpm. About 5 kg grain sample was fed in the hopper with a fixed feed rate of 44 kg/h and 54 kg/h at 75 rpm and 115 rpm, respectively. The initial temperature of the grains were taken using infrared temperature gun and rise in flour temperature feed rate was noted. By decreasing clearance coarse flour was fed repeatedly to hopper for milling till finely grounded flour was obtained. Total time taken for milling was noted. Flour prepared was compared with that prepared by commercial flour mill. Af er preparation of flour at different speeds, sieve analysis of the flour was done by sieving for 10 min in a Rotap sieve shaker using Tyler sieves (2.4, 2.0, 1.7, 1.4, 1.2 mm and pan) having successive openings $2^{1/4}$ times less than the previous opening storage of flours.

The flours were stored in three different packaging material i.e. high density polyethylene HDPE of thickness 37.5 µm (150 gauge), low density polyethylene LDPE of thickness 51 µm (200 gauge) and in plastic jars at ambient temperature (25-35°C). The samples were analyzed for various quality parameters as outlined earlier for 50 days at regular intervals of 10 days.

Proximate composition of pearl millet flour

The proximate composition i.e. moisture, protein, fat, ash, FFA and crude fibre of cleaned-cum-graded pearl millet kernels were determined using standard procedures please millet flours (AOAC, 2000). Moisture content was determined using standard hot air oven method (AOAC, 2000). Color was measured in terms of L (whiteness/darkness), a (redness/greenness) and b (yellowness/blueness) by using a Hunter colorimeter (Model No: Miniscan XE plus 4500 L, Reston, VA, USA). Crude protein content was estimated by available nitrogen in the sample by Micro Kjeldhal method (AOAC, 2000). The digested mixture was used for protein analysis. The fat content was determined by using petroleum ether in Soxhlet apparatus.

Ash content of the sample was determined by incineration for 6 hours at 600°C. Crude fiber was estimated by digesting two grams of moisture and fat free sample with 200 ml boiling 0.255N H_2SO_4 for 30 min. Af er acid digestion, the mixture was filtered and washing of residue with hot water was carried out to remove traces of acid. Then, alkali digestion was performed with 200 ml of 0.313 N NaOH for 30 min. Again the mixture was filtered and washed with hot water followed by alcohol and ether to remove traces of alkali. The residue was dried and weight was noted down (M_1). It was ignited in muffle furnace at 550°C for 3 hours and cooled and weighed (M_2). Further, the crude fiber content was determined using standard formula (AOAC, 1980). The FFA was estimated by standard method of (AOAC, 2000). The proximate composition was performed in triplicate. Mean values were calculated and reported.

Statistical Analysis

The data obtained from the experiments were analyzed using the technique of analysis of variance (Panse and Sukhatme, 1978). The data were analysed for significance at ($P \leq 0.05$) using SPSS 20.0 Pair wise comparisons were made as per SPSS.

Results and Discussion

Effect of milling speed on different parameters of pearl millet flour

The time taken for milling millet flour at different speeds of 75, 115 and 400 rpm was 25, 20 and 14 min, respectively (Table 1).

Table 1: Effect of milling speed on different parameters of pearl millet flour

Parameters	Mini Flour Mill		Commercial Flour Mill
	75 Rpm	*115 Rpm*	*400 Rpm*
Flour temperature rise (°C)	13.45 ± 5.5	26 ± 7	36.5 ± 8.5
Time taken for milling (min)	25	20	14
Feed rate (kg/h)	44 ± 1.21	54 ± 1.34	100 ± 1.04
Recovery of flour (%)	95.26 ± 0.14	89.81 ± 0.20	87.95 ± 0.10
Fineness modulus	1.74	1.64	1.72
Average particle size (cm)	0.136	0.127	0.135
Uniformity index (coarse: medium: fine)	0.02: 7.43: 2.55	0.01: 7.96: 2.03	0.00: 7.88: 2.12

The recovery of flour obtained at sieve size of 1.4 mm was maximum i.e. 95.26% in 75 rpm milling, closely followed by 115 rpm milling i.e. 89.81% and minimum in commercial milling i.e. 87.95%. The overall flour recovery for sieve size of 1.4 mm was found to be higher at 75 rpm milling, followed by 115 rpm milling and commercial milling at 400 rpm. The fineness modulus was higher for 75 rpm milling (1.74) followed by 400 rpm commercial milling (1.72) then 115 rpm milling, (1.64) whereas average particle size of the flour was more at 75 rpm milling (0.136 cm) followed by 400 rpm commercial milling (0.135 cm) then by 115 rpm milling (0.127 cm), respectively.

Effect of milling speed on the proximate composition of pearl millet flour stored in different packaging material

The effect of different process parameters viz., milling speed, storage days and packaging material on proximate composition of pearl millet flour has been presented in Table 2, 3 and 4. All the process variables had a significant affect ($P<0.05$) on quality characteristics i.e. moisture content, protein content, crude fat content, carbohydrates and free fat y acids except for crude fiber content and ash content which had a non-significant affect ($P<0.05$).

Moisture content plays a very important role in determining the shelf-life of flour as lower the moisture content; more is the storage stability (But *et al.,* 2004). From the results, depicted in Figure 1, it is evident that the moisture content of flour increased significantly ($P<0.05$) with the increase in storage period and milling speed in all the packaging materials. The initial moisture content of flour of commercial flour mill was lower could be because of the increase in flour temperature due to high speed (rpm) but tends to increase rapidly with storage period thus, shortening its shelf-life. This percentage increase in moisture content varied from 9.42 to 11.45%, although it was within the maximum permissible limit of 12.0% as prescribed by BIS (Bureau of Indian Standard) standard for pearl millet flour. The pearl millet flour packed in LDPE at 75 rpm was found to be the best with less moisture content increase followed by 115 and then by 400 rpm. These changes in moisture content were due to hygroscopic properties of flour. Rehman and Shah (1999) and Kirk and Sawyer (1991) also reported that the moisture content was significantly affected by the storage times, packaging material and their interaction.

The crude fat content of pearl millet flour decreased significantly ($P<0.05$) with the increase in storage period and milling speed in all the packaging materials. It can be apparent from the figure 2, that the

Table 2: Effect of milling speed on proximate composition

Milling speed (RPM)	Moisture (%)	Crude fat (%)	FFA (%)	Ash (%)	Protein (%)	Fiber (%)
75	9.80^{c}	7.93^{a}	11.08^{c}	1.92^{a}	10.74^{c}	1.90^{a}
115	10.03^{b}	7.36^{b}	11.84^{b}	1.91^{a}	10.87^{a}	1.91^{a}
400	10.23^{a}	6.92^{c}	12.73^{a}	1.91^{a}	10.77^{b}	1.90^{a}

Values with different let ers differ significantly (P<0.05)

Table 3: Effect of storage time on proximate composition

Storage time (days)	Moisture (%)	Fat (%)	FFA (%)	Ash (%)	Protein (%)	Fiber (%)
0	9.27^{f}	8.33^{a}	9.34^{f}	1.92^{a}	11.15^{a}	1.90^{a}
10	9.54^{e}	8.00^{b}	10.39^{e}	1.91^{a}	11.06^{b}	1.95^{a}
20	9.96^{d}	7.68^{c}	11.59^{d}	1.91^{a}	10.95^{c}	1.94^{a}
30	10.18^{c}	7.33^{d}	12.42^{c}	1.90^{a}	10.81^{d}	1.94^{a}
40	10.47^{b}	6.82^{e}	13.19^{b}	1.90^{a}	10.77^{e}	1.93^{a}
50	10.70^{a}	6.26^{f}	14.38^{a}	1.90^{a}	10.66^{f}	1.93^{a}

Values with different let ers differ significantly (P<0.05)

Table 4: Effect of packaging material on proximate composition

Packaging material	Moisture (%)	Fat (%)	FFA (%)	Ash (%)	Protein (%)	Fiber (%)
LDPE	10.01^{b}	7.56^{a}	11.77^{b}	1.91^{a}	10.81^{a}	1.89^{a}
HDPE	10.00^{c}	7.47^{b}	11.72^{c}	1.91^{a}	10.78^{c}	1.89^{a}
Plastic jar	10.05^{a}	7.17^{c}	12.17^{a}	1.91^{a}	10.80^{b}	1.89^{a}

Values with different let ers differ significantly (P<0.05)

initial value of crude fat content of the flour at 75 rpm was 8.6%, at 115 rpm was 8.4% and at 400 rpm was 8%. The percentage decrease varied from 8.6% in LDPE packaging at 75 rpm to 5.6% in plastic jar packaging for 400 rpm commercial mill. The decreasing trend however was more in flour milled by commercial mill followed by that milled at 115 rpm then by low speed mini flour mill at 75 rpm. The percentage decrease in crude fat content was higher in plastic jar followed by HDPE and LDPE, irrespective of milling speed. More amount of crude fat content in the flour could have led to rapid degradation resulting in poor keeping quality, so crude fat content of the product is also a limiting factor for good shelf-life of flour. The decrease may be at ributed to the lipolytic activity of enzymes i.e. lipase and lipoxidase. Similar results have been reported by Haridas (1983) and Leelavathi *et al. (*1984).

The effect of storage days and milling speed on the free fat y acids in different packaging material is shown in figure 3. It can be noted that the initial value of free fat y acids of the flour at 75 rpm was 8.81%, at 115 rpm was 9.21% and at 400 rpm was 10.01%.

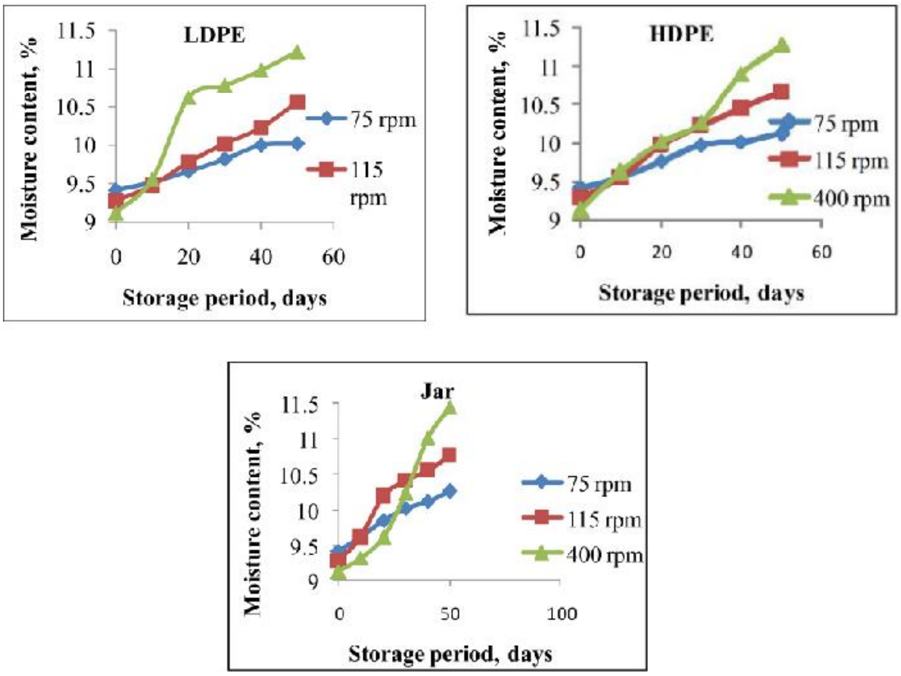

Fig. 1: Effect of milling speed and packaging material on moisture content of pearl millet flour during storage

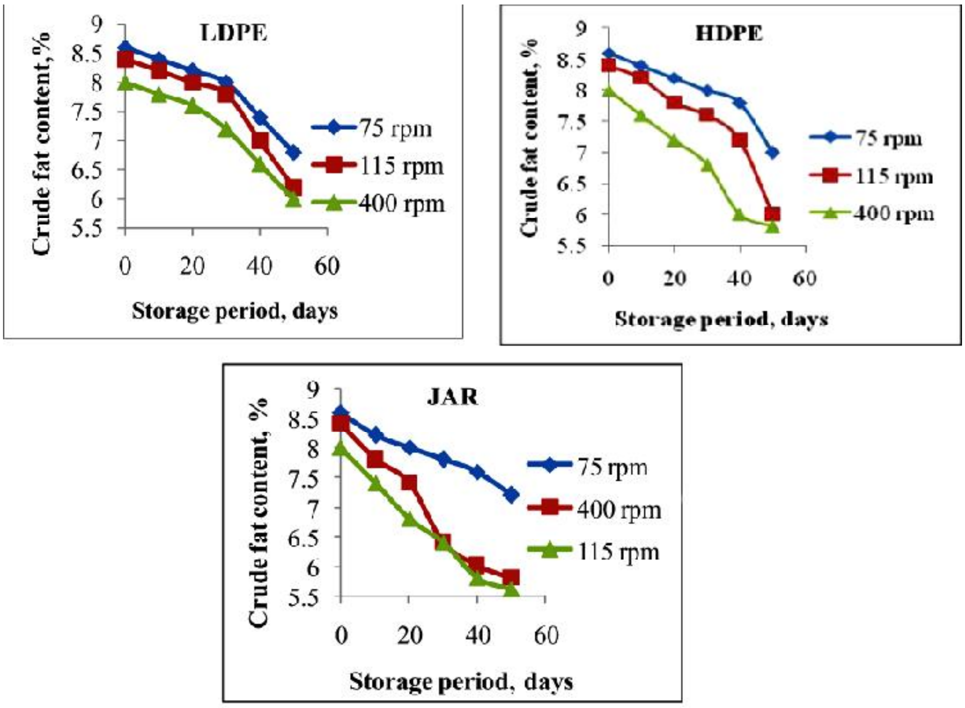

Fig. 2: Effect of milling speed and packaging material on crude fat content of pearl content flour during storage

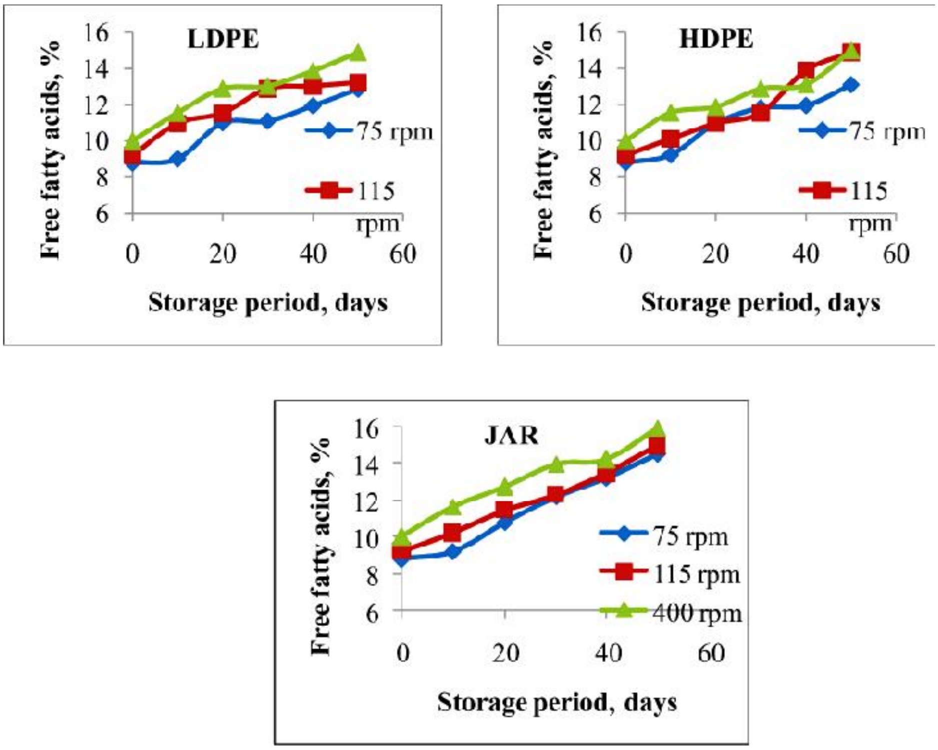

Fig. 3: Effect of milling speed and packaging material on free fatty acids of pearl millet flour during storage

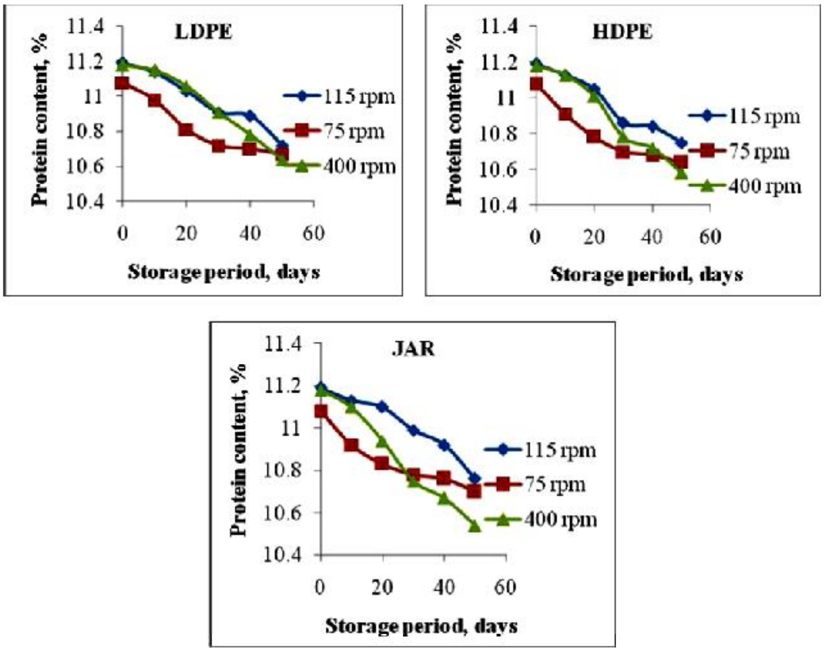

Fig. 4: Effect of milling speed and packaging material on protein content of pearl millet flour during storage

It was also observed that free fatty acids of the flour increased significantly (P<0.05) with increase in the storage period and milling speed in all the packaging materials. However, the rate of increase being higher in plastic jars followed by HDPE packages and LDPE packages. The increasing trend was more in flour milled by commercial mill followed by that milled at 115 rpm then, by low speed mini flour mill at 75 rpm. The percentage increase in free fatty acids varies from 8.81% to 15.98%. The increasing trend of free fatty acids could deteriorate the samples prepared at 400 rpm and packed in plastic jar. Similar results have been documented by Kajuna (2001).

The results pertaining to the crude protein content showed a significantly (P<0.05) decreasing trend with the increase in storage period, irrespective of the type of packaging material used (Fig. 4). The percentage decrease in protein content was higher in plastic jar followed by HDPE and LDPE, irrespective of milling speed. The initial protein content was found to be higher for high speed grounded flour but have been attained higher decreasing rate as storage period increases irrespective of packaging material. These results are in close agreement with the results obtained by Leelavathi *et al*. (1984) and Upadhyay (1994).

It was observed from the analysis that the fiber content and ash content of pearl millet flour was non-significantly affected at 5% level by the milling speed, storage period and packaging material.

Table 5 shows variation in *L*, *a*, *b* values of color of pearl millet flour after 60 days of storage period in different packaging material. The *L*-value indicating the whiteness was determined to be increased with the increase in the storage period in all the packaging material.

It was noted that the color of flour milled at low speed was light brown and at higher rpm was dark brown i.e. the '*a*' value of color was more in flour milled at higher rpm. The overall change in color was less pronounced in LDPE packs at 75 rpm speed i.e. 1.23, whereas it was the highest in HDPE pack at 400 rpm speed.

Conclusion

Overall it can be concluded from the study that the pearl millet flour prepared at 75 rpm was the best in quality among those milled at 115 rpm and 400 rpm, due to longer storage period as the percentage decrease in the nutrients was less. Pearl millet flour prepared at low speed can be best stored in low density polyethylene LDPE packaging material of 200 gauge for 50 days without change in quality parameters. The outcome is likely to be useful for

Table 5: Effect of storage time and milling speed on the color of pearl millet flour

Milling speed	Packaging material	*L*		*a*		*b*		Δ*E*
		0	60	0	60	0	60	
	LDPE	68	69	-0.1	+0.5	+14.7	+14.3	1.23
75	HDPE	68	69.1	-0.1	-0.9	+14.7	+13.8	1.63
	Plastic jar	68	70.2	-0.1	-0.9	+14.7	+13.8	2.50
	LDPE	67.6	68.2	+0.1	-1.6	+14.4	+12.2	2.45
115	HDPE	67.6	70.5	+0.1	-0.6	+14.4	+12.2	2.62
	Plastic jar	67.6	70.2	+0.1	-0.3	+14.4	+13.1	2.42
	LDPE	70.8	72.1	-0.5	-1.1	+18.6	+16.3	2.78
400	HDPE	70.8	70.9	-0.5	-0.6	+18.6	+16.6	3.06
	Plastic jar	70.8	71.1	-0.5	-0.9	+18.6	+16.9	2.77

small scale manufacturers as mini flour mills are easily available and are less costly as compared to other mills.

References

Adekunle, A.A. 2012. Agricultural innovation in sub-saharan Africa: experiences from multiplestake holder approaches. Forum for Agricultural Research in Africa, Ghana. ISBN 978-9988-8373-2-4.

Anonymous, 2012. Ministry of Agriculture, Govt. of India. (ON321), *Statewise production data*, Ministry of Agriculture, Govt. of India. (14105) and (14268), *Statewise yield data.*

AOAC 1980. Official methods of Analysis, 11th edn. *Washington, DC, Association Official analytical chemists.*

AOAC 2000. Official methods of Analysis, 17th edn. *Washington, DC, Association Official analytical chemists.*

Barnwal, P., Kore, P. and Sharma, A. 2013. Assessment of storage stability of whole and degermed maize flours. *Internet J of Fd Safety.* **15**: 83-87

Belton, P.H. and Taylor, J.R.N. 2004. *Sorghum and millets: protein sources for Africa.* Trend in *J Fd Science Technol.* **15**:94-98.

Bhupender, S.K., Rajneesh, B. and Baljeet, Y. 2012. Physicochemical, functional, thermal and pasting properties of starches isolated from pearl millet cultivars. *International Fd Research J..* **20**(4): 1555-1561.

Butt , M.S., Nasir, M., Akhtar, S. and Sharif, K. 2004. Effect of moisture and packaging on the shelf life of wheat flour. *Internet J Fd Safety,* **5**: 1–6.

Carnovale, E. and Quaglia, G.B. 1973. Influence of temperature and humidity controlled storage on the chemical composition of milling products from millet. *Ann Technol Agric.* **22**: 371.

Florence, S.P., Urroj, A., Asha, M.R. and Jyotsna, R. 2014. Sensory, physical and nutritional qualities of cookies prepared from Pearl Millet. *J Fd Process Technol.* **3**: 5-10.

Goussault, B. and Adrian, J. 1977. The milling of Pennisetum millet and the value of the protein in the products, in: Dendy, D.A.V. (ed). *Proceedings of a Symposium on Sorghum and Millet for Human Food*. Tropical Products Inst.: London, p. 13.

Haridas, P.R., Leelavathi, K. and Shurpalekar, S.R. 1983. Comparative studies on atta (whole wheat flour) and resultant atta a by-product of roller flour milling industry. *J Food Sci Technol*. **20**(1): 5-8.

Kajuna, S.T. 2001. Millet: Post harvest Operations. *Sokene University of Agriculture*.

Kirk, S.R. and Sawyer, R. 1991. Pearson's Composition and Analysis of Foods. Addison-Wesley Longman Ltd. Edinburg Gate, Harlow, England.

Lai, C.C. and Varriano, M.E. 1980. Lipid content and fatty acid composition of free and bound lipids in pearl millets. *Cereal Chem*. **57**: 271.

Leelavathi, K., Rao, P.H., Indrani, D. and Shurpalekar, S.R. 1984. Physicochemical changes in whole wheat flour (Atta) and resultant atta during storage. *J Food Sci Technol*. **21**:10-14.

Obilana, A.B. and Manyasa, E. 2002. Millets In: P.S. Belton and J.R.N. Taylor (ed). Pseudo cereals and less common cereals: Grain properties and utilization potential. Springer–verlag: Newyork, pp. 177-217.

Pichan, P. and Punaroor, H.R. 2001. Effect of different milling methods on chemical composition of whole wheat flour. *Eur Food Res Technol*. **213**: 465-469.

Rasper, V.F. 1977. Palyi's compact system for debranning of sorghum and millet. in: Dendy, D.A.V. (ed). Proceedings of a Symposium on Sorghum and Millet for Human Food. Tropical Products Inst.: London, p. 59.

Rehman, Z.U. and Shah, W.H. 1999. Biochemical changes in wheat during storage at three temperatures. *Plant Food for Human Nutri*., **54** (2): 109-117.

Tiwari, A., Jha, S.K., Pal, R.K., Sethi, S. and Krishan, L. 2012. Effect of pre- milling treatments on storage stability of pearl millet flour. *J of Fd Processing and Preservation,* **37**(3): 72-82.

Upadhyay, R.K., Thangaraj, M. and Jaiswal, P.K. 1994. Storage studies of suji in different packages. *J Food Sci Technol.* **31**(6):494-496.

Wyss, E. 1977. Millet and sorghum. Pp 111.in: Dendy, D AV (ed). *Proceedings of a Symposium on Sorghum and Millet for Human Food*. Tropical Products Inst.: London.

Yadav, D.N., Kaur, J., Anand, T. and Singh, A.K. 2012. Storage stability and pasting properties of hydrothermally treated pearl millet flour. *International J of Fd Sci and Technol.* **47**(12): 32-37.

Yang, X.Z., Wan, L. Perry., H. Lu., Wang, Q., Hao, C., Li, J., Xie, F., Yu, J., Cui, T., Wang, T., Li, M., and Ge, Q.H. 2012. Early millet use in northern China. *Proc Nat Acad Sci.* USA, pp 1-5.