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Nutritional Quality and Storage Stability of Processed Biofortified Pearl Millet Varieties

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ABSTRACT

Background: Poor shelf life and nutrient availability is a limiting factor in adoption of pearl millet. It can be addressed by indigenous processing like malting, blanching and roasting. This study delineates outcome of processing on protein, fat, ash, nutrient digestibility and storage stability of biofortified pearl millet varieties.

Methods: Unprocessed, malted, blanched and roasted millet grains' flour was analysed and compared for protein, fat, ash and nutrient digestibility. To assess storage stability, flours were stored at 25±1°C at 40±2% RH and fat acidity and per oxide values analysed at an interval of 10 days.

Result: It was found that the protein and fat contents of flours decreased on processing. Blanched and roasted flours possessed more ash compared to malted flour. The amount of fat and ash in HC-20 was significantly more than that of *Dhanshakti* variety. Digestibilities of protein and starch, of processed flours improved significantly and maximum improvement was exhibited by malted flours followed by roasted and blanched. The fat acidity and peroxide value of stored flours increased and this increase was more in unprocessed compared to processed flours. The findings of this study can be useful for augmenting the nutritional and keeping quality of pearl millet.

Key words: Blanching, Digestibility, Malting, Nutrient availability, Pearl millet, Roasting.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is a climate resilient hardy crop and can sustain with least maintenance cost (Singh and Kumar, 2016). It holds the status of Nutri-Cereal and has potential to ensure food and nutrition security in low income economies, where combating hunger and hidden hunger is a challenge. It is rich in carbohydrates (70-80%) and contain varying amounts of protein, fat, fibre and ash ranging from 12.25 to 13.09, 4.32 to 5.11, 4.30-5.30 and 1.53-2.00 per cent, respectively. It also contains appreciable amount of minerals like phosphorus, calcium, iron, zinc, copper and manganese (Bajaj *et al.* 2021). It also possesses certain functional qualities, it being free from gluten and containing enough complex carbohydrates, dietary fibres, phytochemicals *etc*. It offers protection from life style diseases like diabetes, obesity, hypertension, cardiovascular complications, malignancies, constipation, hyperlipidemia *etc*. (Ambati and Sucharitha, 2019). However there are certain limitations in the utilisation of pearl millet, because its flour exhibits low shelf life due to activity of lipase enzyme (Goyal *et al*. 2017). The chemicals of concern include tannins, phytates and nutrient complexes which impede mineral absorption, palatability and starch and protein digestibilities. It is well documented that the storage life of pearl millet flour can be enhanced by premilling processing like blanching, soaking, germination, malting, roasting, *etc*. (Zuberi and Sangwan, 2020). It is advocated that processing of pearl millet, improves, not only bioavailability of nutrients (Krishnan and Meera, 2018), but also makes pearl millet and its flour microbiologically safe which can be utilized for development of innovative food products of good shelf life (Saleh *et al.* 2013; Subastri *et al.* 2016; Jalgaonkar *et al.* 2016; Sharma and Sahni, 2021). This study assessed the impact of malting, blanching and roasting on protein, fat and ash contents, digestibility of protein and starch and keeping quality characteristics of biofortified pearl millet. Utilising processed pearl millet for food products' development will augment the sustained efforts for crop diversification and improving the economic status of farmers. Governments are extensively working on solving the problem of hunger and endorsing preventive health measures. The utilisation, popularization and promotion of processed pearl millet products can serve as a healthy alternative to junk foods.

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MATERIALS AND METHODS

Procurement of pearl millet

This study was conducted in the Department of Foods and Nutrition, CCS Haryana Agricultural University for a period of 90 days from November, 2017 to January, 2019. Variety *Dhanshakti* was procured from Mandor, Jodhpur and HC 20 from Department of Genetics and Plant Breeding, CCS HAU, Hisar.

Processing of pearl millet

Malting was done as mentioned in earlier communication (Bajaj *et al.,* 2021) and involved soaking, aeration, sprouting and kilning. Blanching was done using method of Johari and Kawatra (2018). Grains were oven roasted at 50°C for 24 hours and pan roasted at 200°C for 15 minutes.

Nutrient composition

Crude protein (N × 5.95), fat, ash and *in vitro* protein and starch availability of grains were analyzed using the standard methods (AOAC, 2010; Rani and Grewal, 2009).

Shelf life characteristics

Pearl millet grain flours were stored under controlled conditions (25±1°C at 40±2% Relative Humidity) and evaluated for fat acidity and peroxide value as per the standard procedure of AOAC (2000).

Statistical analysis

Data were validated and analyzed in SPSS software version 20.0 (SPSS Inc., Chicago, IL). One way ANOVA and LSD multiple comparison tests were applied.

RESULTS AND DISCUSSION

Protein

A significant decrease (0.67 to 9.10%) was observed in the protein value of malted, blanched and pan roasted flours, compared to unprocessed flours (Table 1). Among different types of processed flours, the maximum protein content was found in oven roasted pearl millet flour while minimum was detected in malted (germination- 30°C, 72 hours). There are different theories governing reasons for such reduction in protein content of processed grains that, the grain protein get hydrolyzed during metabolic changes accompanying germination which is a step in preparation of malt. Some workers suggested that protein content decreased due to leaching of water soluble amino acids and other light weight compounds of nitrogen during moist processing treatments

Table 1: Effect of processing on crude protein content (%) of pearl millet (on dry weight basis).

Processing			HC-20	Dhanshakti
Unprocessed (Control)			11.89^{a}±0.13†	11.20^{a}±0.12‡
Malted	25°C	48 h	11.41^{c}±0.14† (↓4.03)	10.88^{b}±0.14‡ (↓2.85)
		60 h	11.25^{d}±0.22† (↓5.38)	10.65^{c}±0.22‡ (↓4.91)
		72 h	11.14^{de}±0.23† (↓5.38)	10.19^{d}±0.26‡ (↓9.01)
	30°C	48 h	11.41^{c}±0.21† (↓4.03)	10.91^{b}±0.23‡ (↓2.58)
		60 h	11.26^{d}±0.13† (↓5.29)	10.61^{c}±0.13‡ (↓5.26)
		72 h	11.11^{e}±0.11† (↓6.56)	10.18^{d}±0.12‡ (↓9.10)
Blanched			11.52^{bc}±0.15† (↓3.11)	10.90^{b}±0.14‡ (↓2.67)
Pan roasted		10 m	11.79^{a}±0.15† (↓0.84)	10.81^{bc}±0.14‡ (↓3.48)
		15 m	11.64^{b}±0.21† (↓2.10)	10.68^{c}±0.25‡ (↓4.64)
Oven roasted			11.81^{a}±0.12† (↓0.67)	10.86^{b}±0.12‡ (↓3.03)

Note: Values are expressed (dry weight basis) as mean±SE of three independent determinations.
Different letters (a-d) within the same rows indicate significant difference at P<0.05.
Different symbols (†-‡) within the same columns indicate significant difference at P<0.05.

Table 2: Effect of processing on fat content (%) of pearl millet flours (on dry weight basis).

Processing			HC-20	Dhanshakti
Unprocessed (Control)			5.66^{a}±0.35†	5.47^{a}±0.22‡
Malted	25°C	48 h	5.32^{bc}±0.25† (↓6.00)	4.82^{c}±0.21‡ (↓11.88)
		60 h	5.12^{d}±0.27† (↓9.54)	4.62^{d}±0.34‡ (↓15.53)
		72 h	4.59^{f}±0.23† (↓18.90)	4.38^{e}±0.33‡ (↓19.92)
	30°C	48 h	5.31^{bc}±0.32† (↓6.18)	4.82^{c}±0.22‡ (↓11.88)
		60 h	5.15^{d}±0.31† (↓9.01)	4.60^{d}±0.21‡ (↓15.90)
		72 h	4.87^{e}±0.24† (↓13.95)	4.31^{e}±0.22‡ (↓21.20)
Blanched			5.45^{b}±0.22† (↓3.71)	5.33^{ab}±0.31‡ (↓2.55)
Pan roasted		10 m	5.43^{b}±0.21† (↓4.06)	5.34^{a}±0.21‡ (↓2.37)
		15 m	5.38^{b}±0.31† (↓4.94)	5.27^{ab}±0.32‡ (↓3.65)
Oven roasted			5.45^{b}±0.22† (↓3.71)	5.29^{ab}±0.23‡ (↓3.29)

Note: Values are expressed (dry weight basis) as mean±SE of three independent determinations.
Different letters (a-d) within the same rows indicate significant difference at P<0.05.
Different symbols (†-‡) within the same columns indicate significant difference at P<0.05.

(Nithya *et al*. 2007). The decrease in protein of malted flour was more compared to roasted and this may be due to hydrolysis of protein for supporting growth of sprouts while in roasting decline was owing to destruction of some amino acids due to heat treatment.

Fat

Malting, blanching and roasting of HC-20 and *Dhanshakti* varieties, caused 3.71 to 18.90 and 2.37 to 21.20 per cent, decrement in the fat value, respectively (Table 2). The processed and unprocessed HC-20 variety's fat value was significantly more than *Dhanshakti*. This reduction of fat in germinated flours (malt) was explicated to enhancement in the lipolytic enzymes' activity or due to utilization of grain nutrients by growing shoots during germination (Jan *et al*. 2018; Khare *et al*. 2021). It is proposed that subjecting of pearl millet to heat treatments during malting, blanching and roasting dissociated fatty acids from fat thereby causing reduction in fat content of processed flours. The consequence of these chemical changes also augmented storage stability in processed flours (Olagunju and Ifesan, 2013; Jan *et al*. 2016).

Ash

Amount of ash in blanched and roasted pearl millet flours, of both the varieties, increased from 4.23 to 30.68 per cent compared to unprocessed flours (Table 3). This increase may be due to modification in the molecular structure of grains and decrease in the content of oxalates, phytates, tannins (Krishnan and Meera, 2018) and insoluble dietary fibres in processed grains (Pushparaj and Urooj, 2011; Tiwari *et al*. 2014). In malted flours ash (mineral matter) decreased by 4.83 to 8.99 per cent, in comparison to unprocessed, and this may be owing to leaching and loss of soluble mineral ions from grains soaked in water, a step during malting, or due to their utilization by the growing sprouts (Bhati *et al.* 2016). HC 20 pearl millet variety's ash was higher than that of *Dhanshakti* and this may be due to variations in characteristics of different varieties, diverse cultivation environment, soil quality, harvesting time *etc.* (Govindaraj *et al.* 2010).

Nutrient availability

There was 4.06 to 26.46 and 7.99 to 100.92 percent increase in the protein and starch digestibility of processed flours (Table 4, 5). Maximum improvement was observed for malted flours followed by roasted and blanched. This improvement in protein digestibility of processed flours was explained due to modification in their protein structure, decreased resistance of proteins to enzyme action, degradation of complex protein-polyphenol complexes and increased exposure of peptide bonds to proteases (Dharmaraj *et al.* 2013; Tiwari *et al.* 2014; Bhati *et al.* 2016). Some studies proposed that improvement in the processed grain assimilation capacity may be attributed to increased activities of amylases and β glucanase enzymes during germination which were responsible for hydrolysing endosperm cell wall and increased availability of starch (Bhandal, 2008; Nambiar *et al*. 2011; Iswarya and Narayanan, 2016). Some researchers advocated that soaking, sprouting, malting, roasting and boiling treatments reduced the antinutrients (Kamalasundari *et al.* 2019; Sharma and Sahni, 2021), non starch polysaccharides and fibre complexes in grains so as to improve their nutritional merit (Dicko *et al.* 2006; Platel *et al*. 2010; Daniel *et al.,* 2011; Jan *et al*. 2016; Jimenez *et al*. 2020).

Shelf life characteristics

A gradual increase was observed in the level of fatty acids and peroxides in stored flours (Fig 1, 2), which is a sign of breakdown of fat by lipase and also indicates deterioration of quality of flour during storage (Pawar and Machewad, 2006; Jalgaonkar *et al.* 2016). All types of unprocessed flours were noted to have fatty acid and peroxides higher than that of processed flours beyond 70 days of storage, thus suggesting that processing improved the shelf life

Table 3: Effect of processing on ash content (%) of pearl millet flours (on dry weight basis).

Processing		HC-20	Dhanshakti
Unprocessed (Control)		1.89^{d}±0.12†	1.86^{d}±0.14‡
Malted 25°C	48 h	1.78^{e}±0.06 (↓5.82)	1.77^{e}±0.08 (↓4.83)
	60 h	1.75^{e}±0.11 (↓7.40)	1.74^{f}±0.06 (↓6.45)
	72 h	1.72^{f}±0.06 (↓8.99)	1.72^{f}±0.09 (↓7.52)
30°C	48 h	1.78^{e}±0.08 (↓5.82)	1.77^{e}±0.08 (↓4.83)
	60 h	1.76^{e}±0.07 (↓6.87)	1.75^{e}±0.07 (↓5.91)
	72 h	1.73^{f}±0.07 (↓8.46)	1.72^{f}±0.12 (↓7.52)
Blanched		1.97^{c}±0.06 (↓4.23)	1.96^{c}±0.07 (↓5.37)
Pan roasted	10 m	2.46^{a}±0.08† (↓30.15)	2.30^{b}±0.06‡ (↓23.65)
	15 m	2.47^{a}±0.07† (↓30.68)	2.43^{a}±0.08‡ (↓30.64)
Oven roasted		2.33^{b}±0.06† (↓23.28)	2.30^{b}±0.08‡ (↓23.65)

Note: Values are expressed (dry weight basis) as mean±SE of three independent determinations.

Different letters (a-d) within the same rows indicate significant difference at P<0.05.

Different symbols (†-‡) within the same columns indicate significant difference at P<0.05.

characteristics, which is an indicator of storage life, of processed flour compared to unprocessed flours. This improvement in the shelf life of processed grains may be due to purging of micro-organisms, lowering of water activity, riddance from anti-nutritional factors, decrease in lipase enzyme activity *etc.* due to processing (Liu *et al.* 2012;

Table 4: Effect of processing on *in-vitro* protein digestibility (%) of pearl millet flours (on dry weight basis).

Processing			HC-20	Dhanshakti
Unprocessed (Control)			53.66^{g}±0.08†	60.83^{f}±0.20‡
Malted	25°C	48 h	59.83^{c}±0.03† (↑11.49)	65.90^{c}±0.11‡ (↑8.33)
		60 h	63.13^{b}±0.14† (↑17.64)	69.80^{b}±0.23‡ (↑14.74)
		72 h	67.50^{a}±0.20† (↑25.79)	74.30^{a}±0.11‡ (↑22.14)
	30°C	48 h	59.76^{c}±0.06† (↑11.36)	65.70^{c}±0.10‡ (↑8.00)
		60 h	63.53^{b}±0.08† (↑18.39)	69.86^{b}±0.14‡ (↑14.84)
		72 h	67.86^{a}±0.12† (↑26.46)	74.43^{a}±0.06‡ (↑22.35)
Blanched			56.23^{f}±0.08† (↑4.78)	63.30^{e}±0.05‡ (↑4.06)
Pan roasted		10 m	58.43^{d}±0.06† (↑8.88)	65.26^{cd}±0.06‡ (↑7.28)
		15 m	58.60^{d}±0.05† (↑9.20)	65.66^{c}±0.09‡ (↑7.94)
Oven roasted			57.66^{e}±0.18† (↑7.45)	65.06^{d}±0.08‡ (↑6.95)

Note: Values are expressed (dry weight basis) as mean ± SE of three independent determinations
Different letters (a-d) within the same rows indicate significant difference at P<0.05.
Different symbols (†-‡) within the same columns indicate significant difference at P<0.05.

Table 5: Effect of processing on *in-vitro* starch digestibility (mg maltose/g) of pearl millet flours (on dry weight basis).

Processing			HC-20	Dhanshakti
Unprocessed (Control)			21.63^{h}±0.14†	22.36^{g}±0.29‡
Malted	25°C	48 h	39.33^{d}±0.06† (↑81.83)	40.03^{c}±0.12‡ (↑79.02)
		60 h	41.53^{b}±0.14† (↑92.00)	42.56^{b}±0.08‡ (↑90.33)
		72 h	43.43^{a}±0.12† (↑100.92)	44.80^{a}±0.15‡ (↑100.35)
	30°C	48 h	39.83^{c}±0.08† (↑84.14)	40.23^{c}±0.23‡ (↑79.91)
		60 h	41.53^{b}±0.13† (↑92.00)	42.40^{b}±0.05‡ (↑89.62)
		72 h	43.46^{a}±0.16† (↑100.92)	44.66^{a}±0.16‡ (↑99.73)
Blanched			23.36^{g}±0.08† (↑7.99)	24.43^{f}±0.06‡ (↑9.25)
Pan roasted		10 m	29.30^{f}±0.25† (↑35.46)	30.30^{e}±0.05‡ (↑35.50)
		15 m	29.70^{e}±0.05† (↑37.30)	30.56^{d}±0.13‡ (↑36.67)
Oven roasted			29.13^{f}±0.23† (↑34.67)	30.10^{e}±.15‡ (↑34.61)

Note: Values are expressed (dry weight basis) as mean±SE of three independent determinations.
Different letters (a-d) within the same rows indicate significant difference at P<0.05.
Different symbols (†-‡) within the same columns indicate significant difference at P<0.05.

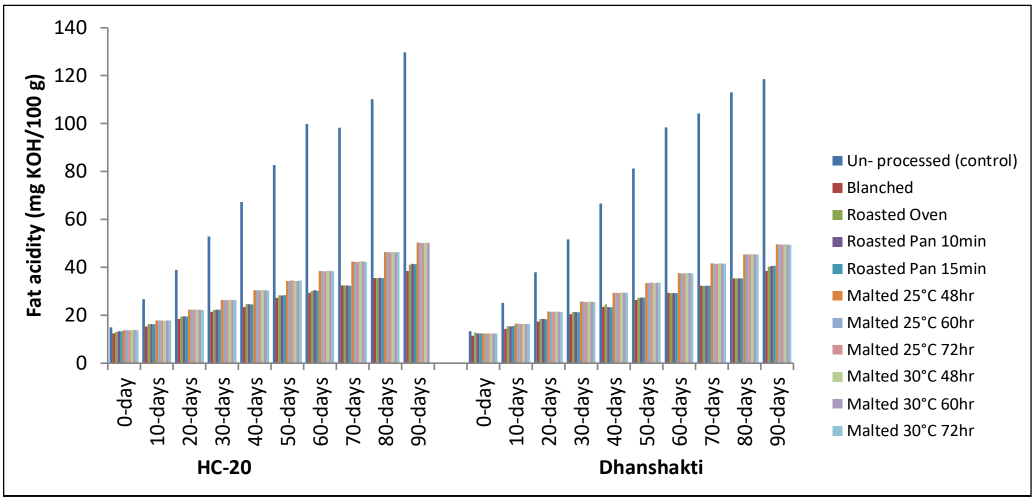

Fig 1: Effect of storage on fat acidity (mg KOH/100 g) of pearl millet flour.

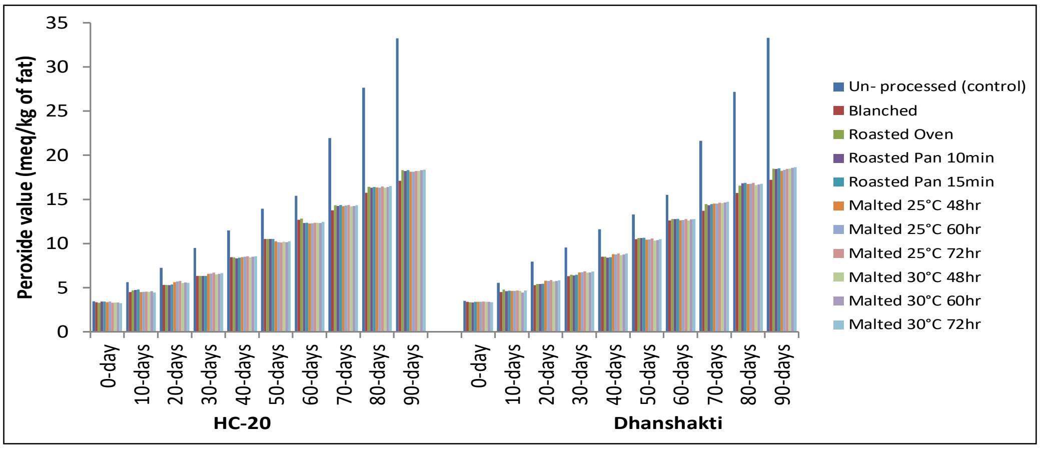

Fig 2: Effect of storage on peroxide value (meq/kg of fat) of pearl millet flour.

Shobhana *et al*. 2012; Hithamani and Srinivasan, 2014; Pandey and Awasthi, 2015; Bhati *et al.* 2016; Atlaw *et al*. 2018).

CONCLUSION

The present study concluded that the protein and fat contents of unprocessed flour were lower, but they exhibited superior protein and starch digestibilities and shelf life characteristics, than unprocessed flours. A significant improvement in the ash content of blanched and roasted flours was detected. It is recommended that value addition of pearl millet by processing is a viable solution for making available easily digestible and nutritious grains having better keeping quality. It is proposed that the utilization of processed pearl millet in daily diet can augment the health and nutritional status of marginalized sections of society. The utilization of climate smart, undervalued and underutilized processed pearl millet, to develop nutrient rich food products can help diversify its use to achieve cost effective food and nutrition sufficiency and resiliency, especially in small farm households of developing nations. The need of day is to promote, endorse and create awareness among masses on nutritional importance of processed biofortified pearl millet varieties, and making efforts to link them with several national and international nutrition intervention programmes. Thus increased utilization of pearl millet per se will usher in getting higher income for farmers and can open avenues of entrepreneurship development.

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Conflict of interest

The authors declare that they have no conflict of interest.

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