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Comparative Evaluation of effect at Fermentation on Functional and Anti Nutritional properties of Pearl Millet Flours (Nandi 65 & Pioneer 8885)

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ABSTRACT: The present study was undertaken to evaluate various functional properties of different pearl millets varieties (NANDI 65 and PIONEER 8885) the various functional properties like water holding capacity, oil holding capacity, swelling properties, bulk density were evaluated. The highest water holding capacity was found in Nandi 65 at fermented 24 hours flour (276±0.76) and lowest was observed in variety pioneer 8885 control flour (219 ± 0.20). Oil holding capacity, swelling properties, bulk density of both the varieties of pearl millet ranged seen. Evaluation of anti-nutritional flour showed that the phytate and tannin were significantly decreased by fermentation. Use of millet based fermented flour improves the food security and improve sustainable agriculture.

Keywords: Functional properties, water absorption capacity, oil holding capacity, swelling properties, bulk density.

INTRODUCTION

In India, pearl millet are processed and cooked by method based on tradition and taste preferences. Functional properties describes how they affects products in terms of it looks, tastes, feel. The water absorption ability performs a crucial role in the improvement of meals as it affects to a massive extent their interaction with water. The use of starch in food applications depend upon its physicochemical and useful properties which can be decided via way of means of its structure that depends on its granule and crystalline properties Nuwamanya *et al.* (2010). The swelling capacity of pearl millet starch and its variety from 14.1 to 16.4 at 95°C. Starches with low swelling and solubility at temperatures below 75°C had excessive swelling and solubility at temperatures from 80 to 95°C. These phenomena might be associated with the stage of bonding forces within the starch granules during swelling. Swelling capacity and solubility have been linearly associated with increase of temperature Suma and Urooj (2015). Swelling aspect and amylose leaching elevated with rise in temperature and maximum at 60 to 70°C and concluded that the low swelling aspect and amylose leaching might be attributed to better content material of lipid complexed amylose chains or to the presence of a larger quantity of crystallites within the granule interior. Balasubramanian *et al*. (2014); Sharma *et al.* (2015) swelling and solubility properties have been additionally contributed by amylopectin content material and chemical elements through examining swelling and solubility of native and changed pearl millet starches. Various processing techniques affecting the ranges affect the protein and starch digestibility of pearl millet.

MATERIALS AND METHODS

Place of Work:

The present was conducted in the department of Food Process Engineering, Vaugh Institute of Agricultural Engineering and Technology SHUATS, Allahabad (Prayagraj).

Water Absorption Capacity (WAC). One g of sample was mixed with water (1:10). The mixture was stirred for 30 min at room temperature. After samples were centrifuged (2500g, 30 min), the supernatant was transferred to a graduated cylinder of 10 mL, where the volume was measured. The WAC was expressed as millilitres of water held per gram of sample (Badau, 2004).

$$\text{WAC (\%)} = \frac{\text{Weight of tube after draining water} - (\text{weight of tube} + \text{sample weight})}{\text{weight of sample}} \times 100$$

Oil-Absorption Capacity (OHC). One g of sample was mixed with vegetable oil (1:10). The mixture was stirred for 30 min at room temperature. After samples were centrifuged (2500g, 30 min), the supernatant was transferred to a graduated cylinder of 10 mL, where the volume was measured. The OHC was expressed as millilitres of vegetable oil held per gram of sample (Badau, 2004).

$$\text{OAC (\%)} = \frac{\text{Weight of tube after draining oil} - (\text{weight of tube} + \text{sample weight})}{\text{weight of sample}} \times 100$$

Swelling Capacity (SC). Swelling capacity was determined by Robertson *et al.* (2016) 100 mg of flour sample was hydrated in a known volume of distilled water (10 mL) in a calibrated cylinder at room temperature. After equilibration (18 h), the bed volume was recorded and swelling capacity expressed as volume occupied by sample per gram of original sample dry weight.

Swelling capacity % = V2 -V1/N × 100

V1 = volume of flour sample before soaking,

V2 = volume of soaking flour sample,

N = grams of flour sample.

Bulk Density (BD) Bulk density was determined according to the technique given through the use of a graduated cylinder (10 mL), previously weighed, and filled with sample to 10 mL through consistent tapping, till there is no further change in quantity and the content is weighed. The content changed into weighed, and from the difference in weight, the bulk density of sample was calculated as grams per millilitre Mariotti *et al.* (2006).

Bulk Density (g/ml) = weight of the sample (gm)/volume of sample (ml)

Phytate: Phytic acid was willpower with slight modification to the technique of Reddy, (2015). About 2 g of the ground sample was taken into a beaker and became soaked in 100 ml of 2 % HCl for 5 h, which was then filtered. Then 25 ml of the filtrate was taken right into a conical flask, to this was brought 5 ml of 0.3 % potassium thiocyanate solution and the mixture was titrated with a standard solution of $FeCl_3$. Persistence of brownish-yellow colour for 5 min, indicates the end point. The concentration of the $FeCl_3$ was 1.04 %w/v and Mole ratio of Fe to phytate = 1:1

Concentration of phytate phosphorous

$$\text{¼ Titre value} = \frac{0.064}{weight\ of\ sample}$$

Tannin: Tannins were determined with a slight modification to the method as described by Reddy (2015) using Folin Denis Reagent. This method involves the preparation of standard curve of pure tannic acid. 1 g sample was extracted with 40 ml of 10 % methanol. Filtrate it and made the volume up to 50 ml. Suitable aliquots of the extract of about 1 ml was taken in a volumetric flask and 10 ml of 35 % sodium carbonate reagent were added, Make volume up to 100 ml. Then the absorbance was recorded at 760 nm after 45 min. The amount was calculated as tannic acid equivalent from the standard curve.

RESULTS AND DISCUSSION

Water Absorption Capacity of Pearl Millet Flour (Table 1 Fig. 1). The results show that the water holding capacity of flour Nandi 65 before fermentation (control) ranged 231± 0.2%. This could be attributed to duration of fermented samples (24 hours, 48 hours, and 72 hours). The water holding capacity of fermented flour Nandi 65 at 72 hours is 245 ± 0.56 % which is lower than the value after 24 hours, *i.e.* 293±0.93 %. Water holding capacity decreased due to the effect of fermentation. The water holding capacity of flour for pioneer 8885 before fermentation (control) ranged at 219±0.20 % indicating that the water holding capacity of fermented pearl millet flour 24 hrs is significantly higher than the unfermented flour. The water holding capacity of fermented flour pioneer 8885 after 72 hours is 249 ± 0.11 % which is lower than the value after 24 hours, which is 266±0.08 %. Gull *et al.* (2002) reported that the high Water Holding and oil holding capacity of the flour can positively influence the flavour, moisture, and fat content in food.

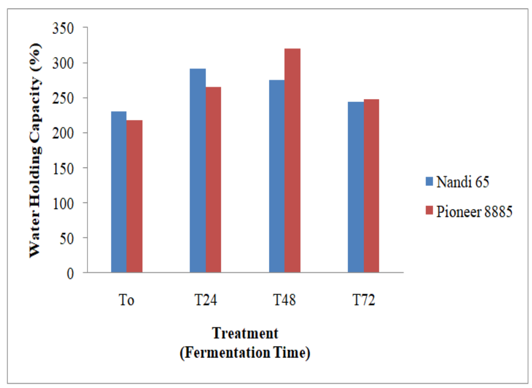

Fig. 1. Water absorption capacity (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

Table 1: Water absorption capacity (%) of different flour varities of pearl millet.

	Water absorption capacity	
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	231 ± 0.20	219 ± 0.20
T_{24}	293 ±2.93	266 ± 0.08
T_{48}	276±0.76	321 ± 0.10
T_{72}	245±0.56	249 ± 0.11

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs

Mean ± standard deviation, values within a column followed by Water absorption capacity (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance.

Oil absorption capacity (Table 2 Fig. 2). The oil holding capacity of flour Nandi 65 unfermented (control) ranged 166±0.11%. The results show that the oil holding capacity of fermented pearl millet flour 24 hrs is significantly higher than the unfermented flour. This could be attributed to duration (24, 48 and 72 hours) of fermented samples. The oil holding capacity of fermented flour Nandi 65 at 72 hours is 179 ± 0.08% which is lower than the value after 24 hours. The oil holding capacity of flour for pioneer 8885 before fermentation (control) was 182 ± 0.92 %. The results show that the oil holding capacity of fermented pearl millet flour for pioneer 8885 at 24 hrs is significantly lower than the unfermented flour. The oil holding capacity of fermented flour for pioneer 8885 at 72 hours is 184 ±0.12% which is higher than the value after 24 hours, *i.e.* and 178 ± 0.08%. The increase in OHC suggests that the flour could be useful in food formulation where optimum oil absorption is desired in food system, the ability of the flours to bind with oil makes it useful, hence potential for use in foods. Suresh *et al.* (2013)

Table 2: Oil absorption capacity (%) of different flour varities of pearl millet.

Oil absorption capacity		
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	166 ± 0.11	182 ± 1.92
T_{24}	182±0.12	178 ± 0.08
T_{48}	196±0.14	172 ± 0.06
T_{72}	179±0.08	184± 0.12

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by oil absorption capacity (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance

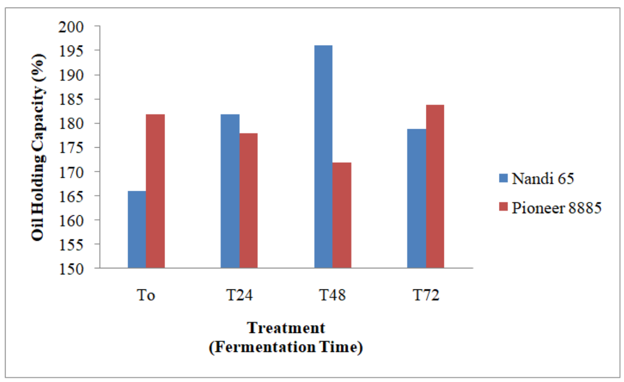

Fig. 2. Oil absorption capacity (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

Swelling capacity (Table 3 Fig. 3). The results show that swelling capacity of fermented pearl millet flour for Nandi 65 at 24 hrs is almost same as unfermented flour. This could be attributed to the duration of fermented samples (24 hours, 48 hours, and 72 hours). The swelling capacity of fermented flour Nandi 65 after 72 hours is 30.16±0.03 % which is higher than the value after 24 hours and non fermented flour. The results show that swelling capacity of fermented pearl millet flour 72 hrs is significantly higher than unfermented flour Nandi 65. The swelling capacity of fermented flour pioneer 8885 after 24 hours is 4.53±0.30% which is almost same as 48 hours *i.e.* 4.53±0.30 %**.** Pawase *et al.* (2021) reported that Swelling capacity of Pearl millet Pioneer 86M32 which is higher than pioneer 8885 24 hours and almost same as unfermented control this is due different variety of flour. Swelling capacity of seeds depend on seed density.

Table 3: Swelling capacity (%) of different flour varities of pearl millet.

Swelling capacity		
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	23.44 ± 2.18	5.4 ± 0.21
T_{24}	23.85±0.46	4.53 ± 0.30
T_{48}	25.41±1.22	4.53 ± 0.30
T_{72}	30.16±0.03	5.69 ± 0.25

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by Swelling capacity (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance.

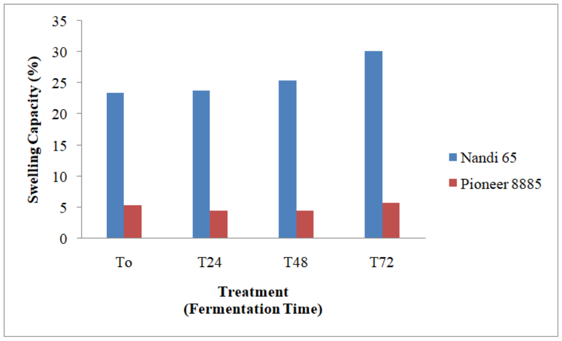

Fig. 3. Swelling capacity (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

Bulk density of pearl millet flour (Table 4 Fig. 4). Nandi 65 pearl millet flour value had increased bulk density when fermentation time was increased. The results show that bulk density of fermented pearl millet flour for Nandi 65 at 24 hrs is almost same as 48 hrs of fermented flour. This could be attributed to the duration of fermented samples (24 hours, 48 hours, and 72 hours). The bulk density of fermented flour nandi 65 at 72 hours is 0.84 ± 0.02 % which is higher than the value after 24 hours and non fermented flour. The swelling capacity of fermented flour for pioneer 8885 at 24 hours had 0.73 ±0.11 % which is lower than 48 hours *i.e.* 0.77 ±0.01 %**.** It was determined as the sample mass to total volume ratio. The larger rise in volume as opposed to the grain mass increase in the moisture range may be the cause of the decrease in bulk density with increasing moisture content (Singh *et al.*, 2010).

Gull *et al*. (2002) reported that bulk density is a measure of heaviness of flour and is generally affected by the density of the flour. The reduction in the bulk density as a result of fermentation is an advantage, when the flour are to be used for the formulation of infant foods since fermentation has been reported by Pragya & Rita (2012) to be a traditional means of preparing low density foods.

Table 4: Bulk density (gm/ml) of different flour varities of pearl millet.

Bulk density		
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	0.81±0.017	0.83±0.11
T_{24}	0.78±0.030	0.73±0.011
T_{48}	0.78±0.030	0.77±0.011
T_{72}	0.84±0.02	0.84±0.30

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by Bulk density (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance

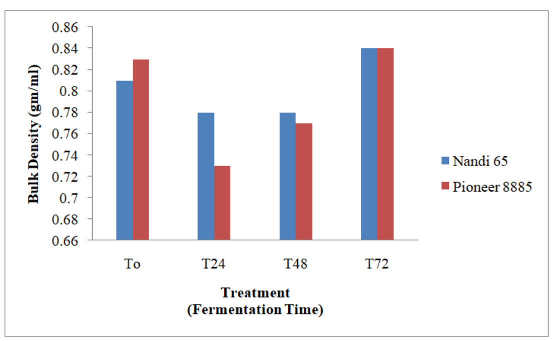

Fig. 4. Bulk density (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

In vitro protein digestibility (Table 5 Fig. 5). The results show that fermented pearl millet flour for Nandi 65 at 24 hrs is almost same as unfermented flour. This could be attributed to the duration of fermented samples (24 hours, 48 hours, and 72 hours). The IVPD of fermented flour Nandi 65 at 72 hours is 72.12 ±0.02 % which is higher than the value after 24 hours and non fermented flour. The IVPD of fermented flour pioneer 8885 at 24 hours is 68.26 ± 0.01% which is higher than 48 hours *i.e.* 52.44 ±0.01 %**.** Fermentation was found to cause a significant improvement in IVPD for two pearl millet varieties. This increases in IVPD may be due to production of proteolytic enzymes during fermentation by the microorganism. In addition, the reduction of phytic acid also contributes to improvement on protein digestibility in fermented pearl millet (Elyas *et al.,* 2002).

Table 5: In vitro protein digestibility (%) of different flour varities of pearl millet.

In vitro protein digestibility		
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	62.42 ±0.14	64.94 ±0.11
T_{24}	62.28 ± 0.030	68.26 ± 0.011
T_{48}	68.42 ± 0.030	52.44 ± 0.011
T_{72}	72.12 ± 0.02	88.96 ± 0.30

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by In vitro protein digestibility (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance

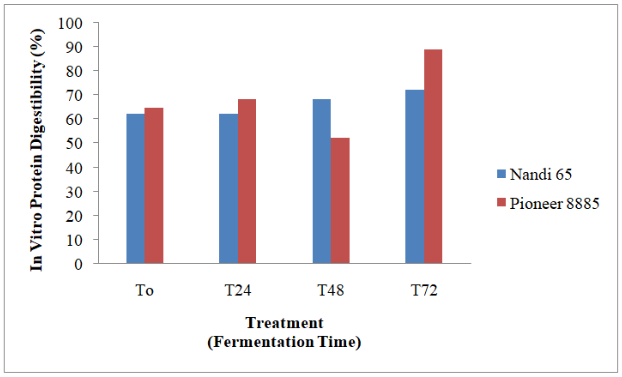

Fig. 5. In vitro protein digestibility (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

***In vitro* starch digestibility (Table 6 Fig. 6).** Results show that fermented pearl millet flour for Nandi 65 at 24 hrs had higher than unfermented flour. This could be attributed to the duration of fermented samples (24 hours, 48 hours, and 72 hours). The IVSD of fermented flour Nandi 65 at 72 hours is 87.29 ±0.36 % which is higher than the value after 24 hours and non fermented flour. The IVSD of fermented flour pioneer 8885 at 24 hours is 53.44 ± 0.06% which is higher than 48 hours *i.e.* 51.59 ±0.06. Fermentation resulted in significant increase in IVSD of pearl millet flour. This is an agreement with report IVSD is increasing with fermentation time which could be attribute to fermentation attribute to the role of fermentation in making starch more accessible to the digestive enzymes (Pragya & Rita 2012).

Table 6: In vitro starch digestibility (%) of different flour varities of pearl millet.

In vitro starch digestibility		
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	44.48 ± 0.44	47.33 ± 0.40
T_{24}	46.47 ± 0.32	53.44 ± 0.06
T_{48}	61.97 ± 0.21	51.59 ± 0.064
T_{72}	87.29 ± 00.36	88.96 ± 0.03

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by In vitro starch digestibility (NANDI 65 and PIONEER 8885) was found significant at 5% level of significance

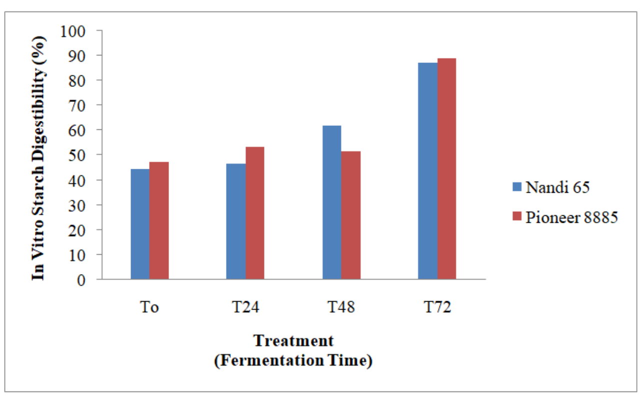

Fig. 6. In vitro starch digestibilty (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

ANTINUTRITIONAL FACTORS

Tannin content in Pearl millet flour (Table 7 Fig. 7). The tannin content in Nandi 65 flour was noted to be maximum. Comparative to the tannin content in unfermented control had higher than fermented 24 hrs, 48 hrs and 72 hrs. The reduction in the anti-nutritional the reduction in the anti-nutrient contents after fermentation could be due to leaching of the anti-nutrients into the soaking. Reduction in tannin contents reduces the risk of bowel irritation, kidney irritation, liver damage, irritation of the stomach and gastrointestinal pain which are associated with foods containing high level of tannin. This is the agreement with Chinenye *et al*. (2017); Gernah *et al*. (2011).

Table 7: Tannin content (%) of different flour varities of pearl millet

	Tannin	
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	6.37 ± 0.21	7.46 ± 0.01
T_{24}	5.62 ± 0.15	7.10 ± 0.05
T_{48}	5.08 ± 0.10	6.62 ± 0.1
T_{72}	4.62 ± 0.12	6.22 ± 0.08

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by Anti- nutritional properties of Tannin content (NANDI 65 and PIONEER 8885) was found non significant at 5% level of significance.

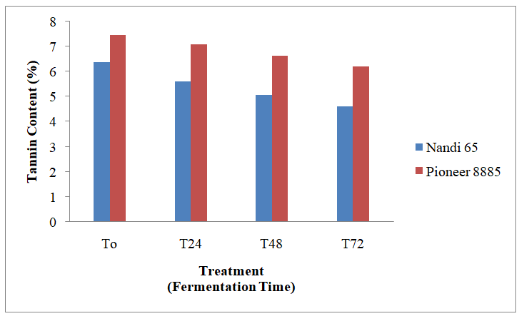

Fig. 7. Tannin content (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

Phytate content in Pearl millet flour (Table 8 Fig. 8). At 24 hours of fermentation, as opposed to 48 and 72 hours, the phytate level is seen to be the high in fermented 24 hours. Phytate content reduced in fermented flour, and when left for the following 24 hours, 48 hrs and 72 hours, a considerable decrease was detected in the phytate content. The decrease in phytate levels in all fermented samples could be due to the endogenous activities of microorganism during fermentation. The presence of endogenous phytate in microorganism which hydrolyses phytic acid during fermentation resulting into reduction in phytic acid content in fermented. Therefore increasing the digestibility (Chinenye *et al*., 2017).

Table 8: Phytate content (%) of different flour varities of pearl millet.

	Phytate	
Fermentation Period	**Nandi 65**	**Pioneer 8885**
T_o	4.24 ± 0.01	5.24 ± 0.12
T_{24}	3.62 ± 0.02	4.64 ± 0.02
T_{48}	3.20± 0.21	4.20 ± 0.01
T_{72}	3.12 ± 0.18	3.98 ± 0.12

Note: -T_o Non fermented, T_{24} Fermented at 24 hours, T_{48} Fermented at 48 hours, - T_{72} Fermented at 72 hrs
Mean ± standard deviation, values within a column followed by Anti-nutritional properties of Phytate content (NANDI 65 and PIONEER 8885) was found non significant at 5% level of significance.

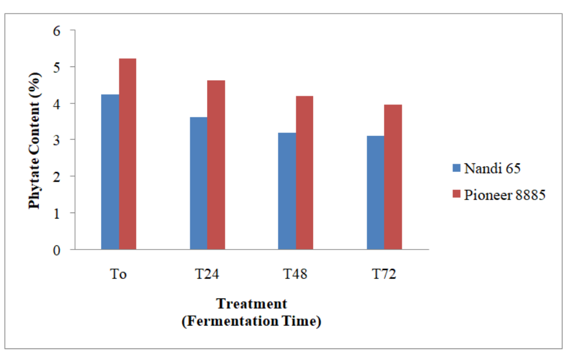

Fig. 8. Phytate content (%) of pearl millet flour (Nandi 65 and Pioneer 8885).

CONCLUSION

Functional properties are playing an essential function in new product development. Treatment like water holding capacity, oil holding capacity, swelling capacity, bulk density therefore to get concept about products textural and sensory quality. Moreover functional properties of pearl millet flour is very essential due to the fact pearl millet is one of the underutilized millet, therefore to explore pearl millet into new cost introduced convenience food products will helps to fulfil the dietary security. However, most important factors which limit its utilization are the presence of anti-dietary factors (phytate, tannins) which decrease availability of minerals.

FUTURE SCOPE

Pearl millet based fermented flour are useful to develop high nutritional based extruded food products and its helpful for school children suffering from malnutrition.

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Conflict of interest. None.

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