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Physico- Chemical and Functional Parameters of Fermented Little Millet (*Panicum Sumantrense*) Flour

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ABSTRACT

Millets are common grains consumed at households' level and processing is done at traditionally and industrially. Fermentation is a traditional food processing method that causes degradation of grain components, especially starch and soluble sugars. Fermentation was carried out for little millet flour at 30°C for 24 hr to analyze the different parameters. The pH decreases (14.6%) while titratable acidity increases (91.5%) after fermentation. There was a 57% decrease in bulk density and 37.7% decrease in tapped density also after fermentation. Fermentation leads to decrease in water absorption index by 8%, water solubility index by 33% and hydrophilic- lipophilic index by 11%. There was a decrease in moisture (8.71%) and ash (9.8%) after fermentation in little millet flour. The protein content increases by 23.8% after fermentation of little millet flour. After fermentation, the fat and crude fiber content of little millet flour decreases with 9.6% and 19%. Carbohydrate and energy were increased by only 1.49% and 2.29% after fermentation in little millet flour.

KEYWORDS: Millets, fermentation, little millets, flour,

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1. INTRODUCTION

Millets are the oldest crops known, whose origin dates back to 4000 years ago (Changmei and Dorothy, 2014). Millets represent a unique biodiversity component in the agriculture and food security systems of millions of poor farmers in regions such as Sub-Saharan Africa (Amadou *et al.,*2013). Millets have immense health benefits partly contributed by presence of phytochemicals, antioxidants and other minerals like calcium, protein, etc. (Izadi *et al.,*2012; Devi *et al*., 2011).

Little millet (*Panicum sumatrense*) is one among the minor millets which have been ignored but now grown to a limited extent all over India up to altitudes of 2100 m. This crop is resistant to adverse agro-climatic conditions (Rao *et al.,* 2017). Superior nutritional and medicinal value along with good storage feasibility of this grain leads to consider it as an important staple food by ancient people (Mannuramath *et al.,* 2015).

Traditionally millets were processed either by malting or fermentation and were extensively used in the preparation of weaning foods, instant mixes, beverages and pharmaceutical products (Rao and Muralikrishna, 2001). Fermentation is one of the traditional technologies that bring about changes in the food which improves taste, texture, nutrient content and also nutritive value and digestibility (Madalageri *et al.,* 2016). Fermentation is one of the processes known to reduce antinutritional factors, such as phytic acid, polyphenols and tannins (Elyas *et al.,* 2002).

Fermented foods have a special significance in the diet of a predominantly vegetarian population as in India. Fermentation helps to increase bacterial levels and fermented millet based products are good source of prebiotics and probiotics foods (Antony *et* al., 1996; Amadou *et al.,* 2013). The possibility of nutritional enhancement by fermentative processing does not appear to be documented and study on fermented little millet flour is nominal. Hence the study was designed to evaluate the physico- chemical and functional parameters of fermented little millet flour which would help to understand and diversify the used of millet.

MATERIALS AND METHODS

Procurement of raw materials: The little millet grains was acquired from MPIC, PJTSAU, Rajendranagar and durum wheat flour from local market of Hyderabad.

Fermentation of the sample: The little millet grain was grounded to fine flour followed by sieving with a 5.0mm sieve. Then, 100.0 grams of little millet flour was taken and mixed thoroughly in 500 ml of distilled water. The little millet batter was allowed to stand for fermentation in water bath shaker at different time intervals of 0, 6, 12, 18, 24 and 30 hours using temperatures at 30°C. Aliquots of the fermenting slurry were drawn at every 6hr for analysis of physico-chemical parameters. The fermentations were carried out in triplicate. The suspension after fermentation was dried at 50°C in a tray dryer until constant weight was obtained (Carciochi *et al.,* 2016).

Physical properties of fermented little millet flour:

Titratable acidity: The acidity of the millet flour samples was determined by titrating with 0.1N NaOH adding phenolphthalein indicator to determine the endpoint (AOAC, 2012).

pH: The pH was determined using pH 700 Digital meter at room temperature. The pH meter was standardized using a pH buffer of 4.0, 7.0 and 9.2 (AOAC, 2012).

Colour: Colour quality of the samples was estimated using a Hunter lab colorimeter (Colour Quest XE Hunter Lab, USA). The L* indicated lightness and extended from 0.0 (black) to 100.0 (white). The other two coordinates a* and b* represented redness (+a*value) to greenness (-a*value) and yellowness (+b*value) to blueness (-b*value) respectively (Hunter Lab, 2013). Chroma (C*) and Hue angle (h*) was determined from the equation for calculation of chroma and hue from Pathare *et al.*(2012).

Bulk density: 100 ml measuring cylinder was taken and weighed (W_1). Selected samples were filled into the measuring cylinder up to 100 ml mark. The weight of the sample filled into the measuring cylinder was noted as W_2 in triplicates (Stojceska *et al*., 2008).

Tapped density: Tapped density was determined by using the method described by Narayana and Narasinga (1982). Selected samples were weighed (W_1) into a 100 ml graduated measuring cylinder and then gently tapped to eliminate spaces between the sample and reweighed (W_2) in triplicates.

Flowability and cohesiveness: Flowability and cohesiveness of the powders were evaluated in terms of Carr index (CI) and Hausner ratio (HR) respectively (Jinapong *et al.,* 2008). Both CI and HR were calculated from the bulk and tapped densities of the powder.

FUNCTIONAL PARAMETERS OF FERMENTED LITTLE MILLET FLOUR:

Water absorption index: WAI is the weight of sediment it was carried as given by Anderson *et al.* (1969).

Water solubility index: WSI is the weight of dry solids in supernatant expressed as percent original weight of the sample it was carried as given by Anderson *et al.* (1969).

Oil retention capacity: The ORC is also known as fat absorption capacity and was determined as described by Beugre *et al.* (2014).

hydrophilic-lipophilic index (hli): The HLI was determined as the ratio of WAI to that of ORC (Njintang *et al.,* 2001).

Foaming capacity (FC): 5.0 g of sample was dispersed in 20.0 ml of distilled water, homogenized for 10 min and centrifuged at 3000 rpm for 15 min. The supernatant obtained was stirred for 5 min using a magnetic stirrer at 1200 rpm, poured into a 100 ml measuring cylinder and its volume was immediately noted (Lawhon *et al.*,1972).

Reconstitution time: The reconstitution time was determined using the procedure described by Nwanekezi *et al.* (2001). A 2.0 g weight of each sample was dispersed onto the surface of 50 ml of cold distilled water in a 150 ml graduated cylinder. The time taken for each of the samples to completely dissolve without stirring was recorded.

Water activity: Water activity was determined at 25°C using an advanced water activity meter (NOVASINA). The equipment was calibrated with a saturated salt solution. 2.0 g of sample was weighed and placed in the instrument and allowed for some time still constant reading ware obtained and then values were noted. For each determination, three replicates were obtained and the average value was calculated (Abramovic *et al*., 2008).

NUTRITIONAL COMPOSITION OF FERMENTED LITTLE MILLET FLOUR

Moisture: The moisture content of the sample was analyzed by the standard procedure of AOAC (2005).

Ash: Ash content of the sample was analyzed by the standard procedure of AOAC (2005).

Protein: The crude protein content of samples was estimated as per micro Kjeldhal method AOAC (2005) and was calculated as percent nitrogen of product and multiplied with 6.25 to obtain the protein content.

Fat: Fat was estimated as crude ether extract of the dry material using an automatic soxtherm extraction unit (AOAC, 1997).

Fibre: The crude fibre content of samples was determined by boiling with 1.25% dilute H_2SO_4, washed with water, followed by boiling with 1.25% dilute NaOH and again washed with water. The remaining residue after digestion was taken as crude fibre (AOAC, 1990).

Computation of carbohydrates: Carbohydrate content was computed by subtracting the total of moisture, ash, protein, fat and crude fibre from 100 (AOAC, 1980).

Computation of energy: Energy content was computed by multiplying protein, fat and carbohydrate values obtained from the analysis by 4, 9 and 4 respectively and expressed as Kcal / 100 g (AOAC, 1980).

statistical analysis: All the results were statistically analyzed to test the significance of the results using percentages, mean and standard deviations35. All analysis was performed in replications and the results were presented as mean ± standard deviation. The difference between the variables was tested for significance by (ANOVA) using SAS version 9.1. z

1. RESULT AND DISCUSSION

Physical properties of fermented little millet flour:

Colour: Millet colour has a significant correlation with fragrance and palatability of cooked grains. The yellower the millet, the stronger the flavour and the better quality cultivar (Wang *et al.,* 2008). Colour scores of unfermented little millet flour (UF) and fermented little millet flour (FF) samples were presented as L*, a*, b*E* C*and h*values as analyzed using Munsell colour charts and presented in Table 1.

The L* was increased in fermented millet flour from 9.51±0.25 to 16.09±0.49, indicates increased luminosity of little millet flour after fermentation. Whereas, the a*value of UF (31.49±0.08) was higher than FF (29.83±0.37) and the b* value of UF (16.16±0.18) was higher than FF (15.29±0.26).Values of a* for fermented and unfermented flour were positive indicating the presence of a slight red tint.

Chroma (C*) is considered the quantitative attribute of colorfulness, used to determine the degree of difference of a hue in comparison to grey colour with the same lightness. The higher the chroma values, the higher is the colour intensity of samples perceived by humans (Pathare *et al.,* 2012). In the present study, the C* value of UF (35.40±0.13) was high than the FF (33.52±0.50) indicating a high intensity of colour in unprocessed little millet sample.

Differences in perceivable colour can be analytically classified as very distinct (E*>3), distinct (1.5< E*< 3) and small difference (1.5< E*; Pathare *et al.,* 2012). The E* value of FF (37.19±0.29) was higher than UF (36.66±0.21).In the present study the difference between the UF and FF of E* value can be classified as a small difference with a value of 0.53. In the present study, there was no significant difference between the h * value of both the samples and the degree of hue shows that the samples were light yellow to white in colour (table 1).

Table 1: Colour parameters of fermented and unfermented millet flours

Sample	L*	a*	b*	E*	C*	h * (degrees)
UF	9.51[a] ±0.25	31.49[b] ±0.08	16.16[b] ±0.18	36.66[a] ±0.21	35.40[b] ±0.13	27.17[a] ±0.13
FF	16.09[b] ±0.49	29.83[a] ±0.37	15.29[a] ±0.26	37.19[b] ±0.29	33.52[a] ±0.50	27.14[a] ±0.50
Mean	12.80	30.66	15.72	36.92	34.46	27.15
S E	1.49	0.40	0.23	0.19	0.51	0.41
C D	2.73	1.64	1.38	1.90	1.36	1.04
C V (%)	6.08	1.52	2.50	1.46	1.56	1.25

Note: Values are expressed as mean ± standard deviation of three determinations.
Mean within the same column followed by a common letter do not significantly differ at p ≤ 0.05.
UF: Unfermented millet flour
FF: Fermented millet flour

Determination of pH: The pH values of unfermented (UF) and fermented (FF) flour was 5.13±0.03 and 4.38±0.04 (table 2). The reduction in pH with increasing fermentation time is likely attributed to the hydrolysis of carbohydrates in little millet dough by microorganisms into sugars, alcohols and organic acids (Sefa-Dedeh *et al*, 2003). The milder acidity of fermented flours is important because they reached pH (5.44 to 5.62) is close to the optimum pH of some enzymes, such as α-amylase, protease, phytase, and β-glucanase (Ilowefah *et al.,* 2017).

Titratable acidity: The titratable acidity of UF and FF was 0.54 and 1.04g/L with a statistically significant difference at $p \leq 0.05$ as seen in table 2.

Bulk density (BD) and tapped density (TD): BD and TD represent an important quality of a flour product and play an important role in package design, material treatment and application in food products. The results as shown in table 2 indicated that the bulk density of FF (0.42±0.05 g/ml) was lower than UF (0.66±0.00 g/ml). There was a slight reduction in BD of little millet flours with fermentation might be as a consequence of macromolecules modification improving their solubility due to microbial action (Chinma *et al.,* 2014).

Tapped density of FF and UF was 0.73 g/ml and 0.53 g/ml respectively. Statistically, there was a significant difference ($p \leq 0.05$) between bulk density and tapped density of UF and FF (Table 2). The reduction in BD shows an advantage in the formulation of baby foods. It has been reported that fermentation is a convenient and effective method for the preparation of infant food supplements (Gong *et al.*, 2020).

Carr index (CI) and Hausner ratio (HR): Assessment of HR is important to understand the impact of relative humidity on powder compression during its shelf-life. Thereupon, HR can serve as a criterion for the measurement of state transition from free flow to cohesion (Barzegar *et al*., 2018). In the present study, the CI of UF and FF were 0.10 and 0.20, whereas HR was 1.10 and 1.26 respectively as seen in table 2 which indicates excellent to good cohesiveness and flowability of the flours (Jinapong *et al.,* 2008).

Table 2: Physical parameters of fermented little millet flour

Sample	pH	Titratable acidity	Bulk density g/ml	Tapped density g/ml	Carr index (CI)	Hausner ratio (HR)
UF	5.13^{b} ±0.03	0.54^{a} ±0.01	0.66^{b} ±0.00	0.73^{b} ±0.02	0.10^{a} ±0.02	1.10^{a} ±0.01
FF	4.387^{a} ±0.07	1.04^{b} ±0.02	0.42^{a} ±0.05	0.53^{a} ±0.02	0.20^{b} ±0.03	1.26^{b} ±0.02
Mean	4.75	0.79	0.77	0.89	0.25	1.18
S E	0.08	0.04	0.02	0.06	0.08	0.02
C D	0.36	0.18	0.01	0.01	0.31	0.32
C V (%)	2.15	6.76	0.76	2.23	1.23	1.12

Note: Values are expressed as mean ± standard deviation of three determinations.
Mean within the same column followed by a common letter do not significantly differ at $p \leq 0.05$.
UF: Unfermented millet flour
FF: Fermented millet flour

The percentage change in physical parameters of fermented little millet flour when compared to the unfermented little millet flour was presented graphically in fig 1. Titratable acidity (TA) shows a notable rise of around 91.5%, suggesting that fermentation produces a considerable amount of acid. A modest rise of about 12.7% in the Hausner ratio (HR) indicates minor shifts in flowability. Other measures, however, show significant decreases: pH falls by around 14.6%, bulk density (BD) falls by 57%, tapped density (TD) falls by 37.7%, and Carr index (CI) falls by 50%. According to these results, fermentation significantly increases acidity while lowering density and compaction, changing the physical qualities of the flour.

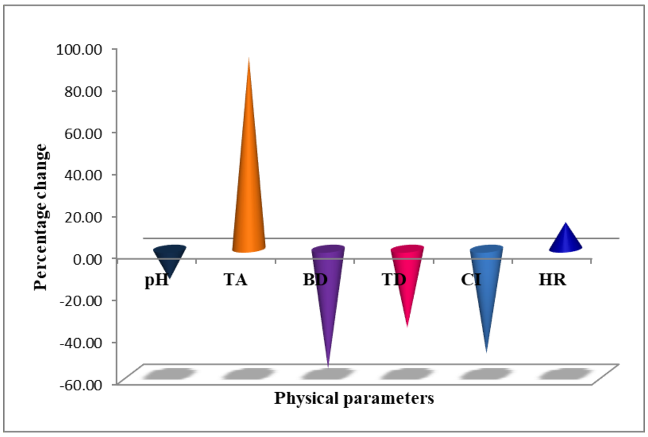

Figure 1: Percentage change in physical parameters of fermented flour

Note: TA: Titratable acidity, BD: Bulk density, TD: Tapped density, CI: Carr index,
HR: Hausner ratio

Functional parameters of fermented little millet flour

The functional properties of little millet flour include water absorption index (WAI), water solubility index (WSI), oil retention capacity (ORC), foaming capacity (FC), reconstitution time (RT), hydrophilic-lipophilic index (HLI) and water activity (aw) are statistically analyzed and reported in Table 3.

Water absorption index (WAI): The WAI is related to the availability of hydrophilic groups (-OH) to bind to water molecules and to gel forming capacity of starch molecules (Ferreira, 2012). The WAI of UF and FF was 2.40±0.00and 2.22±0.01ml/g. with a statistically significant difference at $p \leq 0.05$. The water absorption index was decreased after the fermentation of little millet flour.

Water solubility index (WSI): The WSI is related to the amount of soluble solids present in a dried sample which can be used to verify the intensity of the heat treatment that effects gelatinization, dextrinization and consequently solubilization of starch with other components in foods like protein, fat and fiber (Yousf *et al.,* 2017). The WSI of UF and FF was 0.03 and 0.02 % (table 3).

Oil retention capacity (ORC): The ORC was 1.82±0.01 and 1.90±0.00 g for UF and FF. There was a statistically significant difference at $p \leq 0.05$. There was a slight increase in ORC of FF during fermentation.

Hydrophilic lipophilic index (HLI): Hydrophilic-lipophilic index (HLI) is a ratio between the water absorption index (WAI) and oil retention capacity (ORC). HLP was more for UF (1.31±0.00%) compared to the FF (1.16±0.00%). When compared FF with UF 11% decrease was observed and there was a significant difference ($p \leq 0.05$) between UF and FF (table 3).

Foaming capacity (FC): The development of protein based foams involves the diffusion of soluble proteins towards the air water interface with rapid conformational change and rearrangement at the interface. Stable foam requires the formation of thick, cohesiveness and viscoelastic film around each gas bubble (Kinsella, 1979). Foaming capacity is essential in the maintenance of texture and structure of baked and frozen food products. The foamability of the flour depends on the existence of the flexible protein molecules which decrease the surface tension of water thereby helping in entrapping the air bubbles (Sathe *et al.,* 1982). The FC of UF and FF was 22.93±0.24 and 18.46±0.24%. There was a statistically significant difference at $p \leq 0.05$ between the samples (table 3).

Reconstitution time: Ease of dispersibility is an important flour property in food formulation (Compaore *et al.,* 2011). The reconstitution time of UF and FF was 18.6 and 14.01 minutes.

Water activity (a_w): The water activity was analyzed at around 22° C for the samples. The a_w for UF and FF was 0.42and 0.42 and no statistically significant difference at $p \leq 0.05$ was observed. As these values were less than 0.61 showing good keeping quality.

Studies indicated that not the moisture content but the a_w was responsible for the keeping quality and process attributes of foods (Zamora and Chirife, 2006). Although measuring moisture content is much more practical and economical than measuring a_w, it gives a clear picture of the shelf stability of products (Serin *et al.,* 2018).

Table 3: Functional properties of fermented little millet flour

Sample	WAI(ml/g)	WSI (%)	ORC(g)	HLI (%)	FC (%)	RT (s)	aw
UF	2.40^{b}±0.00	0.03^{b}±0.00	1.82^{a}±0.01	1.31±0.00	22.93^{b}±0.24	18.6^{b}±0.73	0.42^{a}±0.00
FF	2.22^{a}±0.01	0.02^{a}±0.00	1.90^{b}±0.00	1.16±0.00	18.46^{a}±0.24	14.01^{a}±2.08	0.42^{a}±0.00
Mean	2.31	0.02	1.86	1.23	20.69	16.33	0.42
S E	0.01	0.00	0.01	0.01	0.06	1.35	0.02
C D	0.05	0.01	0.06	0.00	0.26	5.83	0.01
CV(%)	0.73	11.50	1.05	0.74	0.36	10.16	0.33

Note: Values are expressed as mean ± standard deviation of three determinations.
Mean within the same column followed by a common letter do not significantly differ at $p \leq 0.05$.
UF: Unfermented millet flour, FF: Fermented millet flour, WAI: Water absorption index, WSI: Water solubility index, ORC: Oil retention capacity, HLI: Hydrophilic lipophilic index, FC: Foaming Capacity, RT: Reconstitution time, $a_{w:}$ water activity

Nutritional composition of fermented little millet flour:

Moisture: The moisture content for UF was 9.30 ±0.16and for FF was 8.49 ±0.20 with a statistically significant difference at $p \leq 0.05$ for the samples (Table 4).

Ash: The ash content was 5.10±0.00for UF and 5.60±0.06% for FF with a statistically significant difference at $p \leq 0.05$ for the samples (Table 4). Marginal decreases in total ash with an increase in fermentation time in both millet and pigeon pea flours were reported. The observed decrease in ash was attributed to possible losses of dry matter and volatiles which normally occur during fermentation (Onweluzo and Nwabugwu, 2009).

Protein: The protein content of UF and FF was 8.70±0.01and 10.77±0.00% (table 4). An increase in the soluble protein content may be ascribed by an increase in the microbial enzyme activity, protein hydrolysis and breakdown of tannins and phytates (Palanisamy *et al.,* 2012).
The effect of fermentation on proteins has yielded inconsistent results likely due to different experimental designs, study durations, and variation in the initial protein or amino acid profile of foods. It appears that most of these effects may not reflect actual changes but relative changes due to loss of dry matter as a result of microorganisms hydrolyzing and metabolizing carbohydrates and fats as a source of energy (Nkhata *et al.,* 2018).

Fat: The fat content of UF and FF was 5.20±0.02 and 4.70±0.00% respectively (table 4). The fat content was lowered (9.6%) in fermented flour as compared to unfermented flour which was similar to the lowered fat content in millet- soya bean flour blends (Ojokoh and Bello, 2014).The decrease in fat content may be attributed to increased activities of lipolytic enzymes which hydrolyzed fat to glycerol and fatty acids (Onweluzo and Nwabugwu, 2009).

Fiber: The fiber content of UF was 11.19 ±0.57and 09.03 ±1.06% for FF. There was a statistically significant difference at $p \leq 0.05$ for the samples (Table 4).

Carbohydrates: The carbohydrate content of UF and FF was 60.51 ±0.59and 61.41 ±0.32% (table 4). The major carbohydrate in cereals and millets is starch which provides the most calories in developing countries (Nkhata *et al.,* 2018).

Energy: The calculated energy content of UF and FF was 323.60±0.03and 331.02±0.12Kcal/100grespectively and there was statistically no significant difference at $p \leq 0.05$ between the samples (Table 4).

Table 4: Nutritional composition of fermented little millet flour

Sample	**Moisture (%)**	**Fat (%)**	**Crude Fiber (%)**	**Ash (%)**	**Protein (%)**	**Carbohydrates (%)**	**Energy (Kcal/100 g)**
UF	9.30^{b}±0.16	5.20^{b}±0.02	11.19^{b}±0.57	5.10^{a}±0.00	8.70^{a}±0.01	60.51^{a}±0.59	323.60^{a}±0.03
FF	8.49^{a}±0.20	4.70^{a}±0.00	09.03^{a}±1.06	5.60^{b}±0.06	10.77^{b}±0.00	61.41^{a}±0.32	331.02^{b}±0.12
Mean	13.54	4.05	10.47	5.35	9.73	60.96	327.31
S E	0.31	0.03	1.41	0.06	0.06	0.07	0.02
C D	1.37	0.13	6.08	0.27	0.06	0.14	0.17
C V (%)	2.46	2.33	14.91	14.28	1.12	1.72	1.32

Note: Values are expressed as mean ± standard deviation of three determinations.
Mean within the same column followed by a common letter do not significantly differ at $p \leq 0.05$.
UF: Unfermented millet flour
FF: Fermented millet flour

Little millet's moisture content dropped to 8.71% following fermentation. When comparing the fermented sample to the unfermented one, the ash concentration dropped by 9.8%. Both millet and pigeon pea flours showed marginal reductions in total ash as fermentation time increased (Onweluzo and Nwabugwu, 2009). When little millet flour was fermented, the protein content increased by 23.8% (Figure 4.4). The breakdown of tannins and phytates, protein hydrolysis, and increased microbial enzyme activity can all be attributed to an increase in the amount of soluble protein (Palanisamy et al., 2012). In comparison to unfermented flour, the fat level of fermented flour was reduced by 9.6% (Figure 4.4), which was comparable to the reduced fat content of millet-soy bean flour blends (Ojokoh and Bello, 2014). Following fermentation, the crude fiber level decreased by 19%. After fermentation, the amount of carbohydrate in little millet flour increased by just 1.49%. The energy content of the fermented sample was only 2.29 percent higher than that of the unfermented sample.

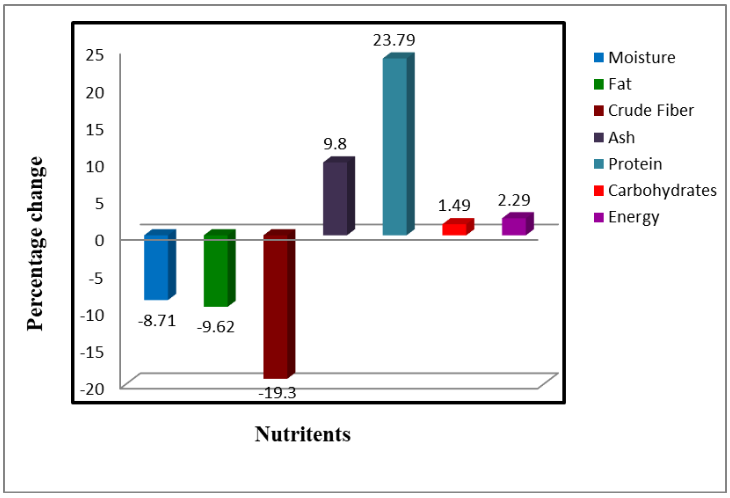

Figure 2: Percentage change in proximate values of fermented millet flour

CONCLUSION

The L* was increased in fermented millet flour after fermentation. Whereas, the a*value of UF was higher than FF and the b* value of UF was higher than FF. Values of a* for fermented and unfermented flour were positive indicating the presence of a slight red tint. There was an increase in TA and HR was observed. Whereas, pH, BD , TD and CI were decreased significantly after fermentation in little millet. Among the functional properties, the water absorption index , WSI and HLI was decreased after fermentation of little millet flour whereas increase in ORC. UF had higher FC than FF indicating that fermentation reduced the foaming capacity. Proximate nutrients were analyzed for fermented and unfermented little millet flour. The moisture and ash content of little millet was decreased after fermentation. There was increase in protein after fermentation in little millet flour. The fat content was lowered and there was a decrease in crude fiber content after fermentation.

REFERENCES

1) Abramovic, H., Jamnik, M., Burkan, L and Kac, M. 2008. Water activity and water content in Slovenian honeys. *Food Control*. 19 (11): 1086-1090.
2) Amadou, I., Gounga, M.E and Le, G. 2013. Millets: Nutritional composition, some benefits and processing- A Review. *Emirates Journal of Food Agriculture*. 25(7): 501-508.
3) Anderson, R.A., Conway, H.F., Pfeifer, V.F and Griffin, E.L. 1969. Gelatinization of corn grits by roll and extrusion cooking. *Cereal Science Today*. 14 (11): 4-7.
4) Antony, U., Sripriya, G and Chandra, T.S. 1996. The effect of fermentation on the primary nutrients in foxtail millet (*Setariaitalica*). *Food Chemistry*. 56(4): 381-384
5) AOAC, 1980.Official methods of analysis. Association of Official Analytical Chemists, Washington, D.C. USA.
6) AOAC. 1990. Official method of analysis for fibre. Association of Official Analysis Chemists.14th Edition. Washington DC. USA.
7) AOAC. 1997. Official Methods of Analysis for fat (crude) or ether extract in flour. Association of Official Analytical Chemists.16th Ed. 3rd Revision. Gaithersburg, Maryland 20877-2417. AOAC 920.85.Chap 32, pp 05.

8) AOAC. 2005. Official Methods of Analysis for ash in flour. Association of Official Analytical Chemists. 18th Ed. Arlington VA 2209, USA. AOAC 929.09, chap 32, pp 01.
9) AOAC. 2005. Official Methods of Analysis for moisture in flour. Association of Official Analytical Chemists. 18th Ed. Arlington VA 2209, USA. AOAC 929.03.32: 02.
10) AOAC. 2005. Official Methods of Analysis for protein. Association of Official Analytical Chemists. 18th Ed. Arlington VA 2209, USA. AOAC 984.13, chap 04, pp 31.
11) AOAC.2012.19th edition, volume II (pH).
12) Barzegar, Z., Jahadi, M and Hanifpour, M.A. 2018. Physical Properties of Fermented Milk Tablets.*Journal of Food Biosciences and Technology*.*8*(1): 21-28.
13) Beugre, G.A., Yapo, B.M., Blei, S.H. and Gnakri, D., 2014. Effect of fermentation time on the physico-chemical properties of maize flour. International Journal of Research Studies in Biosciences, 2(8), pp.30-38.
14) Carciochi, R.A., Alessandro, L.G., Vandendriessche, P and Chollet,S. 2016. Effect of Germination and Fermentation Process on the Antioxidant Compounds of Quinoa Seeds.*Plants Foods Human Nutrition*. 71(4): 361-367.
15) Changmei S, Dorothy J. Millet-the frugal grain. International Journal of Scientific Research and Reviews. 2014;3(4):75–90.
16) Chinma CE, Ilowefah M, Shammugasamy B, Ramakrishnan Y and Muhammad K.2014.Chemical, antioxidant, functional and thermal properties of rice bran proteins after yeast and natural fermentations.*International Journal of Food Science & Technology*.49:2204–2213. doi: 10.1111/ijfs.12533.
17) Compaoré, W.R., Nikièma, P.A., Bassole, H.I.N., Savadogo, A., Hounhouigan, D.J., Mouecoucou, J and Traoré, S.A. 2011.Nutritional Properties of Enriched Local Complementary Flours.*Advance Journal of Food Science and Technology.* 3(1): 31-39.
18) Devi, P. B., Vijayabharathi, R., Sathyabama, S., Malleshi, N. G and Priyadarisini V. B. 2011. Health benefits of finger millet (*Eleusine coracana* L) polyphenols and dietary fiber: a review.*Journal of food science and technology*.DOI: 10.1007/s13197-011-0584-9.
19) Elyas, S.H.A., Tinay, A.H.E., Yousif, N.E and Elsheikh, E.A.E. 2002.Effect of natural fermentation on nutritive value and in vitro protein digestibility of pearl millet.*Food Chemistry*. 78: 75–79.
20) Ferreira, A.E. 2012. Production, characterization and Use of jabuticaba bark flour in cookies. *Journal of Food and Nutrition*. 23 (4): 603-607.
21) Gong, S., Xie, F., Lan, X., Zhang, W., Gu, X. and Wang, Z. 2020. Effects of Fermentation on Compositions, Color, and Functional Properties of Gelatinized Potato Flours.*Journal of Food Science*, *85*(1):57-64.
22) Hunter lab. 2013. Hunter Association Laboratory-Manual Version-2.1.60: 1014-323.
23) Ilowefah, M., Bakar, J., Ghazali, H.M. and Muhammad, K. 2017.Enhancement of Nutritional and Antioxidant Properties of Brown Rice Flour through Solid-State Yeast Fermentation.*Cereal Chemistry*.*94*(3): 519-523.
24) Izadi Z, Nasirpou A., Izadi M and Izadi, T. 2012.Reducing blood cholesterol by a healthy diet.*International Food Research Journal.*19:29-37.
25) Jinapong,N., Suphantharika,M and Jamnong,P. 2008. Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. *Journal of Food Engineering*, 84(2): 194-205. Doi: 10.1016 /j.jfoodeng.2007.04.032
26) Kinsella, J.E. 1979. Functional properties of soy protein.*Journal of American Oil Chemists Society.* 56 (3): 242-258.
27) Lawhon, J.T., Cater, C.M and Maltil, K.F. 1972. A comparative study of the whipping potential of extracts from several oil seed flours.*Cereal Science Today*. 17: 240294.
28) Madalageri,D.M., Yenagi, N.B and Shirnalli, G.2016. Evaluation of little millet Paddu for physico-chemical nutritional, microbiological and sensory attributes. *Asian Journal of Dairy and Food Research*.35(1): 58-64.
29) Mannuramath, M., Yenagi, N and Orsat, V. 2015. Quality evaluation of little millet (*Panicum miliare*) incorporated functional bread. *Journal of Food Science Technology*. 52(12):8357–8363.
30) Michaelraj SJ, shanmugam. A study on millets based cultivation and consumption in India. International Journal of Marketing, Financial Services and Management Research. 2013;2(4):49-58.
31) Narayana, K and Narasinga Rao, M.S. 1982. Functional properties of raw and heat processed winged bean (Psophocarpustetragonolobus) flour. *Journal of Food Science*. 47(5): 1534-1538.
32) Njintang, N.Y., Mbofung, C.M.F. and Waldron, K.W., 2001. In vitro protein digestibility and physicochemical properties of dry red bean (Phaseolus vulgaris) flour: effect of processing and incorporation of soybean and cowpea flour. *Journal of Agricultural and Food Chemistry*.*49*(5): 465-2471.
33) Nkhata, S.G., Ayua, E., Kamau, E.H and Shingiro, J.B. 2018. Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Science and Nutrition*. 6: 2446-2458.
34) Nwanekezi, E.C., N.C. Ohaji and O.C. Afam-Anene. 2001. Nutritional and organoleptic quality of infant food

formulation from natural and solid state fermented tubers (cassava, sprouted and unsprouted yam)-soybean flour bland. *Nigerian Food Journal*.19: 55-62.

35) Ojokoh, A. and Bello, B. 2014.Effect of Fermentation on Nutrient and Anti- nutrient Composition of Millet (*Pennisetumglaucum*) and Soyabean (*Glycine max*) Blend Flours.*Journal of Life Sciences*. 8(8): 668- 675.
36) Onweluzo, J.C and C.C. Nwabugwu. 2009. Development and evaluation of weaning foods from pigeon pea and millet. *Pakistan Journal of Nutrition*.8: 725- 730.
37) Palanisamy B.D., Rajendran, V., Sathyaseelan, S., Bhat, R and Venkatesan, B.P. 2012.Enhancement of nutritional value of finger millet-based food (Indian dosa) by co-fermentation with horse gram flour.*International Journal of Food Sciences and Nutrition*. 63(1): 5–15.
38) Pathare, P. B., Opara, U. L., & Al-Said, F. A.-J. 2012. Colour Measurement and Analysis in Fresh and Processed Foods: A Review.*Food and Bioprocess Technology. 6(1): 36–60.*
39) Rao BD, Bhaskarachary K, Christina, GDA, Devi GS, Tonapi VA. Nutritional and Health Benefits of Millets. ICAR Indian Institute of Millets Research (IIMR) Rajendranagar. 2017;112:1-150.
40) Rao, S.M.V.S.S.T and Muralikrishna, G. 2001. Non- starch polysaccharides and bound phenolic acids from native and malted finger millet (Ragi, Eleusine coracana, Indaf- 15). *Food Chemistry*. 72:187-192.
41) Sathe, A K., Deshphande, S.S and Salunkhe, D.K. 1982. Functional properties of lupin seed (Lupinusmutabilis) protein and protein concentrates.*Journal of Food Science*. 42 (2): 491-497.
42) Sefa-Dedeh, S., Cornelius, B. and Afoakwa, E.O. 2003.Effect of fermentation on the quality characteristics of nixtamalized corn.*Food research international*, *36*(1): 57-64.
43) Serin, S., Turhan, K.N and Turhan, M. 2018. Correlation between water activity and moisture content of Turkish flower and pine honeys. *Journal of Food Science and Technology.* 38 (2): 238-243.
44) Stojceska, V., Ainsworth, P., Andrew, P., Esra, I and Senol, I. 2008. Cauliflower byproducts as a new source of dietary fibre, antioxidants and proteins in cereal based ready to eat expanded snacks. *Journal of Food Engineering*. 87: 554-563.
45) Wang, Y., Li, H., Tian, G., Shi, Q and Guo, E. 2008.Relationship between cooked millet palatability and both visual quality and RVVS profile character of starch.*Journal of Shanxi Agricultural Sciences*. 36 (7): 34-39.
46) Yousf, N., Nazir, F., Salim, R., Ahsan, H and Sirwal, A. 2017. Water solubility index and water absorption index of extruded products from rice and carrot blend. *Journal of Pharmacognosy and Phytochemistry*. 6 (6): 2165-2168.
47) Zamora, M.C and Cherife, J. 2006. Determination of water activity change due to crystallization in honeys from Argentina.*Food Control*. 17 (9): 59-64.