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Original Research Article

Characterization and Development of Wheat based *Kurdi*-An Indegenous Fermented Food

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A B S T R A C T

Traditional fermented foods are now being marketed as extruded foods or neutraceuticals. India has the specific advantage of varied cultures and such traditions are dying a slow death now in a fast-paced world. These traditional fermented food products are a household art prepared by using relatively simple procedures and equipments. Traditional fermented food products prepared in varied parts of India, have been well studied and recognized. However, there is no detailed study reported for foods like *kurdi an* indigenous food item prepared largely in state of Maharashtra, India. Hence, present work was undertaken to characterize and develop a scientifically sound, commercially viable and socially useful wheat based traditional fermented food products. Indigenous fermented product like *kurdi* was prepared from the naturally fermented flour/batter of wheat without addition of any chemical additives. Efforts were made to find out the effect of indigenous fermentation at varied time and temperatures on in-vitro protein digestibility (IVPD), in-vitro starch digestibility (IVSD), nutritional profile and frying characterization of *kurdi* from fermented flour/batter of wheat. Study also deals with gel and functional properties. Hence, this study provides an option to improve the process of making and more nutritious, a popularly consumed traditional fermented foods like *kurdi*. In such situations there will be scope for introduction of such indigenous fermentation technology as functional diet.

Keywords

Neutraceuticals, *kurdi*, in-vitro protein and starch digestibility and functional diet

Introduction

Wheat is grown as a major cereal crop in many parts of the world. It belongs to the *Triticum* family, of which there are many thousands of species (Kent and Evers, 1994), with *T. aestivum* subspecies Vulgare and the hard wheat *T. durum* being commercially the most important in the world (Macrae *et al.*, 1993). Wheat is grown as both a winter and a spring cereal and owing to the number of species and varieties and their adaptability; it is grown in many countries around the world. As human population continued to grow, there is a considerable worldwide interest in the utilization of wheat based food products. Comparative analysis of several food products from wheat flour for both human and animal feed is of greater concern. Wheat is the principal cereal widely used for making bread than any other cereal. The protein called gluten makes bread dough stick together and gives it the ability to retain gas (Oladunmoye *et al.*, 2010). Fermentation is one of the oldest method of preserving foods and beverages, which had been practiced for thousands of years by the primitive people (Borgstorm, 1968). Fermentation is a process by which consumable food products are prepared by use of various micro-organisms (Wood, 1997). Fermented food products prepared from cereals are an integral part of the diet of the people in many parts of the world. The preparation of cereal based traditional fermented food products and other indigenous beverages remains today as a household art; prepared using relatively simple procedures and equipments (Battcock and Azam-ali, 1998; Sankaran, 1998; Aidoo *et al.,* 2006). Cereal based fermented foods and alcoholic beverages like *idli*, *dosa*, *jalebies*, *kurdi*, *seera*, *bhaatijaanr*, *kodokojaanr* etc. have been a part of Indian traditional fermented foods of varied localities, a practice protected by tradition (Thakur *et al.,* 2004; Beuchat 1983; Mukharjee *et al.,* 1965; Soni *et al.,* 1985; Batra, 1986; Tamang and Thapa, 2006; Thapa and Tamang, 2004). Now-a-days fermented foods are receiving world attention due to their disease-preventing and health promoting effects. Improvement of flavour, appearance, nutritional value and storage stability with reduction in cooking time are the additional benefits of fermented foods. Fermented foods also provide variety in the diet (Tamang *et al.,* 1988).

Kurdi is a traditional Indian cereal based fermented food prepared by soaking, fermenting and crushing wheat grains (Thakur *et al.,* 2004), which is subsequently thermally gelatinized, hand extruded and dried (Beuchat, 1983). The preparation of *kurdi* is an art of technology and is a family secret passed from mother to daughter. Since, time immemorial *kurdi* is known as a ceremonial fried food of special significance to the village people of Maharashtra. It marks a special occasion of the *Maharashtrians* such as marriage, religious and cultural festivals. Cereal legume based fermented foods like *idli*, *dosa*, *dhokla*, *khaman*, *wadi*, *papad* and *kinema* from various parts of India have been well studied and documented; however, there is no proper documentation of similar foods, indigenous to the state of Maharashtra (*kurdi*) in India (Nout and Sarkar, 1999; Nout *et al.,* 2007). The purpose with the present work was therefore to elaborate a scientifically sound, more nutritious and most useful wheat based fermented food product i.e. *kurdi* prepared from selected two cultivars of wheat released by VNMKV, Parbhani.

Materials and Methods

Raw Materials

Wheat grains (*Triticum astivum* L., variety: PBN- 51 and PBN- 142) were procured from Wheat Research Station, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India.

Chemicals

The culture media and chemicals used were obtained from Hi-Media laboratories Pvt. Ltd., Mumbai, India. Ethanol, Dinitrosalicylic acid reagent and potassium sodium tartarate (Rochelle salt) were procured from S.D. Fine Chem. Pvt. Ltd., Mumbai, India. Some chemicals obtained from Sigma Chemical Co. s (St. Louis, MO) and chemicals and solvents used were of analytical grade.

Preparation of sample

The grains were sorted by removing broken grains and other unwanted materials. The wheat grains were soaked in water (1:3w/v) for a period of 15, 22.5, and 30 hr and were incubated at varied temperatures of 30, 37.5 and 45°C, for natural fermentation to take place. Water was replaced after every 6 hr so as to get fresh microbial growth and thus to have better fermentation of the wheat grains. At the end of soaking period, the soaked water was discarded. The grains were rinsed twice with water and the softened wheat grains were ground in electrical grinder (Anjali make, Mumbai, India) at 2500 rpm for 30 s and kept at -20°C until analysis. Fermented wheat batter samples were dried in oven at 70^{o}C for 12 hr. The oven dried samples were ground in electrically operated grinder with stainless steel blades. The ground samples were stored in polythene pouches with proper labelling and used for further investigation.

Methodology

Determination of IVPD and IVSD

In vitro protein digestibility (IVPD) was determined according to the method of Maliwal (1983), as modified by Manjula and John (1991). In vitro starch digestibility (IVSD) was assessed by the method of Singh *et al.*, (2010).

Characterization of fermented wheat batter

Preparation of sample

Fermented wheat batter was dried in oven at 70^{o}C for 12 hr. The oven dried samples were ground in electrically operated grinder with stainless steel blades. The ground samples were stored in polythene pouches with proper labelling and used for further investigation.

Thermal properties (Differential scanning calorimetry)

A TA-60WS DSC (Shimadzu Analytical Pvt. Ltd., Singapore) was utilized to measure the gelatinization properties of the sample. 20 mg fermented wheat batter sample and control sample was transferred in to a DSC pan. The pan was hermetically sealed and inserted in the calorimeter. Thermal curves included onset temperature (T_o), peak temperature (T_p) and end set temperature (T_e). Heating rate was maintained at 10°C/min from 20 to 250°C. DSC-60 software, supplied by the instrument manufacturer, was used to determine the mentioned temperatures and peak area. The software drew a tangent line at the steepest point of the DSC curve and a baseline connecting the starting and the ending points of the peak. The intersections of the baseline with the DSC curve determined the onset and ending temperatures. Gelatinization energy was calculated by drawing a straight line between onset temperatures and ending temperature and was recorded as endothermic heat(J/g).The enthalpy (ΔH) was estimated by integrating the area between the thermo gram and a base line under the peak and was expressed in terms of calories per unit weight of dry starch (cal g^{-l}). All DSC experiments were replicated at least three times.

Gel hydration (functional) properties

Water absorption index (WAI), water solubility index (WSI) and swelling power of different fermented and unfermented wheat flour sample were determined following the method of Toyokawa *et al.*, (1989), with slight modification as reported Rosell *et al.*, (2011). Briefly, flour (50.0 ± 0.1 mg) sample was dispersed in 1.0 ml of distilled water in an eppendorf tube using a micropipette and cooked at 90^{0}C for 10 min in a water bath. The cooked paste was cooled in an ice water bath for 10 min, and then centrifuged at 3000 rpm at 4^{0}C for 10 min. The supernatant was decanted into an evaporating dish and the weight of dry solids was recovered by evaporating the supernatant at 105^0C till constant weight. Three replicates were made for each sample. Residues (Wr) and dried supernatants (Ws) were weighed and water absorption index (WAI), water solubility index (WSI) and swelling power (SP) were calculated as follows:

WAI (g/g) = Wr/ Wi (1)
WSI (g/100 g) = Ws/ Wi × 100 (2)
SP (g/g) = Wr/ Wi – Ws (3)

Where,

Wi was the initial sample weight (g, db)
Wr was the residual sample weight (g, db)
Ws was the supernatant weight (g, db)

Degree of gelatinization

The degree of gelatinization was measured according to the method reported by (Birch and Priestley, 1973). The cooked (fermented) sample was dried in oven at 58°C, ground and pass through the sieve (80mesh).

The sample (0.2g) was prepared in 125 ml Erlenmeyer flasks; 98 ml of distilled water was added and KOH 10 M 2.0 ml and then mixed for 5 minutes prior to centrifugation at 3000 rpm for 15 min. The supernatant (1.0 ml) was pipetted and added with hydrochloric acid 0.5M 0.4 ml followed by 10 ml of distilled water and 0.1 ml of iodine solution. The mixture was homogenized and measured the absorbance at 600 nm.

The estimation was repeated using 95 ml water and 5 ml 10M-KOH solution, and 1.0 ml 0.5 M-HC1 for neutralisation. The ratio of the two absorbances obtained from each sample enabled degree of gelatinisation to be obtained.

Nutritional profile and frying characteristics of Kurdi

Physical Parameters

The diameter of the *kurdi* was measured at two diametrical positions to an accuracy of 0.02 mm using a Vernier caliper (Mitutoyo, Kawasaki, Japan).

Each *kurdi* was weighed in a mono pan analytical balance (AEG-220, Shimadzu, Tokyo, Japan) to an accuracy of 0.0001 g.

Moisture content

Moisture was determined by hot air oven method by drying the sample in hot air oven at 105 ^{o}C temperature until a constant weight (AOAC, 2010). The moisture content of sample was estimated by the formula:

Moisture content (%) = Initial weight − Final weight /Initial weight ×100

Frying characteristics of *kurdi*

Frying

Kurdi stored at ambient temperature were deep fat fried in a frying pan containing fresh refined peanut oil at 175± 5 ^{o}C for 6–9 sec.

Oil Uptake

Kurdi from each selection were weighed before and after deep frying in an electronic balance.

Before measuring the weight after frying, the *kurdi* were wiped with tissue paper to remove the adhering surface oil.

The difference in weight was worked out and expressed as oil uptake in percentage.

Expansion

Kurdi from each selection were observed for diameter in two directions at a right angle before and after frying. The difference in diameter was worked out and expressed as expansion in percentage. The percent expansion of *kurdi* was calculated by using the following formula:

Expansion (%) = (DF- DR/ DR) ×100

Where,

DF is the diameter of fried *kurdi* and
DR is the diameter of raw *kurdi.*

Statistical analysis

The results were statistically analyzed by one-way ANOVA using SPSS (IBM statistical analysis, Version 19). Duncan's new multiple-range test was used to determine significant differences. Statistical significance was declared at $p \leq 0.05$ post-hoc comparisons, SPSS 19 version (Duncan, 1955).

Results and Discussion

In-vitro protein digestibility (IVPD) and in-vitro starch digestibility (IVSD) of wheat

The results of fermentation temperature and time on IVPD and IVSD are shown in Table 1.1. A significant increase ($P \leq 0.05$) was first observed at 15 and 22.5 hr fermentation time at all temperature in the IVPD of both wheat cultivars. The increase was from 82.65 to 85.05 % for PBN-51 cultivar and from 80.41 to 82.03 % for PBN-142 cultivar. The IVPD of PBN-51 cultivar was higher than the IVPD of PBN-142 cultivar. Protein digestibility was highest in PBN-51 cultivar fermented at 45°C for 22.5 hr whereas, 30 hr for PBN-142 cultivar. This may also contribute to the improvement in protein digestibility as a significant *(P ≤* 0.05) negative correlation coefficient existed between phytic acid and protein digestibility (in vitro***)*** of wheat. Thus, fermentation offers unique nutritional advantages for making protein of wheat more digestible, possibly by significantly reducing its phytate content and decreasing the level of polyphenols.

This improved IVPD caused by fermentation could be attributed to the partial degradation of complex storage proteins to more simple and soluble products (Chavan *et al.,* 1988); it could also be attributed to the degradation of tannins, polyphenols and phytic acid by microbial enzymes. Micro flora may produce proteolytic enzymes during fermentation which may be responsible for the increased protein digestibility (Hasseltine, 1983). In addition, the elimination of phytic acid contributes to the improvement in protein digestibility in fermented millet (Khetarpaul, 1988).The soaking can increase the protein digestibility due to the incidence of reserve protein catabolism in seed and a decrease in antinutrient compounds (Laetitia *et al.,* 2005). Dicko *et al.,* (2006) also noted that the improving of digestibility was the process which provides essential nutrients for growth through the hydrolysis reaction.

The soaking treatment positively affected the IVSD. The IVSD of PBN-142 cultivar was higher than of PBN-51 cultivar. The significant increase ($P \leq 0.05$) was first observed at 30^{o}C temperature for 30 hr of fermentation time and further significant increase at 45 ^{o}C for 30 hr of fermentation in the IVSD of the two wheat cultivars. Breakdown of starch to oligosaccharides impart the improvement in starch digestibility during fermentation (Cronk, 1977).

Among the factors known to influence starch digestibility in foods, the presence of certain antinutrients such as R-amylase inhibitors can greatly determine the extent of starch hydrolysis. However, during soaking and also during germination, these heat-labile inhibitors are inactivated and the starch digestibility thus also improved.

Improvement was most pronounced when fermentation occurred at 45°C for 9 hr (Mulumani *et al.,* 1994). The difference in IVSD among the studied samples (PBN-51 and PBN-142) might be due to differences in the degree of crystallinity or amylose/amylopectin ratio of the starch granules, which are known to affect starch digestibility (Englyst *et al.,* 1992; Saura Calixto and Abia, 1991). The low starch digestibility has also been attributed to a high content of dietary fiber (Bach *et al.,* 1988). During cooking, starch granules are gelatinized and partly solubilized, becoming available to digestive enzymes. This explains the great improvement of starch digestibility attained after cooking.

Characterization of fermented wheat

Thermal properties of wheat (Differential scanning calorimetry)

The thermal properties of unfermented and fermented flour of two cultivars of wheat were investigated by differential scanning calorimetry (Figure 1.1 to 1.4). Unfermented wheat starch displayed a major peak of starch gelatinization and minor peak of fermented wheat starch of both cultivars; due to the melting of an amylose-lipid complex during heating. Gelatinization properties of starches like peak temperature (T_p), and gelatinization enthalpies (ΔH) before and after fermentation of two wheat cultivars are summarized in Table 1.2. The gelatinization peak temperature of unfermented wheat starches was about 1-3 °C higher than that of fermented wheat starch. This study showed that the starches from the two wheat cultivars differed generally in gelatinization transition temperatures (T_o, T_P and T_c) and enthalpy of gelatinization (ΔH). The total enthalpy change for the transition decreased substantially for the fermented wheat while that of unfermented wheat. However, the decrease of ΔH was greater for PBN-51 cultivar than for PBN-142. These differences are probably influenced by differences in the amount of lipid-complexed amylose molecules, the magnitude of interaction between starch chains within the native granule, and the chain lengths of amylose and amylopectin (Biliaderis *et al.,* 1986a). The peak gelatinization temperature is believed to be an indicator of crystallite quality, which is related to double helix length, whereas the gelatinization enthalpy (ΔH) is a measure of the loss of molecular order (Cooke and Gidley, 1992; Singh *et al.,* 2007). Hoseney (1994) reported that the starch gelatinization range of sorghum (68–78°C) is higher than that of wheat (58–64°C). These results confirm previous suggestion made by Donovan *et al.,* (1983).

Gel hydration (Functional) properties

Water uptake during thermal processing involves starch gelatinization and protein denaturation, was assessed by determining the water absorption index (WAI), water solubility index (WSI) and swelling power (SP). The WAI, WSI and SP values of processed and unprocessed wheat of both cultivars were presented in Table 1.3. The WAI, WSI and SP values for unfermented wheat flour of cultivar PBN-51 were 0.880 g/g, 9.0 g/100g and 0.967 g/g, respectively whereas, 0.870 g/g, 9.5g/100g and 0.961 g/grespectively for cultivar PBN-142.

Table.1 Effect of fermentation temperature and time on in-vitro protein digestibility (%) and in-vitro starch digestibility (mg/maltose/gm/2hr) of wheat*

Variety		PBN – 51		PBN – 142	
Fer. Temp. (^{0}C)	Fer. Time (hr)	IVPD	IVSD	IVPD	IVSD
Control	0	82.65 a ± 0.35	90.80 a ± 0.42	80.41 a ± 0.29	92.30 a ± 0.14
30	15	83.95 b ± 0.21	92.40 b ± 0.42	81.60 b ± 0.28	94.30 b ± 0.28
	22.5	85.05 c ± 0.21	93.40 c ± 0.42	81.95 bc ± 0.04	95.60 c ± 0.28
	30	84.45 bc ± 0.49	94.35 d ± 0.21	82.03 bc ± 0.02	95.75 c ± 0.21
37.5	15	85.00 c ± 0.14	93.76 cd ± 0.49	81.69 bc ± 0.32	94.60 b ± 0.28
	22.5	84.65 bc ± 0.78	92.95 bc ± 0.21	82.07 c ± 0.04	95.10bc± 0.99
	30	84.40 bc ± 0.42	94.45 d ± 0.49	82.53 d ± 0.16	95.60 c ± 0.42
45	15	85.25 c ± 0.21	94.40 d ± 0.42	81.77 bc ± 0.18	95.15bc± 0.35
	22.5	85.05 c ± 0.21	93.60 cd ± 0.28	82.03 bc ± 0.02	94.60 b ± 0.14
	30	84.95 c ± 0.35	94.40 d ± 0.42	82.06 c ± 0.03	95.80 c ± 0.14

*Values are means ± (S.D.).Means not sharing a common letter in a column are significantly different at $P \leq 0.05$, as assessed by Duncan's multiple range tests.

Table.2 Thermal Properties of wheat

Variety		Endothermic Heat (J/g)	Peak Temperature (^{o}C)
PBN-51	Unfermented	13.4	111.48
	Fermented	11.3	110.52
PBN -142	Unfermented	12.2	113.56
	Fermented	11.2	110.25

Table.3 Functional Parameters of wheat

Variety		Water Absorption Index (WAI) g/g	Water Solubility Index (WSI) g/100g	Swelling Power(SP) g/g
PBN-51	Unfermented	0.880	9.0	0.967
	Fermented	0.860	2.0	0.877
PBN -142	Unfermented	0.870	9.5	0.961
	Fermented	0.650	2.0	0.663

Table.4 Effect of cooking time on degree of gelatinization at 99.5^{0}C temperature (On dry wt. basis)

Treatment Time (min)	Degree of gelatinization (%)*	
	Variety PBN - 51	Variety PBN - 142
0	75.43 ± 0.04	78.21 ± 0.04
15	94.14 ± 0.04	93.43 ± 0.04
18	98.41 ± 0.03	97.36 ± 0.03
21	99.46 ± 0.04	99.28 ± 0.02

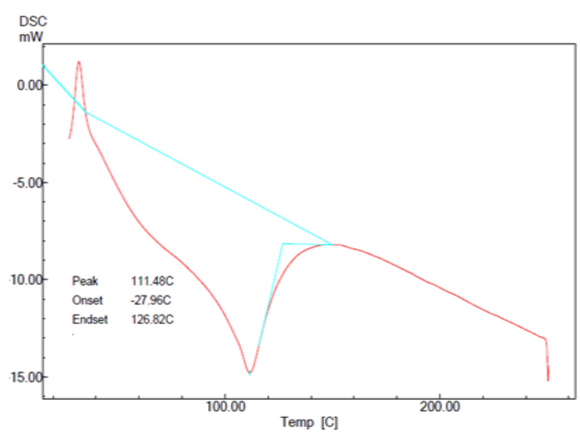
*Values are means ± (S.D.).

Table.5 Nutritional profile and frying characteristics of *Kurdi**

Parameter	PBN-51	PBN-142
Moisture (%)	7.45 ± 0.24	7.65 ± 0.28
Protein (%)	10.13 ± 0.21	10.81 ± 0.24
Fat (%)	1.72 ± 0.09	1.86 ± 0.07
Ash (%)	12.04 ± 0.12	12.06 ± 0.14
Crude Fiber (%)	1.13 ± 0.07	1.19 ± 0.09
Frying oil Temp ºC)	175.3 ± 1.1	175.8 ± 1.3
Oil uptake (%)	31.02 ± 0.46	29.09 ± 0.42
% expansion	31.46 ± 1.2	31.02 ± 1.4

*Values are means ± (S.D.).

Fig.1 DSC analysis of unfermented wheat PBN-51. **Fig.2** DSC analysis of fermented wheat PBN-51



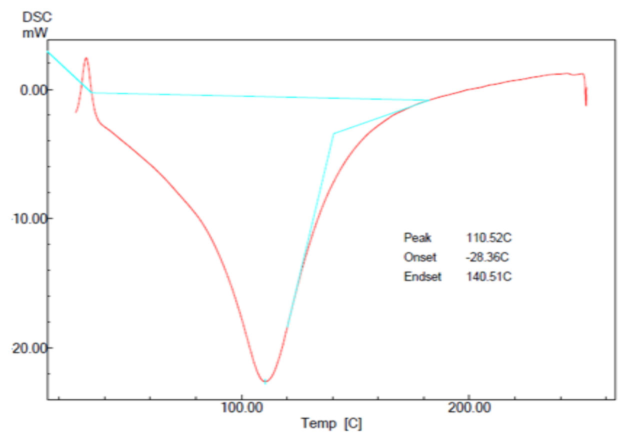
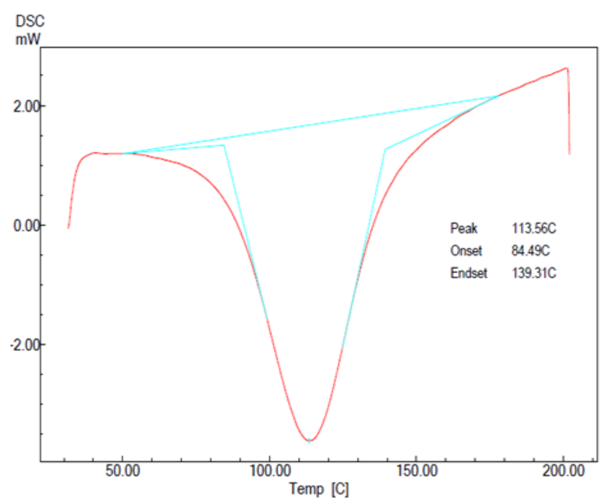


Fig.3 DSC analysis of unfermented wheat PBN-142. **Fig.4** DSC analysis of fermented wheat PBN-142



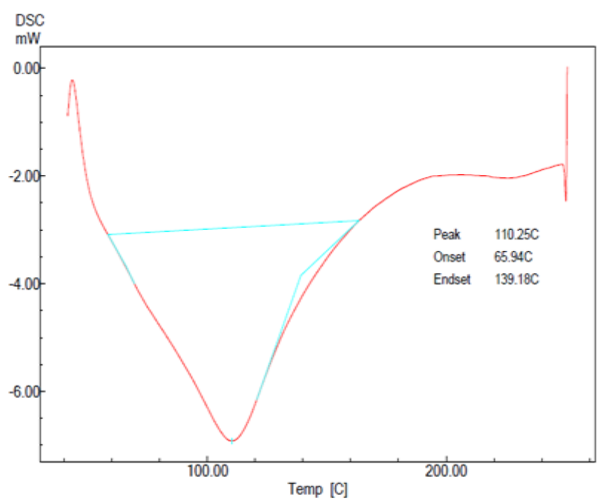


Fig.1 Preparation of *kurdi* (Flow sheet)

Wheat
↓
Sorted and removal of broken grains
↓
Soaked in water (1:3 w/v)
↓
Discarded excess water
↓
Ground the softened wheat grains (at 2500 rpm for 30s)
↓
Filtration (through muslin cloth)
↓
Centrifugation (at 3000 rpm for 10 min)
↓
Discarded the supernatant
↓
Precipitated portion
Boiled water (1:1 w/v) → ↓ ← Salt (3%)
Cooked and stir it continuously (for 24 ± 1 min)
↓
Extrudate the cooked batter
↓
Dried (at 45^{0}C for 8 hr) and fried
↓
Kurdi

Fig.2 *Kurdi* (fried) prepared from fermented wheat batter var. PBN-142 and PBN-51

There was no significant effect of variety on these parameters.

In fermented wheat batter, the WAI, WSI and SP values were decreased from 0.880 to 0.860 g/g, 9.0 to 2.0 g/100g and 0.967 to 0.877 g/g in cultivar PBN-51. A similar decrease in the WAI, WSI and SP values were also observed in case of cultivar PBN-142. Most probably, this might be attributed due to more intensity of starch damage and further the interactions with proteins and cell walls matrices affected the water uptake ability. The water absorption capacities of wheat flours were found to be higher than 0.32 g/g reported by Owen (2001). The level of amylose has been linked with swelling power of rice (Andrade-Mahecha *et al.*, 2012; Chung *et al.*, 2011). Swelling was main property of amylopectin, but the amylose inhibited amylopectin to swell (Tester and Morrison, 1990). It also seems that the presence of other non-starch components affects the swelling pattern of amylopectin. The extent of swelling depends on the temperature, availability of water, species of starch and other carbohydrates. A high WAI is a desirable property in ready to eat products of cereals (Pelembe *et al.*, 2002). At high temperatures the starch is degraded or dextrinized to smaller soluble molecules, thus increasing WSI, and the WAI decreases (Ding *et al.*, 2005).

Degree of gelatinization of wheat (Pasting properties)

The pasting properties of fermented wheat starches are presented in Table 1.4. A quantitative measure of phenomena like gelatinization is provided based on the heat flow behaviour. The fermented wheat starches showed identical pasting temperatures (95±5^{0}C), which were higher than those of corn (81^{0}C) starches (Hoover and Vasanthan, 1994; Hoover *et al.*, 1991). The degree of gelatinization of fermented and cooked wheat of different cooking time (15, 18 and 21 min) ranged from 75.43% to 99.46%. The degree of gelatinization of fermented and cooked wheat starch of both cultivars tend to increase with increasing the cooking time and it was 21 min (maximum) for both varieties.

The degrees of gelatinization of fermented and cooked wheat starch of var. PBN-51 at different cooking time were higher as compared to fermented and cooked wheat starch of var. PBN-142. The gelatinization of fermented and cooked wheat starch depends on cooking time and wheat variety (Belitz *et al.*, 2004).

Nutritional profile and frying characteristics of *Kurdi*

Moisture Content of kurdi

The moisture content of *kurdi* had a positive impact on its texture and it mostly depends on the carbohydrate constituents of the wheat batter. The *kurdi* made in the traditional way (18 hr fermentation) from wheat batter of var.PBN-51 and var.PBN-142 exhibited a moisture content of 7.45% and 7.65% respectively.

It is clear from Table 1.5 that the moisture content was slightly less in *kurdi* as compared with unprocessed wheat. It was observed that moisture content of *kurdi* made from var.PBN-51 cultivar showed less value compared to that of *kurdi* prepared from wheat var. PBN -142 was found to be more fragile to handle. As per the Bureau of Indian Standards (BIS, 1972), moisture content in *kurdi* should be between 10.0 and 12.0%. Several other reports also indicate the variation in moisture content of *kurdi* prepared from different cereal blends (Shurpalekar *et al.*, 1970; Arya, 1992;

Sangeetha, 1997). *Kurdi* become brittle and break if the moisture content is very low and prone for spoilage, if moisture is more than the desired level (Kulkarni *et al.,* 1996).

Nutritional profile of *kurdi*

Table 1.5 shows that the *kurdi* prepared from wheat var.PBN-51were found to have nutritional profile such as protein (10.13%), fat (1.72%), fiber (1.13%) and ash (12.04%). Whereas, nutritional profiles of *kurdi* prepared from wheat var.PBN-142 were protein (10.81%), fat (1.86 %), fiber (1.19%) and ash (12.06%). It was observed that nutritional profile of *kurdi* made from var. PBN-51 showed less values compared to that of *kurdi* prepared from wheat var. PBN-142.

The results of this study indicated that soaking is one of the methods used to improve the nutritional value of wheat as raw material and it was also observed that protein and ash levels of *kurdi* increased after fermentation. The proximate analysis showed that *kurdi* made from fermented batter of PBN-142has higher nutritional quality attribute compare to *kurdi* of PBN-51. These constituents were slightly higher than those reported by Savitri *et al.,* (2000) and Gopalan *et al.,* (1996). These variations could be attributed to variety, season, species and stage of harvesting of wheat cultivar (Rangarajan and Kelly, 1996).

Frying characteristics of kurdi

Frying

Kurdi stored at ambient temperature were deep fat fried in a frying pan containing fresh refined peanut oil (Fig.1.5). The *kurdi* of wheat cultivar PBN-51 showed frying oil temperature 175.3ºC, whereas the *kurdi* of PBN-142 showed 175.8 ºC.

Oil Uptake

Varietal selection of wheat cultivar for *kurdi* making exhibit a wide discrepancy for oil uptake (%). The *kurdi* prepared from wheat var. PBN-51 were found to have significantly maximum oil uptake, while *kurdi* of PBN-142 had absorbed lower oil (Table 1.5). The absorption of oil by fried products might be influenced by the water content and biochemical constitution of the product to be fried (Sangeetha, 1997). A similar kind of wide variation in oil uptake by potato-sago *papads* of different Indian potato varieties was observed by Sandhu and Marwaha (2001). However, it is interesting to note that the quantity of oil absorbed (29.09-31.02%) by *kurdi* was similar as that of *dal papads* (Sangeetha, 1997) and potato-sago *papads* (Sandhu and Marwaha, 2001).

Expansion

The diametrical expansion of fried *kurdi* is one of the important frying characteristic which influence crispness and taste (Shurpalekar and Venkatesh 1975; Kamaraddi and Naik 2002). In the present study, diametrical expansion of *kurdi* made from two wheat cultivars show no apparent variation (Table 1.5). The *kurdi* of wheat cultivar PBN-51 showed 31.46% expansion, whereas the *kurdi* of PBN-142 expanded 31.02%. Moreover, variation in the expansion behaviour of *kurdi* of different ingredient composition has been reported by several workers, need further investigation (Shurpalekar *et al.,*. 1970; Sangeetha 1997; Kamaraddi and Naik 2002).

Kulkarni *et al.,* (1996) observed 4.8-17.8% expansion in commercially spiced *papads* of Uttar Pradesh (India) and Sangeetha (1997) reported 14.8-17.5% expansion in defatted soy *papads*, which are contradicting to the a fore said reports. However, Shurpalekar *et* *al.*, (1970) consider *papad s*having an expansion of less than 24% as poor.

This study has demonstrated that the traditional fermentation of the local wheat varieties resulted in a significant reduction in phytic acid contents and results were clearly indicate that fermentation may be useful for improving the nutritional quality of the wheat with respect to protein and carbohydrate utilization as well as mineral bioavailability. On the other hand, soaking significantly ($P \leq 0.05$) enhanced the IVPD and IVSD. This was accompanied by significant improvement in protein digestibility (*in vitro*). An improvement in protein digestibility *(in vitro*) was noticed at all the temperatures of natural fermentation, the highest being at 45.0°C. Fermentation and soaking could be regarded as viable means for improvement of the nutritional quality of wheat. This type of fermented food product not only offers unique nutritional value but also has therapeutic value. The consumption of such food mixtures may be useful in controlling some infections induced by pathogens or antibiotics.

Traditional methods of preparation of *kurdi* from fermented wheat batter thus, seem to have certain nutritional advantages. *Kurdi* offers unique dietary reward of not only improving the amino acid profile of wheat but also of making the starch and the resultant protein more digestible. Reduction in the phytic acid and polyphenol content of wheat through *kurdi* fermentation may imply improved digestibility of proteins and carbohydrates. Hence, this study provides an option to improve the process of making and more nutritious, a popularly consumed traditional fermented food, *kurdi*. Expansion (percent) was increased due to increased water uptake during frying of *kurdi* by the ruptured granules of starch during cooking.

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