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RESEARCH PAPER

Effect of Alkaline Treatment and Storage Qualities of Maize Flour

B. Subblakshmi[1]*, S. Amutha[2], G. Gurumeenashi[1] and P. Preetha[3]

[1]Post Harvest Technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
[2] Home Science College & Research Institute, Tamil Nadu, India
[3]Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, India

*Corresponding author: subhafsn@gmail.com

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ABSTRACT

An attempt was made to study the effect of lime treatment, packaging materials and storage periods on biochemical qualities of CO1 and HQPM 7 maize varieties flour. The flours were treated with calcium hydroxide, packed in the two packaging materials *viz.*, polyethylene bags (P_1) and metalized polyester polypropylene laminated bags (P_2) and its biochemical qualities were determined at 15 days storage intervals of 90 days storage. It was found that an increase in moisture content was noticed during storage but it was lesser in the lime treated flour compared to the untreated maize flour of both varieties. In P_2 package, moisture content was significantly lower in compared to P_1. The free fatty acid and peroxide value increased on storage but the changes were minimum in samples packaged in P_2. Biochemical qualities of maize flour showed that lime treated maize flour can be stored for a longer period compared to untreated maize flour in the both the varieties.

Keywords: Quality protein maize, storage condition, nutritional security, maize

Cereal grains like wheat, rice, maize, oats, rye, barley, sorghum and other millets are known to be excellent sources of carbohydrate, protein, dietary fibre besides a large number of phytochemicals which together with vitamins and minerals are protective against the degenerative diseases (Bhavya and Prakash, 2012) not only this, cereal based foods are a major source of inexpensive dietary energy and nutrients in developing countries (Opere *et al.,* 2012). Maize (*Zea mays* L.) also known as corn, is one of the world's leading cereal grains along with rice and wheat. It contributes significantly to global grain pool of 2200 million metric tons annually in achieving food and nutritional security. It also provides nutrients for human and animals and serving as a basic raw material for the production of starch, oil, protein, alcoholic beverages, food sweeteners and more recently, fuel (Anandakumar *et al.,* 2010) The kernel of a maize plant consists of three main parts; the pericarp, endosperm and embryo. Maize grain is subdivided into distinct types based on endosperm and kernel composition, kernel colour, environment in which it is grown, maturity and its use. There are 6 major varieties commercially grown speciality maize for human consumption including flint, floury, dent, pop, waxy and sweet corn (Suleiman *et al.*, 2013). The utilization pattern of maize in India include as a source of human food 25 %, animal feed 12%, poultry feed 49%, industrial products mainly as starch (12%) and one per cent each in brewery and seed (Jat *et al*., 2009).

Maize is processed into two ways namely, dry milling and wet milling. Dry milling is the common method that yields by-products such as maize meal (whole flour), grits, suji (semolina) and bran, while wet milling concerned one step further and some of their parts are separated into their chemical constituents (Shobha *et al.,* 2011).

Maize contains 65 -70 per cent starch, 8 -10 per cent protein, 3 -4 per cent fat and some of the vitamins and minerals. However, inspite of several uses, maize has an inbuilt drawback of deficiency in essential amino acids, particularly lysine and tryptophan that limits its nutritional value (Gibbon *et al*., 2003). This was overcome by conventional breeding efforts have yielded several modern maize varieties, collectively referred to as quality protein maize (QPM) (Gunaratna *et al.,* 2008). Nixtamalization or lime cooking is the alkaline cooking of corn kernels in calcium hydroxide solution which is responsible for important physico-chemical, nutritional and sensory characteristics of corn based products, During lime cooking process calcium ions penetration into maize kernels improves niacin bioavailability; formation of flavor and aroma compounds that impart special organoleptic charactertics to the products and the partial disintegration of the kernel pericarp take place (Pozo- Insfran *et al*., 2007).

Nixtamalization is used to produce many staples food such as tortillas, tortilla chips and snacks (Rojas- Molina *et al*., 2007). Maize flour used as main ingredient in the preparation of bread, cake and porridge. Maize oil is used in cooking, bakery products, oleomargarine, salad dressing and pharmaceutical. Maize starch is used for producing bio fuel as ethanol after fermentation. Further, maize has also been included in the shortening compounds, soaps, varnishes, paints and similar other products (Shamim *et al.,* 2010). The present work was carried out to study the effect of lime treatment on biochemical qualities maize varieties flours stored in two packaging materials during storage.

MATERIALS AND METHODS

The research work was carried out in the Department of Food Science and Nutrition, Home Science College and Research Institute, Madurai, India. Maize variety CO1 (Coimbatore 1) was obtained from the Department of Millets, Tamil Nadu Agricultural University, Coimbatore and HQPM 7 (Haryana Quality Protein Maize 7) variety was obtained from Zonal Agricultural Research Station, Mandyal, Karnataka, India.

Lime treatment of maize grains

Lime treatment of maize grains were carried out using the methodology reported by Shobha *et al*. (2011). Maize grains (0.5Kg) were soaked in one per cent calcium hydroxide solution (10 g in one litre of water) cooked at 85°C for 30 minutes. The temperature was maintained by a thermometer and the mixture was steeped overnight (15 hours) at ambient temperature of 32±1°C. Alkaline cooked maize grains were washed with excess (5 litre) tap water for three times and then dried for 6 hours at 60°C to final moisture of 10-12 per cent. The flowchart for lime treatment of maize grain is shown in Fig.1.

Storage studies of maize flour

The storage stability of untreated and lime treated CO1 and HQPM 7 maize flour with two package materials was studied. About 200 g of flour was packed in 200 gauge polyethylene bags (P_1) and 200 gauge metalized polyester polypropylene laminated bags (P_2) and stored at room temperature. During storage changes in chemical characteristics *viz.,* moisture, acidity, free fatty acid and peroxide values were analysed at fifteen days storage interval for 90 days of storage.

Maize
↓
Cleaning
↓
Soak 1kg grain in 1 % lime water (10 g of lime in 1 l of water)
↓
Heat treatment at 85° C for 30 minutes
↓
Remove the vessel and leave it overnight (32 ±1° C)
↓
Wash 3-4 times to remove lime
↓
Dry in drier (60°C, 6 hrs)
(Moisture level should be 10-12%)
↓
Milling
↙ ↘
Maize flour   Maize semolina

Fig. 1: Lime treatment of maize flour

Chemical analysis

The untreated and lime treated maize varieties were pulverized, sieved using a BS 60 mesh sieve and evaluated for chemical constituents such as moisture content of the sample estimated by hot air oven method, protein was determined by available nitrogen in the sample by microkjeldhal method in Kjel plus (Pelican equipment, India), fat estimated by soxhlet extraction in Socs plus (Pelican equipment, India) and the ash content was estimated by dry ashing method (AOAC, 2005). The starch and fibre content were estimated by anthrone method (Sadasivam and Manickam, 2008) and acid and alkali method (AOAC, 2000), respectively. The free fatty acid and peroxide value of the maize varieties were estimated by titration method (AOAC, 1995). Carotene and niacin content were estimated using calorimetry method as given by Sadasivam and Manickam (2008). The minerals viz., calcium, iron, copper, magnesium, potassium, phosphorous and zinc estimated using atomic absorption spectro photometer (Malomo *et al.* 2011).

Statistical analysis

The data obtained from experiments were subjected to statistical analysis to find out the impact of lime treatments, packaging materials used and storage periods on the quality of maize flours. Factorial Completely Randomized Design (FCRD) as per the method described by Gomez and Gomez (1984) was employed for the analysis with triplicate number of samples.

RESULTS DISCUSSION

Lime treatment of maize grains

Maize flour cooked with lime water afforded the finest flour compared to plain water cooked maize as reflected by the optimum water absorption and the particle size index. Water absorption capacity of maize flour increased significantly after lime water treatment. The alpha-amylase susceptibility was highest in lime treated flour. The contents of total ash and crude protein of maize flour increased whereas those of crude fibre, fat and carbohydrates decreased after lime and heat treatments. Boniface and Gladys (2011) studied the effect of alkaline soaking followed by cooking on sorghum flour. The result indicated that alkaline cooking of sorghum flour significantly increased the protein content, water absorption capacity, oil absorption capacity, pH, hydroscopicity and significantly lower ash, tannins cyanide contents, phytate and trypsin inhibitor than control and water treated sorghum flour. Roy and Singh (2013) compared the untreated and lime treated maize flour and found that lime treated maize flour had high amount of calcium, carotene and niacin content than untreated maize flour.

Nutrient composition of maize flour

Chemical composition of CO1 and HQPM 7 maize varieties are given in Table 1.

Table 1: Chemical composition of untreated and lime treated maize varieties (per 100 g)

Parameters	CO 1				HQPM 7			
	T_0	T_1	SED	CD (0.05)	T_0	T_1	SED	CD (0.05)
Moisture (g)	9.30	8.40	0.1934	0.5371**	10.10	8.70	0.0985	0.2735**
Protein (g)	12.63	12.72	0.2340	0.6496**	12.15	12.27	0.3387	0.9404**
Fat (g)	4.60	4.30	0.0965	0.2679*	5.20	5.40	0.1008	0.2325**
Starch (g)	68.66	71.28	1.5436	4.2857^{NS}	67.89	70.24	0.8070	1.8610**
Fiber (g)	2.60	2.10	0.0488	0.1354**	2.70	2.30	0.0511	0.1419**
Ash (g)	1.50	1.30	0.0403	0.1118**	1.30	1.20	0.0422	0.1171^{NS}
Carotene (μg)	84	86	1.3714	3.8077^{NS}	89	91	1.9914	1.5290^{NS}
Niacin (mg)	3.60	3.90	0.0575	0.1598**	2.70	3.10	0.0447	0.1242**
Tryptophan (mg)	38	39	0.5125	1.4229^{NS}	63	65	1.2746	3.5388^{NS}
Iron (mg)	2.60	2.60	0.0581	0.1614^{NS}	2.70	2.60	0.0845	0.2345^{NS}
Copper (mg)	0.36	0.35	0.0058	0.0160^{NS}	0.41	0.41	0.0094	0.0262^{NS}
Zinc (mg)	2.20	2.40	0.0213	0.0593**	2.80	2.90	0.0712	0.1976^{NS}
Magnesium (mg)	124	125	2.2018	6.1132^{NS}	121	120	0.1185	0.2733^{NS}
Potassium (mg)	287	283	5.2884	14.6831^{NS}	289	281	0.0994	0.2293**
Calcium (mg)	8.0	32	0.7607	2.1120**	9.0	31	0.5871	1.6302 **
Phosphorous (mg)	314	324	9.8699	19.4038^{NS}	348	353	5.5271	5.3458^{NS}

T_0 - Untreated maize T_1 - Lime treated maize

Moisture: The untreated maize grain had higher moisture content (9.30 g/100 in CO1 and 10.10 g/100 in HQPM 7) compared to the lime treated samples 8.40 g/100g (CO1) and 8.70 g/100 (HQPM 7). Sharma *et al.* (2002) reported that moisture content of five maize genotypes ranged from 8.21 to 8.79 per cent. Paes and Maga (2004) reported that the moisture content of four maize cultivars ranged from 9.15 to 11.88 per cent. The lower moisture content of lime treated maize might be drying of grain in the cabinet drier during lime treatment process at 60ºC for 2 hours.

Protein: The lime treated samples had high protein content compared to the untreated maize varieties, ranging from 12.72 to 12.63g/100g in CO1 maize and from 12.27 to 12.15g/100g in HQPM 7 maize respectively. Gupta (2001) found that the protein content of normal maize, processed defatted maize germ cake and maize germ were 12.63, 23.94 and 23.41 per cent respectively. Sharma *et al.* (2002) reported that the five maize genotypes had the protein content ranged from 8.6 to 10.23 per cent. Paes and Maga (2004) reported protein content of four maize cultivars ranged from 6.99 to 9.20 per cent. Guria (2006) reported that protein content of three maize varieties *viz.,* QPM, S.A. Tall and DHM-2 were 10.15, 8.90 and 10.29 per cent, respectively. Significant increase in protein content during lime treatment of sorghum has been reported by Bonface and Gladys (2011). The protein content of sorghum was increased from 19.77 to 21.69 per cent after lime treatment. Ocheme *et al*. (2010) also reported that cooking of grains in lime solution resulted in significant increase in the protein content of the flour. Significant increase in the protein content is due to small increase in nitrogen content of lime treated maize flour which was attributed to a concentration effect.

Fat: The untreated CO1 and HQPM 7 maize grains had fat content of 4.6 per cent and 5.2 per cent, respectively. The corresponding value for lime treated CO1 and HQPM 7 maize were 4.3 per cent and 5.4 per cent respectively. The values were found to be statistically significant. Gupta (2001) reported that the fat content of normal maize, processed defatted maize germ cake and maize germ were 4.60, 4.34 and 34.19 per cent respectively. Sharma *et al.* (2002) recorded that the five maize genotypes had the fat content ranged from 4.00 to 5.00 per cent. Paes and Maga (2004) reported that the fat content of four maize cultivars ranged from 3.24 to 6.16 g/100g.

Starch: Lime treated maize showed higher starch content compared to untreated maize. The starch content of lime treated CO1 and HQPM 7 were 71.28 and 70.24 per cent while untreated CO1 and HQPM 7 were 68.66 and 67.89 per cent, respectively. Gupta (2001) recorded the starch content of normal maize; processed defatted maize germ cake and maize germ as 69.97, 33.11 and 8.30 per cent, respectively. Grajales-Garcia *et al*. (2012) stated that the total starch content of QPM masa and QPM tortilla were 77.68±0.20 and 76.69±0.82g per 100g, respectively.

Fibre: The fibre content was slightly reduced during the lime treatment. The fibre content of untreated CO1 and HQPM 7 were 2.60 and 2.70 per cent reduced to 2.10 and 2.30 per cent, respectively after lime treatment. Gupta (2001) reported the fibre content of normal maize, processed defatted maize germ cake and maize germ were 2.60, 4.10 and 5.68 per cent respectively.

Ash: The untreated and lime treated CO1 maize variety had the ash content of 1.5 and 1.3 per cent which was higher than untreated and lime treated HQPM 7 maize variety with the values of 1.3 and 1.2 per cent, respectively. Gupta (2001) found the ash content of normal maize, processed defatted maize germ cake and maize germ were 1.55, 4.60 and 5.68 per cent, respectively. Paes and Maga (2004) reported that the ash content of four maize cultivars (Pioneer 3779, Br 451 QPM, BR 473 QPM and BR 2121 QPM) ranged between 1.14 and 1.41 g/100g. Mestres *et al.* (2003) have reported on the ash content of six maize cultivars (Dente, Aviso, Kalis, Tiemantie, EV 8432 SR and Sotubaca) ranged between 1.17 and 1.63 per cent.

Carotene, niacin and tryptophan: Higher values interms of carotene and niacin were found in lime treated CO1 variety (86 μg and 3.90 mg/100g respectively) and HQPM 7 (91 μg and 3.10 mg/100g respectively) than to untreated CO1 variety (84 μg and 3.60 mg/100g respectively) and HQPM 7 (89 μg and 2.70 mg/100g respectively). The result was supported by Pozo-Insfran *et al.* (2007) in which lime cooking of maize improved the niacin bioavailability and formation of flavour and colour compounds that impart special sensory characteristics to the products. The untreated and lime treated HQPM 7 maize recorded higher tryptophan content (63 and 65 mg/100g, respectively) compared to CO1 maize (38 and 39 mg/100g respectively)

Minerals: The maximum values for calcium and phosphorus were 32 and 324mg/100g respectively for CO 1 maize variety and as 31 and 353 mg/100g, respectively in HQPM 7 maize variety after the lime treatment of maize grains. Similar result have been obtained by Bressani *et al.* (1990) revealed that average calcium content for three maize varieties increased from 35 in raw maize to 206 mg/100g in lime treated maize flours. The increases in calcium content after lime treatment due to usage of calcium hydroxide (1per cent) in lime cooking process which penetrate into the maize kernel. Nuss and Tanumihardjo (2010) reported that lime cooking of whole maize kernels greatly enhances the amount of calcium and the bio availability of niacin, lysine, tryptophan and isoleucine content.

The trace minerals iron, copper, magnesium, potassium and zinc were higher in HQPM 7 maize (2.70, 0.41, 121, 289 and 2.80 mg / 100g respectively) compared to CO 1 maize (2.60, 0.36, 124, 287 and 2.20 mg/100g respectively. The trace minerals copper, magnesium, potassium and zinc content in untreated and lime treated maize showed no significant difference of both maize varieties. Guria

(2006) reported that mean values of iron, copper, manganese and zinc content of three maize varieties were 1.98, 0.30, 0.16 and 1.22 mg per 100 g of maize. Roy and Singh (2013) reported the lime treated maize flour contained 10g calcium, 348 mg potassium, 2g iron and 90 mcg of carotene per 100g.

Chemical changes of maize flour during storage

The chemical changes viz., of raw and lime treated CO 1 and HQPM 7 flour during storage are presented in Table 2.

Moisture and acidity: Significant differences were observed between treatments, packaging materials and storage period with respect to the moisture content of both maize varieties. The moisture content of CO1 maize flour was lesser in the lime treated flour which varied from an initial value of 8.43 to 11.63 and 9.72 per cent in respectively in P_1 and P_2

Table 2: Changes in moisture and acidity of maize flour during storage (g/100g)

Storage period	Moisture								Acidity							
	CO 1				HQPM 7				CO 1				HQPM 7			
	T_0		T_1		T_0		T_1		T_0		T_1		T_0		T_1	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
Initial	9.31	9.31	8.43	8.43	10.15	10.15	8.72	8.72	0.8	0.8	0.6	0.6	0.9	0.9	0.7	0.7
15	9.52	9.43	8.85	8.48	10.43	10.27	8.84	8.77	1.2	0.9	1.1	0.8	1.3	1.2	1.2	0.9
30	9.96	9.84	9.27	8.51	10.86	10.61	9.15	8.94	1.6	1.0	1.5	1.0	1.8	1.5	1.6	1.2
45	10.24	10.11	9.74	8.57	11.37	10.95	9.47	9.12	2.2	1.3	1.9	1.3	2.4	1.9	1.8	1.6
60	10.73	10.35	9.10	8.61	11.79	11.29	9.84	9.43	2.8	1.8	2.3	1.7	2.8	2.2	2.1	1.9
75	11.35	10.76	8.68	8.63	12.36	11.64	10.28	9.67	3.4	2.5	2.5	2.1	3.3	2.7	2.6	2.1
90	11.95	10.92	11.63	9.72	12.85	11.96	10.57	9.88	3.7	2.8	2.9	2.5	3.7	3.3	3.0	2.7

T_0 - Untreated maize flour ; T_1 - Lime treated maize flour ;
P_1- Polyethylene bags (200 gauge);P_2- Metalized polyester polypropylene laminated bags (200 gauge)

	Moisture (g/100g)			Acidity (g/100 g)	
	SED	CD (0.05)		SED	CD (0.05)
V	0.00401	0.00795**	V	0.04162	0.08119**
T	0.00401	0.00795**	T	0.04067	0.08059**
P	0.00401	0.00795**	P	0.04067	0.08059**
S	0.00751	0.01488**	S	0.07608	0.15077**
VT	0.00568	0.01125**	VT	0.06751	0.11627^{NS}
VP	0.00568	0.01125**	VP	0.06651	0.11397**
VS	0.01062	0.02104**	VS	0.10759	0.21322**
TP	0.00568	0.01125**	TP	0.05751	0.11397**
TS	0.01062	0.02104**	TS	0.10759	0.21322**
PS	0.01062	0.02104**	PS	0.10759	0.21322^{NS}
VTP	0.00803	0.01591**	VTP	0.08133	0.16118**
VTS	0.01502	0.02976**	VTS	0.14216	0.32154^{NS}
VPS	0.01502	0.02976**	VPS	0.11116	0.30354^{NS}
TPS	0.01502	0.02976**	TPS	0.15216	0.30154 ^{NS}
VTPS	0.02123	0.04208**	VTPS	0.21518	0.42645 ^{NS}

packaging materials. The moisture content of lime treated HQPM 7 increased from 8.72 to 10.57 and 9.88 per cent respectively in P_1 and P_2 packaging materials. In the untreated flour of both the varieties, the moisture content was significantly lower in P_2 (ranging from 9.31 to 10.92 per cent in CO1 maize and 10.15 to 11.96 per cent in HQPM 7) compared to P_1 (ranging from 9.31 to 11.95 per cent in CO1 and 10.15 to 12.85 per cent in HQPM 7) during a storage period of 90 days. This study indicated that the lime treated flour stored in P_2 had lower moisture content which contributes to better storage life. Similar result have been reported by Kadam *et al.* (2012) showing the that moisture up-take was higher in low density polyethylene bags compared to high density polyethylene bags on storage of whole and degermed maize flour for the period of 90 days. A similar trend was observed for acidity during storage. The lime treated flour had lower values for acidity compared to untreated maize flour of CO1 as well as HQPM 7 maize varieties. The acidity of lime treated CO1 maize flour stored in P_2 increased from 0.6 to 2.5g per cent compared to 0.8 to 2.8 g per cent in untreated maize flour. The corresponding figures for HQPM 7 maize flour recorded an increase from 0.7 to 2.7g per cent compared to untreated HQPM 7 flour (0.9 to 3.3 g per cent). The samples packaged in P_1 recorded higher values comparatively for both varieties and significant difference was observed between treatments, packaging materials and storage periods. The finding was supported by Kadam *et al.* (2012) showed that whole maize flour had maximum total acid as compared to the degermed maize flour. The packaging material, storage days and its interactions were highly significant. The increase in acidity is due to rancidity that increases the acidity of the flour due to increase in number of peroxides. Butt *et al.* (2004) have reported that breakfast cereal packaged with 0.02 per cent antioxidant in aluminium foil bags found best and there were no sign of rancidity even after six months storage.

Madaan and Gupta (1990) indicated that raw maize flour of normal and QPM maize varieties recorded an increase of 62 and 64 folds of acid value respectively over 180 days of storage. The appearance of acidity and its sharp increase could be attributed to the release of fatty acids from 1, 3 position of triacyl glycerol on fat hydrolysis. Nasir *et al.* (2003) studied that the wheat flours were packaged in polypropylene bags with different levels of moisture content (9 to13.5 %) for 60 days of storage period. During storage, protein and fat content were found to decrease with increased the storage period and this trend was more in treatments of higher moisture content. Mould growth and insect infestation was more in samples higher moisture during storage. Hence, higher moisture content of flour will decrease the flour quality.

Free fatty acid and peroxide value: The chemical changes in free fatty acid and peroxide value of maize flour during storage are presented in Table 3. Significant difference in free fatty acid content between untreated and lime treated maize flour was observed during storage. The lime treated CO1 maize flour had lower values of free fatty acid compared to untreated CO1 maize flour. The free fatty acid in lime treated flour stored in P_2 package increased from 4.2 to 6.8 mg KOH/g which was lower compared to untreated CO1 maize flour packaged in P_2 package and the values being increased from 5.3 to 10.4 mg KOH/g. The corresponding figures for HQPM 7 maize flour recorded an increase from 3.9 to 6.2 mg KOH/g and 5.7 to 9.4 mg KOH/g respectively. The samples packaged in P_1 package recorded higher values of free fatty acid content in flours of both maize varieties. Significant differences were observed between the treatments, packaging materials and storage periods.

The results have been supported by Kadam *et al.* (2012) who stated that the free fatty acid content in both degermed and whole maize flours were increased with increase in storage intervals. The minimum free fatty acid was present in degermed maize flour packaged in aluminium laminated foil and high density polyethylene bags. Maize germ is responsible for fat and free fatty acid content in it. Higher lipolytic and proteolytic activities lead to loss in nutrients (protein and fat) and production of higher free fatty acid resulting with rancid sensory characteristics.

Table 3: Changes in free fatty acids and peroxide value of maize flour during storage (g/100g)

Storage period	Free fatty acid (mg KOH/g)								Peroxide value (meq of P/kg of fat)							
	CO 1				HQPM -7				CO 1				HQPM -7			
	T_0		T_1		T_0		T_1		T_0		T_1		T_0		T_1	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
Initial	5.3	5.3	4.2	4.2	5.7	5.7	3.9	3.9	7.8	7.8	5.2	5.2	8.1	8.1	7.5	7.5
15	6.7	5.8	4.6	4.6	6.2	5.9	4.3	4.2	8.3	8.1	5.9	5.9	9.6	8.3	8.5	8.3
30	7.9	6.3	5.3	5.2	7.4	6.7	4.8	4.6	9.8	8.8	6.6	6.3	10.4	8.6	9.1	8.8
45	9.3	7.1	5.7	5.5	8.5	7.1	5.2	5.1	10.4	9.6	7.2	6.9	11.5	9.2	9.8	9.3
60	10.2	8.4	6.2	5.9	9.6	8.2	5.5	5.6	11.2	10.2	7.9	7.5	12.6	9.8	10.6	9.8
75	11.5	9.6	6.7	6.3	10.3	8.9	5.9	5.9	12.6	10.9	8.6	8.3	13.2	10.3	11.4	10.5
90	12.7	10.4	7.4	6.8	13.6	9.4	6.2	6.2	13.2	11.5	9.7	9.2	14.5	10.7	12.1	11.3

T T_0 - Untreated maize flour ; T_1 - Lime treated maize flour ;
P_1- Polyethylene bags (200 gauge);P_2- Metalized polyester polypropylene laminated bags (200 gauge)

Free fatty acid (mg KOH/g)			Peroxide value (meq of P/kg of fat		
	SED	CD (0.05)		SED	CD (0.05)
V	0.03387	0.06712**	V	0.04670	0.08591**
T	0.03467	0.06514**	T	0.04276	0.08542**
P	0.03254	0.06213**	P	0.04166	0.08259**
S	0.06387	0.12558**	S	0.07608	0.15077**
VT	0.04790	0.09493**	VT	0.05151	0.11297**
VP	0.04560	0.04993^{NS}	VP	0.05751	0.11397^{NS}
VS	0.08961	0.17759**	VS	0.10759	0.21322**
TP	0.04790	0.09493**	TP	0.05751	0.11397**
TS	0.08691	0.14769**	TS	0.10759	0.21322**
PS	0.08961	0.17559**	PS	0.10759	0.21322**
VTP	0.06774	0.13425**	VTP	0.08133	0.16118**
VTS	0.16731	0.28711**	VTS	0.15216	0.30154**
VPS	0.10673	0.24560**	VPS	0.15216	0.30154**
TPS	0.12673	0.25116**	TPS	0.15216	0.30154**
VTPS	0.17922	0.35519^{NS}	VTPS	0.21518	0.42645^{NS}

A similar trend was observed for peroxide value during storage. The peroxide value (meq/kg) of untreated CO1 maize flour samples increased from 7.8 to 13.2 for P_1 and 7.8 to 11.5 for P_2 during storage, the comparative figures for the lime treated CO1 maize flour being significantly less, the values increasing from 5.2 to 9.7 in P_1 and 5.2 to 9.2 respectively in P_2 packages. The initial value for peroxide content of the untreated and lime treated HQPM 7 flour packaged in P_2 were 8.1 and 7.5 meq/kg respectively and at the end of storage period the values increased to maximum of 10.7 and 11.3 meq/kg respectively. The corresponding figures for P_1 recorded an increase from 8.1 to 14.5 and 7.5 to 12.1 meq/kg peroxide value respectively.

Shobha *et al.* (2011) reported that raw and lime treated QPM stored in LDPE bags and plastic box with antioxidant treatment had significant increase in peroxide value over six month of storage period.

Madaan and Gupta (1990) have reported an peroxide value of QPM flour was slightly more than that of normal maize samples. According to Butt *et al*. (2004), about the reason for increase in peroxide value is due to oxidation of fat that increase the peroxide percentage in the product. Peroxide value for fresh oils and fats is below 10 meq/kg and for rancid oils and fats the values are above 20 meq/kg (Eagan, 1981). Navaratne (2013) recommended that flour packaged in double lamination with moderately high moisture barrier packaging material namely LDPE and PET (Low density polyethylene, Polyester) or LDPE and OPP (Low density polyethylene, Oriented polypropylene having maximum allowable moisture content of 12 per cent at 85 per cent relative humidity level provide the longer keeping quality flour.

CONCLUSION

The maize grains (CO1 and HQPM7) treated with lime solution had improved the protein, starch, calcium and niacin content. Though both the CO1 and HQPM7 had high amount of protein. HQPM7 maize flour is expected to be better in terms of protein quality since the maize has more quantity of the amino acids compared to CO1 maize flour. Hence, maize grain treated with lime can be stored for longer period for the development of various foods (infant foods, health mixes, convenience foods, bakery foods, specialty foods and emergency ration to support the mission of food and nutritional security in developing country) would be useful.

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