Original Research Article

Effect of nixtamilization on the physical functional and nutritional properties of foxtail millet flour

Abstract

Aims: To investigate the physico-functional and nutritional properties of nixtamalized foxtail millet and compare them with non-nixtamalized millet. Nixtamalization is an ancient processing technique involving the soaking and cooking of grains in an alkaline solution, typically lime water. This process enhances the nutritional profile, flavor, and functional properties of grains, making them more suitable for various culinary applications. Minor millets possess immense nutritional value, comparable to that of wheat, rice, and maize.

Study design: Experimental design

Place and Duration of Study:Foxtail millet grain and maize grain were procured from Millet Processing and Incubation Centre (MPIC) PJTSAU, Rajendranagar, Hyderabad and food grade calcium hydroxide chemical was purchased from local market in Hyderabad. This study was concluded during 2023

Methodology: Maize grain and foxtail milletwere nixtamalized and analyzed for physical parameters viz. thousand kernel weight, thousand kernel volume and bulk density. Functional properties of nixtamilized grains such as swelling power, swelling capacity water solubility index, water holding capacity , oil absorption capacity; water absorption capacity and oil retention capacity and nutritional properties like moisture ,fat, ash, crude fibre , carbohydrates, protein , energy

Results: It was found that physical parameters viz. thousand kernel weight, thousand kernel volume and bulk density decreased in nixtamilized maize and foxtail grains. Functional properties of nixtamilized maize and foxtail flours such as Swelling power, water solubility index, water holding capacity oil absorption capacity; water absorption capacity and oil retention capacity also increased significantly ($p \leq 0.05$) and swelling capacity significantly decreased in nixtamilized maize and foxtail flours. Significant increase ($p \leq 0.05$) in moisture NM (34.31 %) NF3 (27.51 %),ash content NM (49.61 %) NF3 (2.37 %) , carbohydrate content (2.35 %) NF3 (2.10 %) and fat content NM (35.85 %) NF3 (26.30 %) , crude fibre NM (26. 35 %) NF3 (29.22 %), energy (3.2 %)NM , NF3 (3.56 %) in nixtamilized grains was observed while protein value of nixtamilized grains were significantly lower NM (11.76 %) NF3 (6.50 %) compared to untreated grains.

Key words: Nixtamalization, foxtail millet, physical properties, functional properties, Nutritional properties

Introduction

Millets are highly nutritious, yet they have traditionally been overlooked as a primary food source. However, with increased research, their beneficial health effects have become more evident, and they have gained significant importance in biomedical research (Bhat *et al.,* 2018). Millets provide numerous nutritional and medicinal benefits and serve as a major source of energy and protein for people in underdeveloped countries (Belton *et al*., 2002).

Foxtail millet (*Setaria italica L*.) is one of the oldest cultivated crops, widely grown in the arid and semi-arid regions of Asia and Africa. It is also cultivated in some economically developed countries, and considered to be one of the world's highly productive major cereals (W*et al*., 2023; Sharma& Niranjana 2018).Foxtail millets yield 351 kcal of energy per 100.0 g sample and contained 12.3 g protein, 60.9 g carbohydrates, 4.3 g fat, 8.0 g crude fibre, and 3.3 g of minerals and also it contains high amounts of protein, trace elements, vitamins, and antioxidants (Muthamilarasam*et al*. 2016) Anti-nutrients can be reduced through various treatment methods such as nixtamalization soaking, germination/sprouting, cooking, malting, and fermentation of the grains (Hassan *et al*., 2023)

Nixtamalization, is a pre-treatment method in the tortilla industry, is an ancient technique for processing corn that is extensively used in many countries, particularly in Central America. This process is known to enhance the nutritional value of maize by improving protein quality, increasing the bioavailability of calcium and niacin, and reducing phytic acid levels, which in turn boosts iron digestibility and bioavailability (Owusu- Kwarteng *et al*., 2013).Cooking maize in an alkaline solution softens the kernels and modifies their grain structure, thereby releasing bound nutrients and making them more accessible for the body to utilize upon consumption(Sunico *et al* ., 2021).Nixtamalization induces several physicochemical changes in maize kernels, improves flavor, and reduces mycotoxin levels in the final product (Matendo *et al* ., 2023).

Systematic research on the effects of nixtamalization treatments on flour quality is limited in foxtail millet. Thorough studies on how different treatments impact the nutritional, physical, and functional properties of flour are needed before incorporating them as ingredients in foods and developing them into value-added products with potential health benefits. In this content the foxtail millet was nixtamilized and all the analysis were performed to see the changes in physico-functionality of foxtail millet flour and compared with popular nixtamalized maize flours.

Material and methods

Procurement of raw materials

Foxtail millet grain and maize grain were procured from Millet Processing and Incubation Centre (MPIC) PJTSAU, Rajendranagar, Hyderabad and food grade calcium hydroxide chemical was purchased from local market in Hyderabad.

Preparation of maize masa by nixtamalization: The masa with maize was prepared by modified method of Owusu-Kwarteng *et al*. (2014). The maize grains(500 grams) was treated with 1.5% alkaline solution, adding 300 ml of water and pressure cooked for 20 mins, then cooked grains were soaked for 20 hours. The nixtamalized grains were then washed to remove pericarp.

Dry masa flour: The nixtamalized grains were coarsely ground and dried in the tray dryer at the temperature between 35-40°C for 12-14 hours to obtain a moisture content of 9-10%. The material is then ground in Nisa mini flour mill to get fine and coarse flour.

Preparation of foxtail masa by nixtamalization: The masa with foxtail millet grain was prepared by modified method of Chhabra *et al*. (2017). The foxtail grains (500 grams) were treated with a 1.5% alkaline solution, andpressure cooked for only 5 minutes, followed by soaking for 1 hour. The nixtamalized grains were then washed to remove the pericarp. Despite these adjustments, the pericarp was not properly removed. Increasing the soaking time to 2 hours resulted in a slight improvement in pericarp removal. Finally, extending the soaking time to 3 hrs further allowed the pericarp to be properly removed. Increase of soaking time more than 3hours was resulted in poor quality of flour.

Dry masa flour: The nixtamalized foxtail grains were coarsely ground and dried in the tray dryer at the temperature between 35-40°C for 12-14 hours to obtain a moisture content of 9-10%. The material is then ground in Nisa mini flour mill to get fine and coarse flour.Non nixtamilized grain flours of maize andfoxtail millet were taken as control samples.

Physical Properties: Physical properties of grains are of paramount importance in all the activities of production, preservation and utilization. Knowledge of physical properties is necessary right from harvesting, drying, handling and storage to milling, packing, cooking, product development and utilization. Foxtail millet and maize were grains measured for their physical properties viz.,Thousand grain weight (AACC 1984)Thousand grain volume (AACC 1984) and Bulkdensity (Stojceska*et al*., 2008).

Functional properties: The swelling capacity was determined according to the procedure ofArivuchudar and Aditi (2018).Swelling power (SP) and water solubility index (WSI) water absorption capacity (WAC) (Awoyale*et al.*2020) Oil Retention Capacity (ORC) (Maxwell Beugre *et al*., 2014), Water Holding Capacity (WHC) (Mesias and Morales, 2017) Oil absorption capacity (Sharma *et al*., 2004 and Sairam *et al*., 2011) were assessed for both nixtamilized and non nixtamilized maize flours.

Nutritional parameters: Best accepted nixtamilized maize grain, foxtail millet samples were analysed for proximates i.e., moisture (AOAC, 2005), ash (AOAC, 2005), protein (AOAC, 2010), fat (AOAC, 2005), carbohydrate (AOAC, 2006), energy (AOAC, 1980) and crude fibre (AOAC, 1995),

Results and discussion

1. **Physical properties of nixtamalized grains:**The data of physical properties were statistically analysed and presented in (Table 1) and the percentage change in physical properties of treated grain when compared with control were illustrated in (Figure1).

Table 1: Physical properties of nixtamilized maize and foxtail grains

Sample	Physical properties		
	Bulk density	Thousand grain wt (g)	Thousand grain volume (ml)
NNM	0.17^{b}±0.10	299.23^{a}±4.23	218.0^{a}±2.12
NM	0.18^{a}±3.39	215.7^{b}±1.14	199.06^{b}±0.3
NNF	0.19^{d}±0.00	2.90^{c}±0.01	3.88^{c}±0.02
NF1	0.18 ±3.39	1.18±0.00	2.33 ± 0.00
NF2	0.18 ±3.39	1.92± 0.02	2.83±0.02
NF3	0.20^{c} ±3.39	2.41^{d}± 0.00	2.90^{d}±0.01
mean	0.17	0.16	0.095
S.E	0.00	0.00	0.002
C.D	0.00	0.00	0.004
C.V %	0.13	0.00	0.001

Note:values were expressed as mean ± standard deviation of three determinations

NNM : Non-nixtamalized maize

NM : Nixtamilized maize

NNF : Non-nixtamalized foxtail

NF1 : Nixtamalized foxtail at 1hour

NF2: Nixtamalized foxtail at 2hour

NF3: Nixtamalized foxtail at 3hour

1.1 Bulk density: The bulk density of nixtamalized maize flour (0.18 g/ml) was significantly higher (p≤0.05) than non-treated maize flour (0.17 g/ml). Significant differences (p≤0.05) was observed among the bulk density of NNF (0.19 ±0.00%), NF1 (0.18 ±3.39%), NF2 (0.18 ±3.39%), and NF3 (0.20 ±3.39%). NF1 and NF2,had 5.2 % lower bulk density than NNF. NF3 had 5.3% higher bulk density than NNF (Figure1).

1.2Thousand grain weight: The thousand grain weight of nixtamalized maize (NM) (215.7±1.14%) was significantly lower than non-nixtamalized maize (NNM) (299.23±4.23%), showing a 27.91% decrease due to nixtamalization. Vandana and Srivastava (2019) reported similar results, attributing the decrease to pericarp loss during lime treatment. NF1 (1.18±0.0%), NF2 (1.92±0.02%), and NF3 (2.41±0.05%) also showed significant decrease in thousand grain weight compared to NNF (2.90±0.5%), with reductions of 59.31%, 33.79%, and 16.83%, respectively. With increased soaking time the thousand grain weight was reduced.

1.3 Thousand grain volume: The results demonstrated that non nixtamalized maize (NNM) had a significantly more thousand grain volume (218±2.12%) compared to the nixtamilized maize (NM) (199.06±0.3 %). Thousand grain volume of NM was decreased by 8.68 % when compare to NNM.Vandana and Srivastava (2019) reported that the thousand grain volume untreated nixtamilized grain was 220 ± 2.0% and thousand grain volume of nixtamilized grain was 200.3 ±0.6 %.The thousand grain volumeof NF1 (2.33±0.09 %), NF2 (2.83±0.02 %), and NF3 (2.90±0.01 %) also showed significant difference (p≤0.05) among the samples. The thousand grain volume was 39.94 % less in NF1, 27.06 % less in NF2 and 25.25 % less in NF3 when compared with NNF (Figure1).

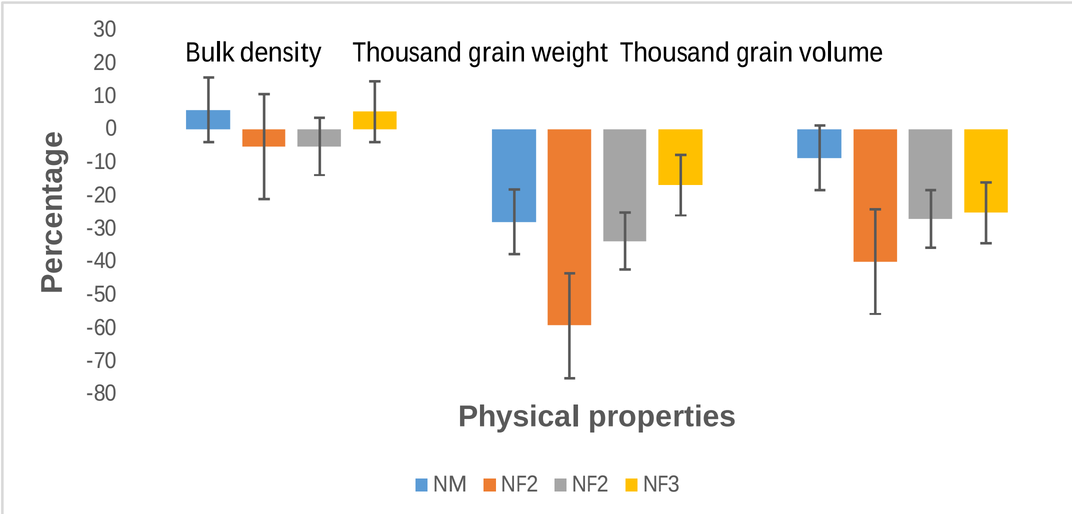

Fig. 1. Percentage change in physical properties of nixtamalized maize and nixtamalizedfoxtail grains when compared to control

Note:

NM : Nixtamalized maize
NF1 : Nixtamilized foxtail at 1 hour
NF2 : Nixtamilized foxtail at 2hour
NF3 : Nixtamilized foxtail at 3 hour

Table: 2 Functional properties of nixtamilized maize and foxtail flours

Sample	**Functional properties**						
	SP	SC	WSI	WHC%	WAC%	ORC%	OAC%
NNM	233.96 ^{b} ±6.45	1.08 ^{b} ±0.00	1.80^{b}± 0.00	141.41^{b} ± 9.43	2.25 ^{b} ± 0.10	1.56^{b} ±0.16	3.03^{a} ± 0.16
NM	255.20 ^{a} ± 5.06	1.186 ^{a} ± 0.00	2.94^{a} ±0.00	167.20^{a} ± 71.20	2.67^{a} ± 0.11	2.160 ^{a}± 0.58	3.52^{b}± 0.39
NNF	188.82 ^{d}± 23.10	1.07^{d}± 0.00	1.39^{d}± 0.14	80.16^{d} ± 6.75	1.34^{d} ±0.87	2.11^{d} ± 0.36	1.69^{d} ± 0.66
NF1	208.52± 1.66	1.053± 0.00	1.41 ± 0.16	114.30 ± 2.31	2.04 ± 0.40	2.80± 0.02	2.02± 0.04
NF2	221.69 ± 2.15	1.086 ± 0.01	1.96 ± 0.01	164.69 ± 1.62	2.23 ± 0.13	2.86 ±0.48	2.18 ± 0.0
NF3	228.01^{c} ± 2.42	1.093 ^{c}± 0.00	2.08^{c}± 0.01	191.51^{c} ±23.56	2.24 ^{c}± 0.19	2.87 ^{c}± 0.21	2.4^{c} ± 0.184
Mean	222.70	1.0949	1.9322	143.2	2.212	2.398	2.49
S.E	5.3966	0.0105	0.1271	10.85	0.1135	0.1308	0.164
C.D	17.999	0.0120	0.1618	55.15	0.463	0.484	0.594
C.V %	4.543	0.618	4.707	21.647	12.259	11.349	13.431

Note: values were expressed as mean ± standard deviation of three determinations

Mean with in the same column followed by a common letter do not differ significantly at (P≤ 0.05)

SP: Swelling Power

SC : Swelling capacity

WSI : Water solubility index

WHC : Water holding capacity

WAC : Water absorption capacity

ORC : Oil retention capacity

(OAC : Oil absorption capacity

NNM: None nixtamalized maize

NM: Nixtamalized maize

NNF: None nixtamalized foxtail

NF1: Nixtamalized foxtail at 1hour

NF2: Nixtamalized foxtail at 2hour

NF3: Nixtamalized foxtail at 3hour

2. Functional properties of nixtamilized flours: Treatedmaize grain and foxtail was powdered and functional properties were measured. The results were statistically analysed and presented in Table 2 and Figure 2.

2.1Swelling power: The results showed that NM had more (255.20±5.06) SP than NNM (233.96 ±6.45). The results indicated that, swelling power of nixtamilized maize grain was significantly ($p \leq 0.05$) more when compared to non nixtamilized maize. There was increased 9.07 % of swelling power in NM when compared to control NNM (Figure 2). The swelling power of NF1 (208.52 ±1.66), NF2(221.69 ± 2.15), NF3 (228.01 ± 2.42) were significantly higher, by 10.43 % , 17.40 % and 20.7 % respectively compared to NNF (Figure 2).

2.2 Swelling capacity: The swelling capacity of nixtamilized maize(NM) had a more swelling capacity (1.186 ± 0.001) compared to non – nixtamilized maize (NNM) (1.08 ± 0.00). The swelling capacity of nixtamilized maize was significantly greater ($p \leq 0.05$) with an increase of 9.81 % compared to the control (NNM) (Figure 2). The Swelling capacity ofNF1 (1.053 ± 0.00), NF2 (1.086 ± 0.001) NF3(1.093 ± 0.00) also showed significant difference among the samples. The swelling capacity decreased(1.58%) in NF1 and 1.49 % increase in NF2 and 1.86 % increased in NF3 when compared to NNF (Figure 2).Flours with high swelling capacity indicate improved functionality, leading to a superior final product (Adebiyi*etal*., 2016).

2.3 Water solubility index: It was found that nixtamalized maize (NM) had a higher water solubility index (WSI) (2.94 ± 0.00) compared to non-nixtamalized maize (NNM) (1.80 ± 0.00), with an increase of 63.3%. The WSI values for NNF (1.39 ± 0.14), NF1 (1.413 ± 0.168), NF2 (1.96 ± 0.01), and NF3 (2.08 ± 0.01) showed significant differences ($p \leq 0.05$). NF1 had a 1.65% higher WSI than NNF, NF2 had a 41.00% increase, and TNF3 had 49.64% increased WSI compared to NNF.

2.4 Water holding capacity: Nixtamilized maize (NM) had a significantly higher water holding capacity (WHC)of (167.20 ± 71.20) compared to non- nixtamilized maize (NNM)at (141.41 ± 9.430).There was an18.23 % increase of water holding capacity of nixtamilized maize with respect to control (Figure 2). Significant differences in WHC were observed among NNF (80.16±6.75) NF1 (114.3±2.31), NF2 (164.69±1.62), and NF3 (191.51±23.56). NF1, NF2 and NF3 showed increase of 42.52 %, 105.45 % 138. 90 % in WHC compared to NNF, respectively.

2.5 Water absorption capacity: The WAC subjectively measures the amount of water absorbed by the flour during masa preparation. The water absorption capacity (WAC) of nixtamalized maize (NM) was 2.67 ± 0.11, significantly higher than the control (2.25 ± 0.10), with an 18.6% increase. Significant differences ($p \leq 0.05$) in WAC were observed among NNF (1.34 ± 0.87), NF1 (2.04 ± 0.40), NF2 (2.23 ± 0.13), and NF3 (2.24 ± 0.19). NF1, NF2, and NF3 had WAC 52.08%, 66.41%, and 67.16% higher than NNF, respectively. The improved water absorption capacity of treated flours is crucial for food applications, as it enhances mouthfeel and flour retention (Adebiyi*etal*.,2016).

2.6 Oil retention capacity The data showed that nixtamalized maize (NM) had a higher oil retention capacity (2.160 ± 0.58) compared to non-nixtamalized maize (NNM) (1.56 ± 0.16), with a 38.46% increase (p≤0.05). Significant differences (p≤0.05) were observed in the oil retention capacity among NNF (2.11 ± 0.36), NF1 (2.80 ± 0.02), NF2 (2.86 ± 0.48), andNF3 (2.87 ± 0.21). The increase in ORC of NF1, NF2, and NF3 had 32.54%, 35.54%, and 36.01% respectively when compared with control.

2.7 Oilabsorption capacity: The results showed that nixtamalized maize (NM) had a significantly higher oil absorption capacity (3.52±0.39) than non-nixtamalized maize (NNM) (3.03±0.16), with a 16.17% increase (p≤0.05). Additionally, significant differences (p≤0.05) were found in the oil absorption capacities of NNF (1.69±0.66), NF1 (2.02±0.04), NF2 (2.18±0.0), and NF3 (2.4±0.184). NF1, NF2, and NF3 had 19.52%, 28.99%, and 42.02% higher oil absorption capacities than NNF, respectively.Oil absorption capacity measures how well proteins bind to fats in food formulations, enhancing the mouthfeel and flavor of food products by absorbing fat or oil (Ekwe and Ihemeje, 2013).

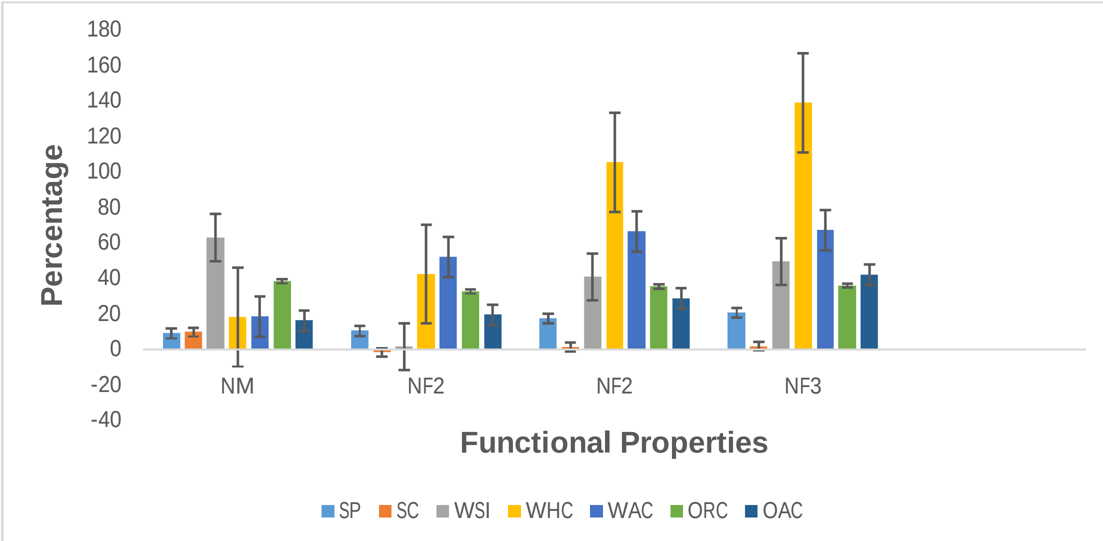

Fig. 2. Percentage change in functional properties of nixtamalized maize and foxtail flours when compared to control

Note:

SP : Swelling power
SC : Swelling capacity
WSI : Water solubility index
WHC : Water holding capacity
WAC : Water absorption capacity
ORC : Oil retention capacity
OAC : Oil absorption capacity

NM : Nixtamalized maize
NF1 : Nixtamilized foxtail at 1 hour
NF2 : Nixtamilized foxtail at 2hour
NF3 : Nixtamilized foxtail at 3 hour

Table. 3. Nutritional properties of nixtamalized maize and foxtail flour

Samples	Nutritional properties						
	Moisture (%)	**Fat (%)**	**Crude fibre (%)**	**Ash (%)**	**Protein (%)**	**Carbohydrate(%)**	**Energy K cal/ 100g**
NNM	4.08^{b}± 0.076	2.54^{b} ± 0.147	1.46 ^{b}± 0.12	1.29^{b}±0.03	9.52^{a} ± 0.11	80.55 ^{b}± 0.01	354^{b}± 0.00
NM	5.50^{a} ± 0.346	3.96^{a}± 0.075	1.87^{a} ± 0.03	1.93^{a}±0.04	8.40 ^{b} ± 0.78	82.46 ^{a} ±0.14	366^{a} ± 0.00
NNF	5.67^{d} ± 0.256	3.65 ^{d} ± 0.221	2.19 ^{d}± 0.015	3.37^{d} ± 0.01	11.06 ^{c}± 0.23	74.35 ^{d} ± 0.25	375^{d} ± 0.00
NF3	7.23^{c} ± 0.115	4.61^{c} ± 0.102	2.83^{c} ± 0.03	3.45^{c} ± 0.0	10.34 ^{d}±0.02	76.36^{c} ± 0.10	388^{c}±0.00
Mean	5.59	3.692	2.0958	2.2842	9.833	78.431	0..00
S.E	0.3410	0.2292	0.1506	0.2726	0.3154	0.973	O.045
C.D	0.4247	0.277	0.123	0.187	0.775	0.2984	0.00
C.V %	4.028	3.989	3.120	4.017	4.188	0.202	0.02

Note: values were expressed as mean ± standard deviation of three determinations

Mean with in the same column followed by a common letter do not differ significantly at (P≤ 0.05)

Note ;

NNM : Non nixtamalized maize
NM : Nixtamalized maize
NNF : Non nixtamalized foxtail
NF3 : Nixtamilized foxtail at 3 hour

3.Proximate composition of nixtamilized flours

3.1 Moisture: Moisture content of NM was 5.50±0.346%, which was significantly ($p<0.05$) more than the NNM sample (4.08±0.076%). The moisture of NM was 34.31% more than NNM. The findings of Matendo *et al*. (2019) showed that moisture content of nixtamilized maize grain was5.6 ±0.34% and untreated grain 4.2 ± 0.17%. The moisture content of NNF was 5.67 ± 0.256% and NF3 was 7.23 ±0.115%. The moisture content of NF3 was 27.51 % increased than NNF (Figure3).

3.2 Fat: The fat content of nixtamalized maize (NM) was significantly higher (3.96±0.07%) compared to non-nixtamalized maize (NNM) (2.54±0.147%), with a 35.85% increase ($p\leq 0.05$). Matendo *et al*. (2019) reported that fat content of nixtamilized maize grain was 3.77 ±0.1 %and untreated grain 2.57 ± 0.2%. NF3 had a significantly higher fat content (4.61±0.102%) than NNF (3.65±0.221%), showing a 26.30% increase.

3.3 Ash: NM and NNM showed significant difference ($p<0.05$) in ash content. The ash content of NM (1.93±0.04%) is greater than NNM with 1.29 ±0.03% (Table 3). On comparison with control NM had 49.61% more ash content. Matendo *et al*. (2019) showed that ash content of nixtamilized maize grain was 1.97 ±0.0% and untreated grain 1.28 ± 0.02%.Ash content of NF3 was 3.45±0.0% which was significantly ($p<0.05$) more than the NNF sample (3.37±0.01%). The ash content of NF3 was 2.37% more than NNF.

3.4 Crude fibre: The crude fibre content of TNM (1.87 ± 0.03%) is more than NNM (1.46 ± 0.12%) (Table 3). On comparison with control TNM had 26.35 % more crude fibre content. Matendo *et al*. (2019) reported that crude fibre of nixtamilized maize grain was 1.86 ±0.5 %and untreated grain 1.48± 0.2%. Crude fibre content of NF3 was 2.83±0.3%, which was significantly ($p<0.05$) more than the NNF sample (2.19±0.015%). There was 29.22% increase of crude fiber in NF3 than NNF.

3.5Protein: NM and NNM showed significant difference ($p<0.05$) in proteincontent. NNM had 11.76 % more protein content than NM. Matendo *et al*. (2019) showed that protein content of nixtamilized maize grain was 9.01 ±0.7% and untreated grain 9.48± 0.3%. Protein content of NF3 was 10.34±0.02%, which was lower than the NNF sample (11.06±0.23%). The protein content of NF3 was 6.50 % lower than NNF.

3.6Carbohydrate: The carbohydrate content of nixtamalized maize (NM) (82.46 ± 0.14%) was significantly higher ($p<0.05$) than that of non-nixtamalized maize (NNM) (80.55 ± 0.14%), with a 2.35% increase due to nixtamalization. Matendo etal. (2019) reported carbohydrate contents of 77.06 ± 7.0% for nixtamalized maize and 74.43 ± 6.2% for untreated grain. NF3 had a carbohydrate content of 76.36 ± 0.10, significantly higher ($p<0.05$) than NNF (74.35 ± 0.25), representing a 2.10% increase.

3.7 Energy: The energy content of NM was (366 ± 0.03Kcal/100g) and in NNM it was (354 ± 0.12 Kcal 100/g) (Table 3).On comparison with control NM had 3.2 % more energy content may due to nixtamalization. Matendo *et al*. (2019) reported similar findings, energy of nixtamilized maize grain was 366 ±2.7Kcal/100g and untreated grain 354± 3.2Kcal/100g. Energy content of NF3 was 388±0.04Kcal/100g, which was significantly ($p<0.05$) more than the NNF sample (375 ±0.01Kcal/100g). The energy content of NF3 was 3.56% more than NNF.

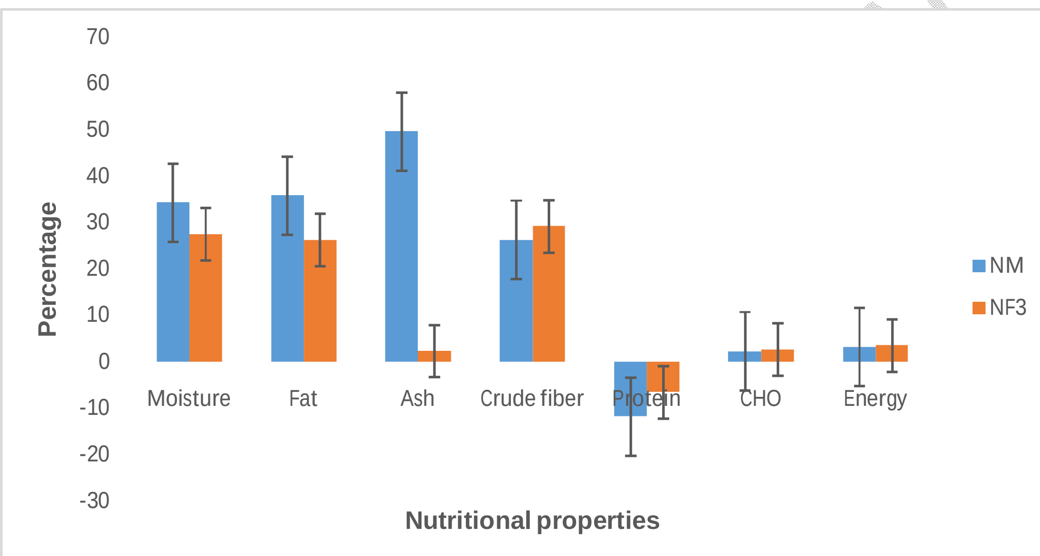

Fig. 3. Percentage change in nutritional properties of nixtamalized maize and foxtail flours when compared to control

Note:NM: Nixtamalizedmaize
NF3**:** Nixtamalizedfoxtailat 3 hours

Conclusion: In the present study physico functional and nutritional properties of nixtamalized foxtail flour was studied. It was found that physical parameters viz. thousand kernel weight, thousand kernel volume and bulk porosity decreased in nixtamilized grains. Functional properties of nixtamilized grains such as Swelling power, water solubility index, water holding capacity , oil absorption capacity; water absorption capacity and oil retention capacity also increased significantly ($p≤0.05$) and swelling capacity significantly decreased in nixtamilized flours. Significant increase ($p≤0.05$) in moisture , ash content ,carbohydrate content and fat content) , crude fibre energy nixtamilized flours was observed while protein value of nixtamilized flours were significantly lower compared to untreatedflours. Flours with high WAC are suitable for incorporation into food formulations, especially inthose involving dough .Consuming meals made from lime-treated millet flour is more beneficial in terms of nutrients compared to untreated millet flour. Nixtamalized foxtail millet exhibits enhanced physico-functional and nutritional properties, making it a valuable ingredient for various food products. The process of nixtamalization improves nutrient availability, digestibility, texture, and flavor. This leads to superior quality in a range of products, including breads, porridges, snacks, baked goods, pasta, extruded items, beverages, infant foods, traditional dishes, and tortilla chips. The importance of nixtamalized foxtail millet lies in its ability to provide a nutritionally enriched and versatile option for food innovation, contributing to the development of healthier and better-tasting products.

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Details of the AI usage are given below:

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