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Effects of processing treatments on nutritional quality of raw almond (*Terminalia catappa* Linn.) kernels

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ABSTRACT

Almond (Terminalia catappa Linn) is one of the lesser utilized oil kernel distributed throughout the tropics including Nigeria ecosystem. In this research work, the effects of soaking, blanching, autoclaving and roasting on the proximate, mineral, vitamin and anti-nutritional concentrations of almond kernel were determined. The result of chemical composition revealed that raw almond kernel contained 11.93% moisture, 23.0% crude protein, 48.1% crude fat, 2.43% crude fiber, 2.69% ash, 12.0% carbohydrate, 0.35mg/100g thiamine, 0.15mg/100g riboflavin, 0.19mg/100g niacin and minerals among which the most important are potassium (9.87 mg/100g), calcium (4.66 mg/100g) and magnesium (4.45 mg/100g). Tannin, phytate and oxalate concentration in raw almond kernel were 0.15, 0.13 and 0.15mg/100g respectively. Increase in ash and fiber was noted for treated samples with time compared to raw almond. Compared to untreated kernels, soaking, blanching and autoclaving decreased fat content but there was increase during roasting of the kernels. Mineral concentrations were significantly increased by various treatments compared to raw kernel. However, roasting for 15 min resulted in highest increase in potassium (41.2 percent), calcium (45.1 percent), phosphorus (43.3 percent) and magnesium (43.6 percent). Vitamin content was significantly lowered upon processing. Vitamin loss was much pronounced during roasting (thiamine: 62.9-85.7 percent; riboflavin: 20-40 percent; niacin: 68.4-89.5 percent). A reduction trend was observed in the level of phytate, oxalate and tannin in the various samples with processing time, however, greatest reduction was observed in roasted samples compared to other treatments. Most importantly, the concentrations of these anti nutrients in raw and treated kernels were below the toxic level and therefore may not pose any effect on human. In overall, roasting in open pan for 15 min appears to be the recommended processing treatment to obtain nutritive almond flour, since it caused a minor decrease in nutritional value and the largest anti nutrient reduction.

Keywords: Almond, soaking, blanching, autoclaving, roasting, nutrients and anti nutrients

INTRODUCTION

Edible nuts have been an important part of the human diet for thousands of years. They are cultivated in a variety of growing conditions and climates. Nuts are rich sources of lipids and proteins with appreciable amounts of vitamins and minerals. The most popular edible tree nuts are almonds (*Terminalia catappa*), hazelnuts (*Corylus avellana*), walnuts (*Juglans regia*), and pistachios (*Pistachia vera*). Other common edible nuts are pine nuts (*Pinus pinea*), cashews (*Anacardium occidentale*), pecans (*Carya illinoiensis*), macadamias (*Macadamia integrifolia*), and Brazil nuts (*Bertholletia excelsa*).

Almond (Terminalia catappa Linn) is an underutilized crop which belongs to a group of nuts with hard shell enclosing a single edible kernel [1]. The almond tree also called tropical almond, is primary a coastal tree belonging to the family *combretaceae* which is distributed throughout the tropics including Nigeria ecosystem [2]. On a global basis, almonds ranked number two after cashew nuts in tree nut production with 2,560,000 metric tons in 2010 [3]. The *T. catappa* tree bears a fruit that is ellipsoid in shape with a bluntly pointed apex, and the fruit is about 7.51cm long and 5.05cm thick. On ripening, it turns from green to purplish yellow and contains a hard shell or nut, which covers the delicate edible kernel [4]. The ripe mesocarp of the fruit is mostly consumed by children as forage snack with the shell and kernels often discarded [2]. The kernel is also used by many rural dwellers in southern Nigeria to fortify the local complimentary foods, which are usually low in protein. However, the kernels are often of small size and difficult to extract from the shell and these factors may have contributed to its lack of use in many areas. The sun-dried kernel yield 38-54% of a bland, yellow oil that is edible but becomes turbid on standing [5]. The oil is used for cooking and the nuts may be consumed fresh after extraction from the shell or preserved by drying or smoking and consumed up to a year later [6]. Other parts of the plant such as bark, leaves, fruit shell, roots and trunks are used for medicinal and other non- food purposes [5]. Many varieties of almond tree are grown but they can broadly be divided into two types, bitter and sweet. Sweet almonds tree kernels do not contain amygdalin and are widely used as edible nuts and food ingredients. Bitter almonds contain amygdalin, an enzyme, which causes its hydrolysis to glucose, benzaldehyde and hydrocyanic acid [7].

Almond kernels contain 21% protein, 46% fat, 25% carbohydrates and appreciable amounts of mineral elements [8]. In addition, almonds are rich source of phytochemicals such as vitamin E, monounsaturated fatty acids and polyunsaturated fatty acids which are associated with improvement in heart health [9]. Although the raw almond kernel provides natural sources of nutrients, it comes with attendant disadvantages such as the presence of secondary plant metabolites, also referred to as anti-nutritional factors (ANFs), such as haemagglutinin, tannin, hydrogen cyanide, phytate and oxalate which could interfere with nutrient utilization when fed to human.

Processing techniques such as soaking, dehulling, boiling, sprouting, blanching, autoclaving, roasting, microwave treatment and fermentation have been reported by several investigators to enhance the nutritional quality of food materials and also reduce or destroy the anti nutrient present in them [10, 11]. With this perspective in mind, the present study was to establish the effect of soaking, blanching, cooking, autoclaving and roasting on the quality characteristics of raw almond kernel in view of increased utilization in human diets.

MATERIALS AND METHODS

Collection and preparation of samples

One batch (500g) of mature almond fruits were purchased from the local market (Nigeria). The fruits were hand-sorted to remove unwholesome fruits and foreign material. The almond fruits were sun dried for 2 weeks to prevent rancidity and to facilitate cracking. The dried shells were carefully cracked along the margins with a piece of pebble to obtain the brown spindle-shaped kernels. The kernels were divided into six portions each: one portion was given no treatment and kept as raw kernel (control), second portion was soaked in distilled water at various time intervals, the third portion was blanched at various time intervals, fourth portion was autoclaved at various time intervals and the last portion was roasted at various time intervals.

Processing methods

Soaking: 50g of nuts were weighed and soaked in tap water (1:10 w/v) at room temperature (25 ± 2 °C) for 6, 12 and 18h respectively as described by Kaur and Kapoor [12]. The soaked nuts were washed twice with ordinary water followed by rinsing with distilled water and then dried in an oven at 60 °C to a constant weight. The dried samples were milled and stored in an airtight glass container for further analysis.

Blanching: 50g of nuts were weighed and blanched in hot water maintained at a temperature of 70^{o}C for 5, 10 and 15 min respectively as described by Kaur and Kapoor [12]. The nuts were drained and dried in a hot air oven maintained at 60 °C, milled and stored in an airtight glass container.

Autoclaving: 50g of nuts were autoclaved at 121°C under 15lb/in for 5, 10 and 15 min respectively as described by Kaur and Kapoor [12]. The autoclaved nuts were dried at 60 °C, milled and stored in an airtight glass container.

Roasting: 50g of nuts were roasted in an open pan at 160°C for 5, 10 and 15 min respectively as described by Yanez *et* al. [13]. The roasted nuts were cooled, milled and stored in an airtight glass container.

Methods

Proximate Composition

The moisture, crude protein (N × 6.25), fat, ash and fibre contents of raw and treated almond samples were determined by standard procedures [14]. Total carbohydrate was calculated by difference. All analyses were carried out in triplicates.

Mineral Elements

Analysis of potassium content of the samples was carried out using flame photometry, while phosphorus was determined by the phosphovanado-molybdate (yellow) method [14]. The other elemental contents (Ca, Mg, Fe, Zn and Na) were determined, after wet digestion of sample ash with an Atomic Absorption Spectrophotometer (AAS, Hitachi Z6100, Tokyo, Japan). All the determinations were carried out in triplicates.

Vitamin content

Thiamine (vitamin B_1) and riboflavin (vitamin B_2) were determined by using spectrophotometric method [14]. Thiamine content was determined by weighing 0.5g of the sample and adding 30mL Dichloroethane and 30mL of 30% HCl (ratio1:1). Then 50mL Ammonium hydroxide solution was added. The solution was then filtered using Whatman filter paper. Then the absorbance was read on a spectrophotometer (Spectronic 20 model) at 415nm. Riboflavin content was determined by weighing 1g of the sample and adding 50mL of 50% methanol and 50mL of 17% sodium carbonate. This is the extraction. Then the absorbance was read on a spectrophotometer at a wavelength of 415nm.

Niacin

5g of sample was blended and 100ml of distilled water added to dissolve all nicotinic acid or niacin present. 5ml of this solution was drawn into 100ml volumetric flask and make up to mark with distilled water. 10-50ppm of Niacin stock solution was prepared. The absorbance of diluted stock solution and sample extract were measured at a wavelength of 385nm on a spectrophotometer. Different concentrations of the standard stock solutions were read on the spectrophotometer for absorbance at the specified wavelength to obtain the Gradient factor. Amount of niacin in sample was calculated using the formula:

Mg/100g niacin= Absorbance x dilution factor x Gradient factor stock solution / 10

Anti-nutrients

Oxalate

Oxalate was determined following the standard method [14]. 1 g of the sample was weighed into 100 mL conical flask. 75 mL of 3M H_2SO4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1 h and then filtered using Whatman filter paper. The sample filtrate (extract; 25 mL) was collected and titrated against hot (80-90°C) 0.1 N $KMnO_4$ solution to the point when a faint pink colour appeared that persisted for at least 30 s. The concentration of oxalate in each sample was obtained from the calculation:

1 mL 0.1 permanganate = 0.006303 g oxalate.

Phytate

The method by Reddy and Kove [15] was adopted for the determination of phytate. 4.0g of sample as soaked in 100 mL of 2% HCl for 5h and filtered. 25mL of the filtrate was pipetted into a conical flask and 5mL of 0.3% ammonium thiocyanate (NH_4SCN) solution was added. The mixture was titrated against 0.1M $FeCl_3$ until a brownish yellow colour end point that persisted for 5mins was obtained. The result was calculated as:
T x constant (0.1635)

Tannin

Tannin was determined according to the method by Trease and Evans [16]. 0.5g of the dry sample was boiled with 20ml of water. 0.1% $FeCl_3$ was added to observe for brownish green or blue-black colouration.

Statistical Analysis

Determinations were carried out in triplicates and the error reported as standard deviation from the mean. Analysis of Variance (ANOVA) was performed and the least significant differences were calculated with the SPSS software for window release 16.00; SPSS Inc., Chicago IL, USA. Significance was accepted at $p \leq 0.05$ levels.

RESULTS AND DISCUSSION

Proximate Composition

The chemical composition of raw and treated almond kernels are presented in Table 1. From the result, it was observed that the moisture contents of soaked, blanched and autoclaved kernels were significantly increased compared to the raw sample. The increase in water uptake with time during these treatments is due to the increasing number of cells within the kernels becoming hydrated [17]. In contrast, roasting drastically decreased the moisture content compared to raw almond; however, the highest reduction was noted after 15 min. This could be explained by the fact that more moisture would be evaporated and diffused out from sample as roasting time increased. This process causes the larger globules to disintegrate and micropores to be developed on the surface indicating the release of volatile matter [18]. Generally, the raw and treated almond kernels would not have good storage properties because of the high moisture.

The protein content reported for raw kernel is in agreement with the range (14.5- 23.4%) as reported by Mbah *et al.* [2]. The value is however higher when compared to cashew nut which has 21.2% protein [19] but comparable to the African walnut with 23.0% protein [20]. The significant decrease in protein content observed during blanching, soaking and autoclaving of almond kernel compared to raw kernel is attributed to leaching of soluble proteins into processing water. Similarly, the observed decrease in protein content during roasting might be attributed to acceleration of Maillard reactions which in turn make protein and its amino acids significantly unavailable for digestion. However, it is imperative to note that excessive heat treatment can reduce both the digestibility and the availability of the essential amino acids, especially lysine and cystine that are essential for growth [21].

Table 1: Proximate composition of almond nut under different processing methods

Treatment	Moisture%	Protein%	Fat%	Ash%	Fiber %	Carbohydrate%
Raw	11.93±0.03^{cd}	22.98±0.13^{d}	48.13±0.02^{e}	2.69±0.02^{a}	2.43±0.03^{a}	11.95±0.21^{de}
Blanched						
5min	11.99±0.04^{d}	22.77±0.03^{d}	47.38±0.07^{f}	3.03±0.01^{b}	3.14±0.02^{c}	11.62±0.07^{bc}
10min	12.17±0.03^{e}	22.66±0.19^{d}	47.52±0.03^{fg}	3.19±0.02^{cd}	3.22±0.02^{c}	11.23±0.26^{bc}
15min	12.36±0.04^{f}	22.54±0.13^{cd}	47.63±0.02^{g}	3.24±0.04^{de}	3.48±0.03^{d}	10.76±0.21^{bc}
Autoclaved						
5 min	12.83±0.03^{i}	22.19±0.31^{cd}	47.11±0.04^{d}	3.12±0.03^{c}	2.60±0.02^{b}	12.16±0.3^{ef}
10 min	12.93±0.06^{ij}	20.93±1.29^{b}	46.53±0.03^{c}	3.25±0.02^{de}	3.17±0.03^{c}	13.20±1.25^{f}
15 min	13.01±0.05^{j}	19.62±0.12^{a}	45.73±0.14^{a}	3.54±0.02^{h}	3.47±0.02^{d}	14.62±0.22^{g}
Soaked						
6hrs	12.52±0.02^{g}	22.76^{d} ±0.05	48.52 ±0.02^{fg}	3.26 ±0.01^{ef}	3.62 ±0.02^{e}	9.31±0.07^{a}
12hrs	12.69±0.04^{h}	22.43±0.05^{cd}	47.23±0.01^{d}	3.32±0.04^{f}	3.73±0.02^{ef}	10.59±0.05^{bc}
18hrs	12.86±0.02^{i}	22.42±0.15^{cd}	46.29±0.01^{b}	3.40±0.02^{g}	4.22±0.11^{h}	10.80±0.10^{cd}
Roasted						
5min	11.82±0.02^{bc}	22.12±0.15^{cd}	49.42±0.01^{h}	3.42±0.02^{g}	3.82±0.02^{fg}	9.40±0.24^{b}
10min	11.73±0.02^{b}	21.46±0.01^{bc}	49.84±0.02^{i}	3.71±0.03^{i}	3.90±0.02^{g}	9.23±0.06^{ab}
15min	10.88±0.07^{a}	20.45±0.26^{ab}	50.92±0.01^{j}	4.56±0.02^{j}	4.15±0.04^{h}	9.04±0.35^{a}

Values are mean of two determinations ± standard deviation (n=2). Values with the different superscript within the same row are significantly different from each other (p≤0.05).

Table 2. Mineral composition of almond nut under different processing methods (mg/100g)

Treatment	Sodium	Potassium	Calcium	Phosphorus	Magnesium	Zinc	Iron
Raw	3.53±0.08^{ab}	9.87±0.03^{a}	4.66±0.06^{a}	5.48±0.02^{a}	4.45±0.05^{a}	3.53±0.03^{a}	2.94±0.03^{ab}
Blanched							
5min	3.62±0.03^{bc}	11.52±0.02^{c}	5.45±0.01^{c}	5.78±0.03^{b}	4.62±0.11^{bc}	3.64±0.04^{b}	2.90±0.08^{a}
10min	3.72±0.03^{cd}	12.43±0.02^{e}	5.68±0.08^{d}	6.55±0.05^{cd}	4.77±0.03^{c}	3.69±0.04^{b}	3.00±0.05^{ab}
15min	4.26±0.05^{g}	12.95±0.01^{f}	6.43±0.03^{g}	6.67±0.04^{cde}	5.63±0.13^{d}	4.12±0.03^{d}	3.14±0.04^{b}
Autoclaved							
5 min	3.85±0.02^{de}	13.24±0.10^{g}	6.49±0.05^{h}	7.26±0.04^{f}	5.90±0.02^{e}	4.12±0.02^{d}	3.49±0.02^{cd}
10 min	3.94±0.02^{e}	13.35±0.02^{gh}	6.57±0.05^{i}	7.50±0.02^{gh}	6.07±0.03^{f}	4.19±0.03^{de}	3.60±0.02^{de}
15 min	4.10±0.03^{f}	13.42±0.03^{h}	6.69±0.03^{j}	7.62±0.04^{h}	6.19±0.03^{f}	4.25±0.03^{ef}	3.62±0.03^{de}
Soaked							
6hours	3.46±0.02^{a}	10.63±0.03^{b}	5.62±0.02^{b}	6.45±0.05^{c}	5.49±0.04^{d}	3.91±0.06^{c}	3.11±0.04^{ab}
12hours	3.58±0.07^{b}	11.46±0.02^{c}	5.84±0.04^{e}	6.68±0.06^{de}	5.65±0.05^{d}	4.13±0.03^{d}	3.46±0.05^{cd}
18hours	4.92±0.02^{h}	11.72±0.03^{d}	6.24±0.04^{f}	7.33±0.21^{f}	6.18±0.02^{f}	4.26±0.05^{ef}	3.62±0.20^{de}
Roasting							
5minutes	3.47±0.07^{a}	12.90±0.06^{f}	6.15±0.04^{f}	6.66±0.09^{cde}	4.50±0.03^{ab}	3.72±0.03^{b}	3.36±0.11^{c}
10minutes	3.86±0.02^{e}	13.45±0.04^{h}	6.43±0.03^{g}	6.79±0.06^{e}	4.74±0.03^{c}	4.17±0.02^{de}	3.73±0.03^{f}
15minutes	4.85±0.07^{h}	13.94±0.03^{i}	6.76±0.04^{k}	7.85±0.05^{i}	6.39±0.02^{g}	4.50±0.03^{g}	3.85±0.05^{f}

Values are mean of three determinations ± standard deviation (n=2). Values with the different superscript within the same row are significantly different from each other (p≤0.05).

Contrary, an increase in protein content was reported for *Terminalia catappa* kernels roasted at a high temperature [22]. The fat content of raw almond kernel is comparable to the value of 51.80% reported by Matos et al. [23]. Moreover, the value is within the range reported for other tree nuts such as cashew 48.1% [24] and African walnut 52.1% [20]. The fat content increased in roasted samples though there was significant decrease in soaked, blanched and autoclaved kernels. The slight increase in fat in the roasted could be due to the fact that at high temperature, the inherent complex organic compounds disintegrate to release more free fat molecules. However, the significant decrease in fat content as almond kernels were soaked, blanched and autoclaved respectively over time compared to raw kernel could be due to total solid loss during treatment. The lowest ash content was reported in raw kernel (2.69%) and the value is lower to 4.40% recorded for cashew nut [19]. The ash content increased between 21.2-26.4% in soaked seeds within 6-18 hr soaking duration. A smaller increase (12.6–20.5%) was observed when the kernels were blanched. Autoclaving also produced a significant increase (16.0-31.6%), whilst roasting brought about highest increase in ash content (27.1-69.5%). Crude fiber was significantly ($P \leq 0.05$) increased by all the treatments. This increase could have been due to protein–fiber complexes formed after possible chemical modification induced by the soaking and heating of the kernels [25]. The total carbohydrate content was found to decrease in soaked, blanched and roasted kernels but increased to a large extent in autoclaved kernels. The significant loss of carbohydrate noted in soaked and blanched almond samples might be as a result of solubility of carbohydrate in water. Similarly, the decrease in carbohydrate content of the roasted almond with time could be due to Maillard reaction which occurred between amino acids, amines, aldehydes and carbonyl group of reducing sugars at high temperature to produce the roasted almond flavour. However, the carbohydrate content seemed to increase during autoclaving and this could have been due to the breakdown of complex carbohydrates which were otherwise bound in the raw sample at elevated temperature.

Table 3. Vitamin Composition (mg/100g)

Treatment	Thiamine	Riboflavin	Niacin
Raw	0.35 ± 0.01^{c}	0.15 ± 0.01^{h}	0.19 ± 0.01^{f}
Blanched			
5 min	0.17 ± 0.03^{fg}	0.12 ± 0.01^{fgh}	0.11 ± 0.01^{ef}
10 min	0.14 ± 0.01^{de}	$0.11^{c}\pm0.01^{cd}$	0.09 ± 0.01^{e}
15min	0.09 ± 0.01^{ab}	0.10 ± 0.01^{abcd}	0.06 ± 0.01^{cd}
Autoclaved			
5 min	0.12 ± 0.01^{cd}	0.13 ± 0.01^{fg}	0.05 ± 0.01^{bc}
10 min	0.10 ± 0.01^{bcd}	0.10 ± 0.01^{abc}	0.04 ± 0.01^{ab}
15 min	0.07 ± 0.01^{abc}	0.08 ± 0.08^{a}	0.02 ± 0.02^{a}
Soaked			
6 hr	0.23 ± 0.01^{h}	0.13 ± 0.13^{gh}	0.12 ± 0.01^{f}
12 hr	0.19 ± 0.02^{g}	0.13 ± 0.13^{fgh}	0.11 ± 0.01^{ef}
18 hr	0.17 ± 0.02^{fg}	0.12 ± 0.12^{cdef}	0.08 ± 0.01^{de}
Roasting			
5 min	0.13 ± 0.01^{de}	0.12 ± 0.01^{efg}	0.06 ± 0.01^{bc}
10 min	0.12 ± 0.01^{cd}	0.10 ± 0.10^{bc}	0.03 ± 0.01^{ab}
15 min	0.05 ± 0.05^{a}	0.09 ± 0.09^{ab}	0.02 ± 0.03^{a}

Values are mean of three determinations ±standard deviation (n=2). Values with the different superscript within the same row are significantly different from each other (p≤0.05).

Mineral Elements

Mineral contents of raw and treated almond kernels are presented in Table 2. Potassium concentration was the highest, followed in descending order by phosphorus, calcium magnesium, sodium, zinc and iron. This is in close agreement with the observation of Olaofe and Sanni [26] and Aremu *et al.* [27] that potassium was the most predominate mineral in Nigerian agricultural products. Moreso, similar trend in elemental concentrations was reported on kernels of *Terminalia catappa* obtained from the centre town of Brazzaville [23]. The observed increase in mineral contents of the treated samples compared to raw kernels could be due to the lower concentrations of anti nutrients. However, roasting resulted in the greatest increase of minerals, followed by autoclaving, soaking and then blanching. Soaking of almond kernel brought about significant increase ($P\leq0.05$) in calcium content, from that of raw sample. Similarly, blanching and autoclaving of almond kernels caused 17.0-38.0% and 39.3-43.6% increase in calcium content respectively. Roasting produced the highest increase in calcium content (32.0- 45.1%). The increase in calcium concentrations in treated almond kernels could be related to the observed decrease in phytate. Urbano et al. [28] showed a relationship between the drop in phytic acid and the increase in the apparent digestibility coefficient of calcium. Similarly, soaking, blanching, autoclaving and roasting caused significant increase in potassium, phosphorus, magnesium, sodium, zinc and iron concentrations compared to raw kernels. Mineral elements are known to play important roles in the maintenance of various biochemical activities in the biological systems.

Vitamin Content

The effects of various treatments on the vitamin content of almond kernels are shown in Table 3. Soaking of almond kernels for 6-12 h produced reduction in vitamin B_1, vitamin B_2 and vitamin B_3 ranging from 34.3–45.7%, 11.3-15.3% and 36.8-42.1% respectively. When the treatment was prolonged to 18 h the reductions was 51.4%, 20.0% and 57.9% respectively. Similarly, heat treatments (blanching, autoclaving and roasting) produce drastic decrease in vitamin concentrations. The only factor that could account for the observed significant decrease in the vitamin concentrations during these treatments was the heat applied as vitamins are thermo labile in nature**.** Considering the effects of heat on the retention of these water-soluble vitamins, it was observed that riboflavin is most stable. Similar observation was reported by Fanelli *et al*. [29]. However, raw and treated almond flour contain miniscule quantities of these vitamins. Vitamins are organic components in food that are needed in very small amounts for growth and for maintaining good health. Vitamins also have very critical role in human vitality and body functioning e.g. vitamin B_1 promotes growth and repair of body tissues, reduces susceptibility to infections and aids in bone and teeth formation; vitamin B_2 enhances muscle tone and proper functioning of the muscles, heart, and nervous system. Vitamin B_3 reduces cholesterol levels in the blood and improves blood circulation. It is however important to note that hypovitaminosis can occur due to lack of one or more vitamins though it is rare on a well-balanced diet [30]. Likewise, hypervitaminosis can occur with excessive intake of one or more vitamins, however, no vitamin supplements should be required if the diet is well balanced [30]. Vitamins when consumed in amounts far exceeding those found in food assume the properties of medications or drugs and as such need careful monitoring. In addition, the consumption of excessive amount of one vitamin could cause deficiency of other micronutrients [30].

Table 4. Anti nutrient composition of almond nut under different processing methods (mg/100g)

Treatment	Tannin	Phytate	Oxalate
Raw	0.15 ± 0.01^{d}	0.13 ± 0.01^{e}	0.15 ± 0.02^{h}
Blanched			
5 min	0.13 ± 0.01^{cd}	0.11 ± 0.01^{de}	0.13 ± 0.02^{fg}
10 min	0.11 ± 0.01^{bc}	0.09 ± 0.01^{cde}	0.11 ± 0.02^{ef}
15 min	0.10 ± 0.01^{bc}	0.08 ± 0.01^{cde}	0.08 ± 0.02^{c}
Autoclaved			
5 min	0.08 ± 0.03^{b}	0.09 ± 0.01^{cde}	0.12 ± 0.01^{fg}
10 min	0.04 ± 0.01^{a}	0.08 ± 0.01^{cde}	0.09 ± 0.01^{d}
15 min	0.02 ± 0.04^{a}	0.05 ± 0.01^{abc}	0.07 ± 0.02^{c}
Soaked			
6 hr	0.14 ± 0.01^{d}	0.12 ± 0.01^{e}	0.13 ± 0.02^{g}
12 hr	0.13 ± 0.01^{d}	0.10 ± 0.01^{de}	0.11 ± 0.02^{ef}
18 hr	0.12 ± 0.07^{cd}	0.09 ± 0.01^{cde}	0.09 ± 0.02^{d}
Roasting			
5 min	0.02 ± 0.01^{a}	0.07 ± 0.01^{bcd}	0.03 ± 0.02^{b}
10 min	0.01 ± 0.01^{a}	0.03 ± 0.01^{ab}	0.02 ± 0.02^{ab}
15 min	0.01 ± 0.00^{a}	0.01 ± 0.01^{a}	0.01 ± 0.02^{a}

Values are mean of three determinations ±standard deviation (n=2). Values with the different superscript within the same row are significantly different from each other ($p\leq0.05$).

Anti-Nutrients

From Table 4, the values of oxalate were 0.15mg/100g, 0.12-0.14mg/100g, 0.10-0.13mg/100g, 0.02-0.08 mg/100g and 0.01-0.02 mg/100g for raw, soaked, blanched, autoclaved and roasted almond kernels. Soaking reduced oxalate concentration by 6.7-20.0%. This is an indication that oxalates are water soluble and that processing time had profound effect on inherent oxalate concentrations in the kernels. Blanching, autoclaving and roasting on the other hand reduced oxalate content by 13.3-33.3%, 46.7-86.7% and 86.7-93.3% respectively. The higher loss of oxalate in blanched, autoclaved and roasted almond kernels could be explained by the fact that oxalate is thermo labile in nature.

The phytate content of raw, soaked, blanched, autoclaved and roasted almond were 0.13mg/100g, 0.09-0.12mg/100g, 0.08-0.11mg/100g, 0.05-0.09mg/100g and 0.01-0.07mg/100g respectively. Soaking and blanching reduced the phytate content by 7.7-30.8% and 15.4-38.5% respectively. As indicated, the percentage reduction during soaking was small compared to that of blanching. This could be explained by the fact that more phytic acids are leached into water at above ambient temperature through the swollen and ruptured cell walls which permeate water and soluble constituents. Autoclaving and roasting reduced phytate content by 30.8-61.5% and 46.2-92.3% respectively. Phytate seems to be heat labile, as blanching, autoclaving and roasting caused more reductions compared to soaked samples. Notwithstanding, dry heating (roasting) brought about the largest reduction in the phytate content of almond kernels, which may be due to insoluble phytins formed between phytate and some minerals. However, phytate level of 0.01 to 0.12mg/100g reported in this study will not be of any nutritional significance.

Similarly, the tannin content was significantly decreased by the different treatments. The concentration of tannins in the raw almond kernel was 0.15%. The value was higher than 1.30% reported for cashew nut [31]. Roasting was the most efficient process to reduce the levels of tannin in almond kernels (80.0-93.3%), followed by autoclaving (20.0-53.3%), blanching (13.3–46.7%) and, finally, soaking (13.3–40.0%).

The observed reduction in tannin content by soaking, blanching and autoclaving of almond kernels could be attributed to leaching out of this anti nutrient into the soaking water under the influence of the concentration gradient. Tannin value of 0.13mg/100g which is the highest in the samples is very low to be of any nutritional significance. It is imperative to note that low concentration of tannin is advantageous as it plays the role of anti-inflammatory agent [32]; however excessive consumption of tannin is both mutagenic and carcinogenic [33].

CONCLUSION

The results of this study have confirmed the fact that raw almond kernels contain high protein and fat with nutritionally valuable vitamins and minerals. However, processing treatments (soaking, blanching, autoclaving and roasting) influenced the nutrient and anti-nutrient composition of raw almond kernels. In an overall consideration of these treatments, roasting in open pan for 15 min appears to be the recommended processing method to obtain nutritive almond flour, since it caused a minor decrease in protein and carbohydrate content and the largest phytate, oxalate and tannin removal, providing an appreciable amount of minerals and vitamins.

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