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Nutrient composition and effect of processing treatments on anti nutritional factors of Nigerian sesame (*Sesamum indicum* Linn) cultivars

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Abstract

Sesame (*Sesamum indicum* Linn) is an underutilized oil seed in Nigeria. Two high yielding sesame seed cultivars (White -NCRI-98-60 and black-NCRI-97-28) were used in this study. Proximate composition, minerals, vitamins and anti nutritional factors of whole seeds, dehulled seeds and hulls were determined. Also, effects of processing namely soaking, germination, autoclaving, roasting and cooking) on the anti nutritional factors were determined for whole and dehulled seeds. The ranges of proximate composition for whole sesame cultivars were: moisture 4.18–5.41%, fat 45.6–46.1%, protein 21.9–23.6%, crude fibre 4.70–7.15%, ash 6.16-7.34% and carbohydrate 10.8–17.0%. Dehulled sesame cultivars had protein (25.3-26.8%), fat (47.7-49.9%) and carbohydrates (9.7-12.4%). The hulls however contain lowest amount of protein, fat and carbohydrate. Calcium was highest (473.6–521.9 mg/100 g) followed by phosphorus (466.0–482.8 mg/100 g) and potassium (465.7–468.8 mg/100 g) in whole seeds compared with lower values observed for dehulled seeds and hulls. The whole seeds also had values of thiamine and riboflavin with a range of 0.71-0.83 and 0.36-0.38 mg/100 g, respectively. The whole seeds of the cultivars contained the highest level of anti-nutrients. Processing treatment were observed to decrease the phytate and oxalate contents significantly ($p < 0.05$) in both whole and dehulled cultivars with a maximum reduction observed after germination.

Introduction

Sesame (*Sesamum indicum* L., synonymous with *S. orientale* L., also known as sesamum, gingelly, sim sim, benniseed, and til) is probably the most ancient oilseed used by humans as a food source (Gharbia Abau *et al*., 2000). The plant is deep rooting and well adapted to withstand dry conditions. It will grow on relatively poor soils in climates generally unsuitable for other crops, and so it is widely valued for its nutritional and financial yield from otherwise inclement areas. It is well suited to smallholder farming with a relatively short harvest cycle of 90 – 140 days allowing other crops to be grown in the field (USDA, 2005). It has been cultivated for centuries, particularly in Asia and Africa because of its high content of edible oil and protein (Johnson *et al*., 1979). India and China are the world's largest producers of sesame, followed by Myanmar (Namiki, 1995). Nearly 70% of the world production is from Asia. Africa grows 26% of the world's sesame, with Sierra Leone, Sudan, Nigeria and Uganda being key producers.

Sesame production in Nigeria probably began in the middle belt region of the country and later spread out between latitudes 6^{o} and 10^{o}N. The major producing areas in order of priority are Nasarawa, Jigawa and Benue States. Other important areas of production are found in Yobe, Kano, Katsina, Kogi, Gombe and Plateau States (Ojiako *et al*., 2010). The black and white cultivars are grown basically in Nigeria. The white cultivar is grown around Benue (Oturkpo), Nassarawa (Doma), Jigawa (Malam-madori) and Taraba states while the black cultivar grows in the Northern Nigerian region; Kano (Dawanau), and Jigawa (near Hadejia) states and in some parts of Katsina state.

Industrial processing and utilization of sesame have not been fully developed in Nigeria as its utilization is restricted to producing regions; for the most part, the surplus crop is commercialized, bulked and exported with minimal processing limited to cleaning and drying. At the local level it is processed into *Kantun ridi* and *Kunun ridi.* Oil is also extracted from the seed and the cake is made into *kulikuli* which together with the leaves are used to prepare local soup known as *Miyar taushe* and also used for cooking. Sesame seeds contain 20-25% protein

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and approximately 50% oil (Kanu *et al*., 2007). It is rich in methionine (3.2%) which is often the limiting amino acid in legume-based tropical diets; tryptophan and minerals like manganese, copper and calcium and vitamins B_1 and vitamin E (Ojiako *et al*., 2010). Lignans and lignin glycosides isolated from sesame seeds and oil have been reported to show hypo-cholesterolemia effects, anti-oxidative effects to rat liver and kidney and suppressive activity on chemically induced cancers (Kapadia *et al*., 2002). However, like all other oilseeds, their use as food ingredient is limited by the presence of anti-metabolites primarily; phytate (Salunkhe *et al.*, 1991) and oxalate (Phillips *et al*., 2005).

There is established rural consumption of sesame in Nigeria partly due to high cost of animal protein, however, its usefulness as ingredient in different food formulations may be limited probably due to the non availability of nutritional information and the presence of these anti nutritional factors. However, the decrease in the levels of anti-nutritional factors to safe limits may be caused by thermal degradation, soaking in distilled water, germination, and extraction of methanol (Yasmin *et al*., 2008).

Several studies have reported on sesame seeds grown in some countries; these include: proximate composition of Turkish sesame seeds and characterization of their oils (Unal and Yalcsn, 2008), amino acid composition and nutritive value of sesame grown at Tarnab, Peshawar (Saleem and Tajammal, 1988), protein and oil composition of sesame seeds grown in the Gizan area of Saudi Arabia (Bahkali *et al.*,1998), biochemical analysis of black and white sesame seeds from China (Kanu, 2011) and some compositional characteristics of sesame seed and oil from Turkey, Mexico, Uganda and Venezuela (Ozcan and Akgul, 1995).

Though considerable attention had been given to the study of sesame seed, there is however very limited information on sesame cultivars grown in Nigeria. Nigeria ranks second in Africa and seventh in the world producing about 120,000 metric ton of sesame annually (USAID, 2002). The two popular sesame seed used in most products in Nigeria are the black and white seeds. But no comprehensive study has been reported simultaneously to show the similarities and differences in the nutritional composition and the effect of treatment on the anti nutritional factors inherent in the seeds.

Therefore, the aim of this study was to analyze the black and white sesame cultivars grown in Nigeria and to determine the effect of processing treatments on anti nutritional factors of the seeds in view of increased utilization.

Materials and Methods

Sample materials

White coloured seed (NCRI-98-60) and black coloured seed (NCRI-97-28) cultivars of sesame seed were collected from National Cereal Research Institute (NCRI), Badegi, Nigeria. The seeds were thoroughly cleaned by removing extraneous materials and stored in airtight polyethylene bag at a temperature of 4°C until needed.

Sample preparation

Whole seed

The whole seeds of the white and black sesame cultivars were divided into six portions each: one potion was kept as whole seed sample, second portion was soaked in distilled water, the third portion was germinated, fourth portion was roasted, fifth portion was autoclaved and the last portion was cooked.

Dehulled seed

White and black sesame cultivars were dehulled separately by soaking in water (1: 5 w/v) for 4 h at 29 ± 2°C according to the method of Mohamed et al. (2007). The ruptured seed coats were then removed by rubbing with palms and washing with water. The dehulled seeds of both cultivars were divided into six sets each: one set was kept as dehulled sample, second set was soaked in distilled water, the third set was germinated, fourth set was roasted, fifth set was autoclaved and the last set was cooked.

Hull

The hulls obtained as by-product respectively after dehulling the whole seeds of the cultivars were also dried and stored for analysis.

Treatments

Soaking

The whole and dehulled seeds of both cultivars of sesame seeds were soaked in distilled water at ratio of 1:10 (w/v) at room temperature (25 ± 2°C) for 12 h. The soaking water was discarded and then the soaked grains were dried in a hot air oven at 40°C to a constant weight. The samples were milled in a Braun (KMM 30, Bico, Chicago) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.

Germination

The whole and dehulled seeds of both cultivars of sesame seeds were germinated at room temperatures

(25 ± 2°C) for 5 days by keeping them in trays lined with wet filter paper. The germinated seeds were dried in a hot air oven at 40°C to a constant weight. The samples were milled in a Braun (KMM 30) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.

Roasting

The whole and dehulled seeds of both cultivars of sesame seeds were roasted in an oven at 120ºC for 1 hr according to the method described by Mohamed *et al.* (2007). The samples were milled in a Braun (KMM 30, Bico, Chicago) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.

Autoclaving

The whole and dehulled seeds of both cultivars of sesame seeds were heat treated (autoclaving at 121°C for 25 min), then dried by hot air oven at 40°C. The samples were milled in a Braun (KMM 30) mill to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.

Cooking

The whole and dehulled seeds of both cultivars of sesame seeds were cooked at 100°C for 30 min in the seed to water ratio of 1:10 (w/v). Consequently, the seeds were dried by hot air oven at 40°C prior to milling and stored.

Proximate analysis

The proximate chemical compositions of the samples were determined using the standard procedure (AOAC, 2005). The crude protein content was calculated by multiplying the total nitrogen by a factor (by convention, 6.25 for oilseeds). The carbohydrate content was estimated by difference.

Determination of mineral contents

Ash was determined by combustion of the sample in a muffle furnace at 550°C for 12 h (AOAC, 2005). The residue was dissolved in HNO_3 with 50 g/l of $LaCl_3$ and the mineral constituents (Ca, K, Mg, Fe, Zn, Se and Mn) were analyzed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Tokyo, Japan). Phosphorus content (P) was determined by the phosphomolybdate method (AOAC, 2005).

Determination of vitamin content

Thiamine (vitamin B_1) and riboflavin (vitamin B_2) were determined by using spectrophotometric method (AOAC, 2005).

Determination of anti nutritional compounds

Phytate content

Phytate of each sample was determined according to the method described by Maga (1982).

Oxalate content

The titration method was used to determine the oxalate content according to Day and Underwood (1986).

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 $p < 0.05$ level.

Results and Discussions

Proximate composition

Proximate composition of the whole seeds, dehulled seeds and hulls of white and black sesame cultivars are presented in Table 1. The whole white seeds consist of 21.9% protein, 46.1 fat, 17.0% carbohydrate, 6.16% ash and 4.70% fiber; while whole black seeds contain 23.6% protein, 45.6% fat, 10.8% carbohydrate, 7.34% ash and 7.15% fiber. The protein, ash and crude fiber of the whole black seed was significantly higher than of whole white cultivar, but the fat and carbohydrate contents were less than observed for the white seeds. However, the protein content of dehulled white and black seeded cultivar was higher than that recorded for whole seeds.

Sesame seeds contain anti-nutritional factor phytic acid which forms complex with protein and make it less available-explains why dehulled seeds contained more protein than whole seed as the hull contains high amount of these anti nutritional factors. The protein content of the dehulled white and black seeds were higher compared to that grown in Uganda (22.4%), Mozambic (24.1%) and Ethiopia Humera (24.2%) as reported by Mehmet *et al.* (2013). The fat was observed to be significantly higher in the dehulled white seed cultivar than in black seeds (49.9 and 47.7%, respectively). Dehulled seeds also contain more fat than the whole seeds and hulls of the cultivars. This shows that fat is majorly concentrated in the endosperm. This also indicates why the seed may be more economically attractive for oil extraction. Tashiro *et al.* (1990) reported the oil content range of 43.4 to 58.8% for 42 strains of Sesamum with the highest oil content found in

Table 1. Mean chemical composition of whole seed, dehulled seed and hull of sesame cultivars

Sample	Moisture	Protein	Ash	Fiber	Fat	Carbohydrate*
NCRI-98-60 (white coloured seed)						
Whole	4.18±0.25[a]	21.94±0.04[c]	6.16±0.02 [c]	4.70±0.10[b]	46.09 ±0.04[d]	16.95± 0.13[e]
Dehulled	4.58 ±0.06[b]	25.27 ±0.04[e]	3.72±0.05[a]	3.70±0.25[a]	49.91 ± 0.02[f]	12.36±0.04[d]
Hull	7.57 ±0.04[e]	2.35 ±0.45[a]	25.12±0.03[e]	46.07±0.02[e]	9.25±0.04[b]	9.64±0.04[b]
NCRI-97-28 (black coloured seed)						
Whole	5.41±0.03[d]	23.64± 0.02[d]	7.34± 0.05[d]	7.15±0.05d	45.63±0.09[c]	10.83±0.03[c]
Dehulled	4.81±0.02[c]	26.79± 0.03[f]	4.62± 0.05[b]	6.41 ± 0.05[c]	47.73± 0.03[e]	9.65 ± 0.02[b]
Hull	8.73±0.02[f]	2.72± 0.03[b]	27.61± 0.01[f]	47.60±0.11[f]	7.62 ± 0.05[a]	5.72± 0.02[a]

* Calculated by difference
Different superscripts down a row indicate significant ($p < 0.05$) difference.

white-seeded strain. Analysis of seeds of white and black-seeded varieties of sesame grown at Tarnab, Peshawar, also demonstrated that oil contents of the white seed varieties were greater than those of the black-seed (Saleem and Tajammal, 1988). Fat content in white and black sesame grown in China was 52.61% and 48.40% respectively as reported by Kanu (2011). El-Nakhlawy and Shaheen (2009) reported lower oil content in Saudi Arabian sesame seeds ranging from 45.37 to 45.96% than what was obtained in this study. However, higher oil contents of 63.25% and 54.26% respectively were also observed in selected Turkish sesame seeds (Baydar *et al.*, 1999; Unal and Yalcsn, 2008). According to Egbekun and Ehieze (1997), variation in oil yield of sesame may be varietal, climatic, ripening stage, the harvesting time of the seeds and the extraction method used. Also, Oplinger et al (1990) reported that genotype and fertilizer requirements significantly affect yield and oil content of sesame seeds. The percentage of fat observed in the hulls of both cultivars expected because the very small seeds that escape the dehulling process remains with the hulls.

Carbohydrate content was significantly ($p < 0.05$) higher in the dehulled white-seed cultivar than in black- seed (12.4 and 9.7% respectively). The dehulled seeds of white and black varieties however contained significant lower percentage of carbohydrate than whole seeds. This is an indication that the hulls also contain some carbohydrate. The moisture content was found to be higher in the dehulled black – seed cultivar as compared to the white- seeded one with a marginal difference of 0.23 between the two cultivars (Table 1). However, it was observed that dehulled seeds had higher moisture content than the whole seeds of the cultivars but the hull had the highest moisture content. Moisture content of less than 10% observed in the hulls of both cultivars could be partly responsible for the non deterioration of the seeds over a long period (Makkar *et al.*, 1998). Bahkali *et al.* (1998) reported that the moisture content of sesame cultivars from some countries was in the range of 3.65-5.60%, which agrees with the result. However, white sesame had higher moisture content (4.71%) compared to black sesame (4.20%) grown in China as reported by Kanu (2011) which is contrary to the result obtained.

Ash content was observed to be significantly different ($p < 0.05$) between the dehulled seeds of the cultivars - 4.62 and 3.72% for black-seed and white-seed, respectively. Highest percentage of ash was however noticed in the hulls of both white and black cultivars. This shows that the ash is majorly concentrated in the hull and suggests its potential to meet part of the nutritional requirements for animal feed. Ozcan and Akgul (1995) reported ash values to be between 3.67 and 5.39% for sesame seeds from Turkey, Mexico, Uganda and Venezuela which corroborates the result for white and black seeds in this study. Kanu (2011) also reported higher ash content in black sesame seed compared to white sesame which agreed with the results of this study.

The fiber content was significantly higher in dehulled black-seed cultivar (6.41%) than that in white – seed cultivar (3.70%). However, the highest percentage of fiber was also noticed in the hulls of white and black cultivars. This indicated that the fiber is mainly concentrated in the hull and suggests potential use in animal feed formulations as it is used as an index of value in poultry and feeding stock feeds (Eze and Ibe, 2005). The higher crude fiber of the hulls of the black-seed cultivar is readily accounted for by the smaller size of the seed compared to that of white seed and consequently high ratio of the seed coat to the endosperm.

Mineral composition

The mineral contents varied significantly ($p < 0.05$) in the two cultivars as shown in Table 2. The mineral composition of white and black sesame seeds and their hull fractions shows that calcium was the predominant mineral followed by phosphorus, potassium and magnesium. All other elements were present in comparatively low concentrations. With the exception of zinc, iron and magnesium, the minerals were found in higher quantity in black seeds than in white seeds. However, the highest amount of these minerals was observed in the hulls of white and black

Table 2. Mean mineral compositions of whole seed, dehulled seed and hull of sesame cultivars

	mg/100 g							
Sample	**Calcium**	**Phosphorus**	**Potassium**	**Magnesium**	**Iron**	**Selenium**	**Zinc**	**Manganese**
NCRI-98-60 (White coloured seed)								
Whole	473.59±0.80^{c}	466.03±1.34^{d}	465.67±1.16^{e}	412.33±0.58^{f}	6.21 ±0.01^{e}	0.030±0.01^{a}	8.78±0.01^{f}	5.90±0.02^{e}
Dehulled	445.61±0.79^{a}	424.48±1.50^{a}	320.85±1.48^{a}	340.60±0.35^{b}	6.06±0.02^{d}	0.024±0.01^{a}	7.67±0.03^{d}	1.43±0.01^{a}
Hull	621.69±1.65^{e}	442.14±1.22^{b}	443.04±1.81^{c}	405.42±0.73^{e}	6.28±0.02^{f}	0.023±0.01^{a}	7.52±0.03^{c}	5.16±0.01^{c}
NCRI-97-28 (Black coloured seed)								
Whole	521.88±1.53^{d}	482.82±1.27^{e}	468.83±1.43^{f}	380.60±0.53^{d}	5.54±0.04^{c}	0.07±0.01^{b}	7.90±0.02^{e}	6.22±0.03^{f}
Dehulled	459.16±1.25^{b}	440.51±0.50^{b}	336.14±1.22^{b}	325.51±1.83^{a}	5.01 ±0.02^{a}	0.06±0.01^{b}	7.40 ±0.02^{b}	2.45±0.02^{b}
Hull	653.96±1.66^{f}	455.59±1.48^{c}	460.80±1.06^{d}	365.80±1.39^{c}	5.33±0.03^{b}	0.05±0.01^{b}	7.24±0.01^{a}	5.22±0.03^{d}

Different superscripts down a column indicate a significance (P < 0.05) difference.

Table 3. Mean vitamin composition of whole seed, dehulled seed and hull of sesame cultivars

	Vitamin (mg/100 g)	
Sample	**Thiamine**	**Riboflavin**
NCRI-98-60 (White coloured seed)		
Whole	0.83 ±0.02^{e}	0.36 ±0.01^{b}
Dehulled	0.76 ±0.02^{d}	0.31 ±0.02^{a}
Hull	0.63 ±0.03^{a}	0.32 ±0.01^{a}
NCRI-97-28 (Black coloured seed)		
Whole	0.71 ±0.01^{c}	0.38 ± 0.02^{b}
Dehulled	0.61 ±0.01^{a}	0.31 ± 0.02^{a}
Hull	0.66 ±0.02^{b}	0.31 ±0.01^{a}

Different superscripts down a row indicate a significance (p < 0.05) difference.

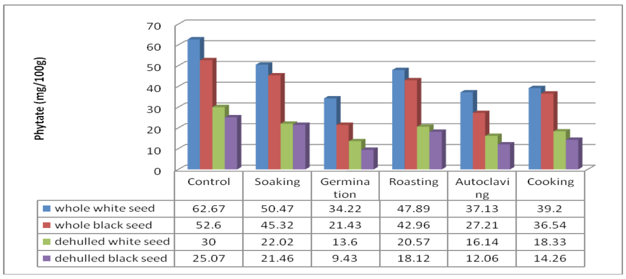


Figure 1. Phytate content of sesame cultivars as affected by processing treatments

seeded cultivars. Calcium content of 621.69 mg/100 g in white sesame hull was considerably higher than 445.61 mg/100 g for the dehulled seed. This can be explained by the fact that most of the calcium was recuperated in sesame hull during the dehulling processes. In agreement with the results obtained in this study, El-Adawy and Mansour (2000) reported a very low content of calcium value for dehulled sesame seed.

Vitamin content

Vitamin content of the cultivars of sesame seeds were shown in Table 3. It was found that dehulled white-seed cultivar was higher in thiamine as compared to that of black-seed cultivar and the differences were significant (p < 0.05), while riboflavin was found to be the same value in both cultivars. The vitamin contents of whole seeds of the cultivars are however higher than that of dehulled seeds. This implies that the hulls contain appreciable content of vitamin as indicated in Table 3. The hulls contain almost the same amount of riboflavin as found

Table 4. Mean anti – nutrient contents of whole seed, dehulled seed and hull of sesame cultivars

	Anti nutrients (mg/100 g)	
Sample	**Oxalate**	**Phytate**
NCRI-98-60 (White coloured seed)		
Whole	183.42 ± 1.68^{e}	62.67 ±2.52^{e}
Dehulled	85.67±0.58^{b}	30.00 ±3.00^{b}
Hull	104.05±3.61^{c}	37.17± 1.04^{c}
NCRI-97-28 (Black coloured seed)		
Whole	154.00 ±3.60^{d}	52.60 ±1.53^{d}
Dehulled	60.22 ± 1.16^{a}	25.07 ±1.10^{a}
Hull	91.01 ± 1.00^{b}	33.40 ± 1.51^{b}

Different superscripts down a row indicate a significance (p < 0.05) difference.

in the dehulled seed. This implies that riboflavin is likely to be evenly distributed in the seed.

Anti nutritional content

The anti nutrient (phytate and oxalate) contents of whole, dehulled and hulls of the cultivars are shown in Table 4. The whole white seeds contain significantly higher oxalate and phytate than whole black seed. In dehulled seeds, these factors were decreased significantly. The values of 85.67 and 30.00 mg/100 g respectively were recorded for the oxalate and phytate in dehulled white cultivar compared to dehulled black cultivar - 62.67 and 25.07 mg/100 g. On the other hand, the whole seeds contain highest quantity of anti nutrients. This shows that the hull contains appreciable quantity of anti nutrients. The physical removal of hulls is associated with decreased phytate and oxalate contents as observed in the two cultivars. The higher amount of the anti nutrients in white-seed might be as a result of its bigger size compared to the black-seed.

Effect of processing treatments on the anti nutrients

Phytate content

Figure 1 shows the effect of processing of whole and dehulled seeds on phytate content of sesame cultivars. Phytate content of untreated whole seed (control) was found to be 62.67 mg/100 g and 52.60 mg/100 g for white and black sesame cultivars, respectively. Data showed that phytate content decreased significantly (P < 0.05) by 19.47% and

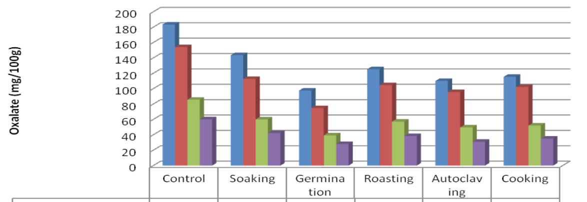
26.60% in whole and dehulled seeds of white cultivar, respectively as a result of soaking in distilled water. Similar trend was observed in whole and dehulled black cultivar. This reduction may be attributed to leaching out of phytate ions into soaking water under the influence of concentration gradient, such losses may be taken as a function of changed permeability of seed coat (Duhan *et al*., 1989).

Germination of white and black sesame cultivars caused a significant reduction in phytate content compared to other processing treatment. Data showed that phytate content decreased significantly ($P < 0.05$) by 45.40% and 54.67% in whole and dehulled seeds of white sesame cultivar, respectively after germination. Phytate content was also reduced by 59.31 and 62.39% in whole and dehulled black sesame cultivar. Reduction in the level of phytic acid during germination could be attributed to leaching out during hydration as well as activation of phytase (Michael and Wiebs, 1983).

Phytate content in whole and dehulled seeds of sesame cultivars was affected significantly by roasting (120ºC /1 hr) as shown in Figure 1. However, greater reduction was observed in dehulled black seeds. Effect of roasting could be attributed to the type of heat treatment and the moisture content of the samples. Khan *et al*., 1990 stated that the higher the moisture content, the higher the phytate loss. This agrees with the result of this finding in that dehulled black-seed cultivar had higher moisture content (4.81%) than white-seed cultivar (4.58%) as shown in Table 1 before being subjected to roasting. Also, the low values of phytate in the roasted black-seed cultivar may be due to smaller size of the seeds compared to the white seed and the thermolabile nature of the anti nutrients (Fasasi *et al.*, 2003). The reduction in the phytate content as a result of roasting may be due to insoluble phytins formed between phytic acid and some minerals. The anti nutritional activity of phytate lies in their ability to form complexes with metals like Ca, Zn, Mg and Fe.

Heat treatment using autoclave affected phytate content significantly ($P < 0.05$) in whole and dehulled sesame seed cultivars. Phytate content was significantly reduced by 40.75 and 46.20% respectively in whole and dehulled white sesame cultivar. Similar reductions were observed in black cultivar. The high level of phytate present in the untreated seeds might decrease the bio-availability of minerals (especially calcium and iron), impaired protein digestibility caused by formation of phytic-protein complexes and depressed absorption of nutrients (Sarwar Gilani *et al*., 2012)

Cooking of the seeds decreased significantly ($P < 0.05$) the phytate content by about 37.45% and 38.90% of the whole and dehulled white sesame cultivar respectively. Similar reduction was observed in whole and dehulled black sesame cultivar. Reduction of the phytate level in the cooked samples may not be due to destruction of the compound, but may rather be due to its ability to complex with protein and minerals (Bishnoi *et al*., 1994).



	Control	Soaking	Germina tion	Roasting	Autoclav ing	Cooking
whole white seed	183.42	143.63	97.6	125.37	110.1	115.42
whole black seed	154	112.76	74.73	104.62	95.64	102.3
dehulled white seed	85.67	60.03	39.29	57.25	49.66	52.07
dehulled black seed	60.22	42.37	28.12	38.44	30.95	35.12

Figure 2. Oxalate content of sesame cultivars as affected by processing treatments

Oxalate Content

Figure 2 shows the effect of processing of whole and dehulled grains on oxalate content of sesame cultivar. The effect of soaking of sesame seeds in distilled water on inactivation of oxalate was studied and data summarized. From the results, it could be inferred that oxalate content was decreased significantly ($P < 0.05$) by 21.69 and 27.60% of whole and dehulled seed of white seed respectively. The oxalate also decreased by 26.78 and 29.64 % of whole and dehulled black seed respectively. This reduction may be attributed to leaching out of oxalate as a result of soaking.

The effect of germination on inactivation of oxalate in white and black sesame cultivars showed that oxalate decreased significantly ($P < 0.05$) by 46.79 and 51.80% of whole and dehulled seed of white seed respectively. The oxalate also decreased by 51.47 and 53.30% of whole and dehulled black seed respectively. Data also showed that the oxalate content of white sesame seed reduced significantly ($P < 0.05$) by 31.65 and 33.17% of whole and dehulled seeds, respectively while black sesame seed reduced significantly by 32.07 and 36.17% of whole and dehulled seeds after roasting. A similar heat effect on the anti-nutritional factor of peanut has been reported by Rahma and Mastafa (1988).

Autoclaving at 121°C for 25 min decreased the oxalate content significantly ($P < 0.05$) by 39.97 and 42.03% of whole and dehulled white sesame cultivar respectively while oxalate content of whole and dehulled black sesame seed reduced significantly by 37.90 and 48.60%. Autoclaving was an effective heat treatment compared to cooking as oxalate are heat labile and can be partially or completely denatured when exposed to elevated temperature. The effects of cooking on inactivation of oxalate showed that the values significantly decreased ($P < 0.05$) by about 37.07 and 39.22% of whole and dehulled white sesame cultivar, respectively while oxalate content of reduced significantly by 34.87 and 41.68% of whole and dehulled black cultivar.

In general, sesame cultivars differ significantly in their phytate and oxalate contents. The amount of these anti nutrients in crop plants depends not only on the plant, but also on the season, soil nutrients and local soil-water conditions where they grow (Singh and Saxena, 1973).

Conclusions

It could be concluded that white and black sesame cultivars are good sources of carbohydrate, protein, fat and minerals. The inherent anti nutrient (phytate and oxalate) in the seeds could be reduced to tolerable limit by processing especially by germination. Processed sesame seed could serve as ingredients in food formulation to reduce malnutrition among vulnerable groups in Nigeria.

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