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Effect of Roasting, Soaking and Alkaline Treatment on Chemical properties of Neem Seed (*Azadirachta indica* A. juss)

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ABSTRACT

Original Research Article

Neem (*Azadirachta indica*) products, particularly its seeds, have considerable scientific and economic importance because they contain bioactive compounds such as azadirachtin, a triterpenoid that is also present in other parts of the plant. Azadirachtin is widely recognised for its insecticidal properties, particularly its ability to suppress feeding and interfere with insect growth and reproduction. Despite these benefits, information concerning the suitability of neem seeds for safe human consumption remains limited. This study therefore evaluated the effects of selected processing methods, namely water soaking, alkaline treatment, and roasting, on the chemical composition of neem seeds. Based on preliminary investigations, the seeds were subjected to water soaking and alkaline treatment using NaOH for 24 h, while roasting was performed at 160°C for 10 min. For each treatment, 200 g of neem seeds was processed separately, with an untreated sample maintained as the control. The proximate composition, including crude protein, crude fat, crude fibre, ash, moisture, and carbohydrate contents, together with selected mineral elements (Ca, Na, Mg, P, K, Cu, Zn, Fe, Mn, and Se), was determined using standard AOAC procedures. The results showed that roasting increased the crude fat content of the seeds, while processing treatments produced measurable changes in their mineral composition. In particular, alkaline treatment increased the concentrations of sodium (40.20 mg/100 g), magnesium (49.10 mg/100 g), and phosphorus (39.30 mg/100 g). Water soaking also altered the proportional distribution of the proximate constituents, whereas alkaline processing enhanced the levels of several of the evaluated minerals. Overall, the findings demonstrate that processing conditions influence the nutritional and mineral characteristics of neem seeds, with different treatments producing distinct changes in their chemical composition.

Keywords: Pre-treatments, Neem Seeds, Minerals, Nutritive Components.

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Introduction

Neem fruits have thin epicarps, mucilagenous fleshy mesocarps and hard endocarps with variable ovoid shaped oil seeds, however its toxic and anti nutritional components limits its benefits of consumption. (Puri, 1999). In order to allow effective usage of neem seeds and boost its nutritional satisfaction, it is necessary to reduce its anti-dietary factors and toxins.

Farran et al. According to [6], for the improvement of characteristics such as protein, carbohydrates and Mineral composition in legumes after processing certain types of anti-nutritional compounds can be reduced or inactivated with soaking, cooking, toasting, autoclaving microwave treatment, germination and chemical processing. Soaking is one of the treatments, as it helps to promote the uptake of water and hydration in legumes or cereals; this hydrating effect softens a material and may induce endogenous enzymes (such as those involved in phytate degradation) that can improve subsequent processing operations. Gupta et al. (2015) stated that cereals such as wheat and barley should be soaked for about 12–24 h before use in order to improve processing and nutritional quality.

Neem seeds offer great opportunity as a natural resource due to the multiple advantages of products derived from neem plant. However, as neem has also been identified as a bioactive agent and toxicological plant, it is necessary to examine what effect processing treatments have on the chemical composition of its seeds. Some of the bitter constituents in neem seeds were used for pest control, neem seed cake (the residue left after oil extraction) is a by-product that can be processed to produce both oil and Neem Cake. It has shown the potential of a cheap and eco-friendly botanical pesticide in field applications, such as rice and cotton trials performed in Pakistan (Siddiqui, 1995). These applications showcase economic and agricultural importance of products derived from neem.

The nutritional content of neem products can vary widely based on the plant material and processing methods used. Whole seeds-based neem seed cake contains lower protein but higher crude-fibre (Ismael et al., 2018; Blackley and Jones, 1989). Cake derived from decorticated seeds, however, has shown that higher protein concentrations and lower fibre levels usually occur. Neem leaves are also a good source of protein, moderate amounts of dietary and antinutritional fibre as well as considerable lignin. Moreover, the leaves are characterized by relatively high concentrations of calcium as well as comparatively low levels of phosphorus (Gowda et al., 2000). This highlights an intimate interdependent relationship between the source material and processing approach that shapes the nutritional properties of neem products.

The amount of oil extracted from neem seeds is also varies depending on method used and has been reported to be about 1–10% (dry weight basis) [13]. In addition, the partial depulpation and decortication of neem seeds during processing may alter the composition and characteristics of neem cakes from such seeds (Dutta et al., 2012). Such differences are critical in the context of assessing the growing potential of neem seed products for nutritional, industrial and agricultural utilization since processing and extraction procedures usually promote a significant alteration of their final chemical composition in various stages.

Materials and Methods

From the premise of Faculty of Education, University of Ibadan, neem seeds were collected from different trees. Collected seeds were cleaned from impurities, damaged and unsuitable materials via manual sorting so that only clean and healthy seeds were used in the experiment. The seeds were then split into four groups based on the processing method. The experimental groups were alkaline soaking (chemical treatment), water soaking, and roasting while untreated raw neem seeds served as a control. A sample of 200 g neem seeds was used for each treatment and the control.

Soaking: Approximately 200 g of neem seeds were immersed in 250 mL of water and allowed to soak for 24 hours following the procedure described by Meseret et al. (2019). After the designated soaking period, the water was completely removed, and the treated seeds were sun-dried. The dried seeds were subsequently milled into powder and aseptically packaged for subsequent chemical analysis.

Roasting: The roasting treatment was performed using a microwave oven. A measured quantity of neem seeds was subjected to a temperature of 160°C for 10 minutes. Following roasting, the processed seeds were allowed to cool before being prepared for subsequent analysis.

Chemical Treatment: This was done by soaking 200g of seed in alkaline solution (10% sodium hydroxide) with 40 g of seed for 24h. The seeds were sun-dried and ground to a powdered condition, stored and sealed in containers for further tests. The seeds were analysed for proximate composition (moisture contents, crude protein, crude fat, crude fibre and ash and carbohydrate contents) and mineral composition (Mg, Na, Phosphorus, Cu, Fe, K, Ca, Zn and Mn) to know the impacts of its treatment on their chemical properties as per the methods of AOCA (2005).

Results and Discussion

The chemical properties of neem oil revealed that the pretreatment of seed gave a resultant increase in proximate composition of neem seed in which case roasting brought about increase in fat contents, alkaline treatment improved the level of Na, Zn and Manganese.

Table 4.1 Nutritional components in raw and treated neem seed. The crude protein content was best kept in roasted neem seed (19.08%) whereas the lowest value was reported in water soaked neem seed (16.99%). The protein content level was not significantly different ($p \leq 0.05$) between the raw seed (18.57%) and alkaline treated seed (18.57%). This is in agreement with the observation of Prakash, (2004) and Wang, (2005) as indicated by their cooking effects on nutritious composition of eight legumes.

Table 1: Proximate Composition of Raw and Pre-treated neem Seeds

Chemical Parameters (%)	Raw Neem Seeds	Water Soaked Neem Seeds	Alkaline Soaked Neem Seeds	Roasted Neem Seeds
Crude protein	18.57±0.09[b]	16.99±0.27[a]	18.57±0.09[b]	19.08±0.11[b]
Crude fat	41.18±0.03[a]	40.35±0.03[b]	41.18±0.03[a]	41.84±0.05[a]
Crude fibre	3.57±0.04[a]	3.53±0.04[a]	3.57±0.04[a]	3.64±0.03[b]
Ash	2.58±0.05[b]	2.42±0.04[a]	2.58±0.04[b]	2.51±0.03[b]
Moisture	6.03±0.02[ab]	12.31±0.03[c]	6.03±0.02[ab]	5.89±0.02[a]
Carbohydrate	28.11±0.02[b]	24.41±0.43[a]	28.07±0.02[b]	27.04±0.02[b]

Values with a different superscript in the row are significantly different (*p<0.05).*

The crude fat content of the roasted neem seeds increased significantly to 41.84%, compared with 41.18% recorded for the raw seeds. In contrast, the lowest crude fat values were recorded for the water-soaked neem seeds (40.35%) and the alkaline-treated seeds. Roasting also resulted in the highest retention of crude fibre, with a value of 3.64%. This increase may be attributed to the formation of protein–fibre complexes resulting from possible chemical modifications induced by the roasting process (Bressani, 1992). The lowest crude fibre content, 3.53%, was observed in the water-soaked seeds, which may be associated with the diffusion or leaching of fibre-related components into the soaking water. No significant difference ($p \leq 0.05$) was observed between the crude fibre content of the raw neem seeds (3.57%) and that of the alkaline-treated seeds (3.57%).

The ash content was lowest in the water-soaked neem seeds, with a value of 2.42%, whereas roasted seeds recorded an ash content of 2.51%. No significant difference ($p \leq 0.05$) was observed in ash content between the raw and alkaline-treated neem seeds, both of which recorded 2.58%. The value obtained was relatively close to the 3.3% reported for raw melon seeds by Omafuvbe et al. (2004). Regarding moisture content, both raw and alkaline-treated neem seeds recorded a value of 6.03%. Water soaking substantially increased the moisture content to 12.13%, which was attributed to the absorption and retention of water during soaking. Conversely, the roasted seeds exhibited the lowest moisture content (5.89%), probably as a consequence of moisture loss caused by the dehydrating effect of roasting.

No significant difference ($p \leq 0.05$) was observed in carbohydrate content between the raw neem seeds (28.11%) and the alkaline-treated seeds (28.07%). The water-soaked seeds recorded the lowest carbohydrate content at 24.41%, while the roasted seeds contained 27.04% carbohydrate. The reduction observed following water soaking may be related to the loss or leaching of soluble carbohydrate components into the soaking medium. Overall, the processing treatments produced variations in the proximate composition of neem seeds, particularly with respect to fat, fibre, moisture, ash, and carbohydrate contents.

Table 2: Minerals Composition of Neem Seed during Treatment Methods

Minerals(mg/100 g)	Roasted Neem Seeds	Raw Neem Seeds	Alkaline Soaked Neem Seeds	Water Soaked Neem Seeds
Ca	54.20[b]	56.93[c]	54.70[b]	52.93[a]
Na	38.10[b]	38.80[b]	40.20[c]	37.50[a]
Mg	47.80[b]	48.50[b]	49.10[b]	45.90[a]
P	38.07[b]	38.40[b]	39.30[b]	37.30[a]
K	111.73[a]	112.50[a]	112.30[a]	111.20[a]
Cu	379.00[b]	382.00[b]	381.00[b]	368.00[a]
Zn	2418.33[b]	2463.00[b]	2429.00[b]	2398.00[a]
Fe	16418.00[b]	16482.00[b]	16425.33[b]	16364.00[a]
Mn	1175.00[b]	1182.00[b]	1179.00[b]	1164.33[a]
Se	5.10[c]	1.50[a]	2.27[b]	1.10[a]

Values with the same superscript are not significantly different ($p \leq 0.05$).

The mineral components of raw and processed neem seeds are given in Table 1.0 Calcium (Ca) levels reduced significantly from 56.93 mg/100 g in the raw seeds to 52.93 mg/100 g after water soaking. Calcium levels for the alkaline method and roasting were also found to be reduced 54.20 and 54.70 mg/100 g. In contrast, the concentration of sodium (Na) increased from 38.80 mg/100 g in untreated seeds to 40.20 mg/100 g after alkaline treatment. This increase could be linked to sodium contribution via alkaline solution of NaOH (sodium hydroxide) used during processing. On the other hand, for sodium content it decreased ($p \leq 0.05$) due to roasting and water soaking up to values of 38.19 and37.50 mg/100 g, respectively. Thus, alkaline treatment generated considerable elevations of sodium (40.20 mg/100 g), magnesium (49.10 mg/100 g) and phosphorus (39.30 mg/100 g) compared to their corresponding values in raw neem seeds.

There was a slight increase in the magnesium (Mg) concentration from 48.50 mg/100 g in raw seeds to 49.10 mg/100 g after alkaline treatment. But the roasting and water soaking reduced magnesium levels to 47.80, and 45.90 mg/100 g respectively. This is similar to Longe (1983) who reported that autoclaving of mature cowpea seeds caused a decrease in magnesium concentration by 23%. The phosphorus (P) content in the three processing methods were also decreased from 38.40 mg/100 g for raw seeds to 38.07 mg/100 g for roasted seeds and 37.30 mg/100 g for water-soaked seeds. There was also a significant ($p < 0.05$) decrease in the concentration of potassium (K), whereby K values for the raw seeds until alkaline treated, roasted and water soaked were 112.50 mg/100 g, 112.30 mg/100 g, 111.73 mg/100 g and 111.20mg/100 g respectively. The average findings are in agreement with those of Heylowitz and Mattew (1983), who noted a potassium loss during the boiling of mature cowpea seeds up to 30 %.

Concentration of copper (Cu) was 382 mg/100 g in raw neem seeds, which decreased to 381, 379 and 368 mg/100 g after alkaline treatment, roasting and water soaking respectively. Zn (zinc) was another element whose content significantly decreased following processing, its concentration in the raw seeds being 2463 mg/100 g and these values decreased to 2429, 2418 and 2398 mg/100 g dry mass for alkaline-treated, roasted and water-soaked seeds respectively. The decrease in zinc contents was according to Hefnawy (2011) who found that autoclaving and microwave processing of lentil seeds lead to significant decline. Such findings suggest a processing related fate of trace minerals in neem seeds and the magnitude of change depends on the type of treatment applied.

The concentration of iron (Fe) decreased due to both body processes, where samples ranged from lower in the raw seeds (16482 mg/100 g) to 16425, 16418 and 16364 mg/100 g in alkaline-soaked, roasted and water-soaked seeds respectively. The manganese (Mn) content also decreased from a value of 1182 mg/100 g in the raw seeds to declining values within the range of 1179–1164 mg/100 g after treatment. Selenium (Se), however, showed an opposite pattern and significantly increased from 1.50 mg/100 g in the raw seeds to 5.10 mg/100 g in roasted seeds and 2.27 mg/100 g in alkaline-treated seeds. Whereas, 1.10 mg/100 g selenium concentration of the soil-water soaking followed with irrigation for 48 h reduced its selenium content which is comparable to the result obtained by Habtamu et al. (2023): The nutritional composition of certain wild and domesticated Lima Beans (Phaseolus lunatus), a response to Arnone et al. The mineral profile showed that the concentrations of some minerals were increased with alkaline treatment whereas several mineral constituents were reduced after roasting and water soaking.

Thus, among the treatment methods, alkaline treatment gave best retention of mineral content of neem.

Conclusion

Roasting and alkaline soaking of neem seeds resulted in variations in the distribution of their proximate nutritional components, with notable increases particularly in crude fat, crude fibre, and carbohydrate contents. Water soaking also produced measurable changes in the overall proximate composition of the seeds, indicating that processing conditions influenced the nutritional profile of the raw material.

The major minerals identified in the neem seeds included iron, zinc, manganese, copper, potassium, and calcium. Although differences in the concentrations of these minerals were observed following the various processing treatments, their overall levels were not significantly affected by the treatments applied. These findings indicate that the principal mineral constituents of neem seeds were generally retained during the processing procedures investigated.

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