The effect of processing methods on the nutritional profile of avocado (*Persea americana* Mill) seeds

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Abstract: The nutritional and antinutritional profiles of raw avocado seeds soaked and boiled for 10, 15, 20 and 20 min were investigated. With increasing boiling times, the ash, crude protein, ether extract, crude fibre, carbohydrate and gross energy decreased. However, crude protein, ether extract, crude fibre and gross energy increase in soaked seeds. The amino acid content of the avocado seeds increased with the boiling process, as the seeds boiled for 25 min had high levels of methionine (6.58/100 g protein), lysine (5.90/100 g protein) and tryptophan (3.00/100 g protein). The vitamin content of the raw avocado seeds were: 207.02 μg/100 g for vitamin A, 14.63 μg/100 g for vitamin C and 0.65 μg/100 g for vitamin E and boiling for 10 min decreased these values to 186.63, 9.12 and 0.61 μg/g, respectively. Boiling for 10–25 min also decreased the calcium, potassium, phosphorus and iron levels of the avocado seeds. While the raw avocado seeds had tannin (11.29/100 g), phytic acid (12.87/100 g), alkaloid (2.05/100 g), saponin (0.92/100 g) and oxalate (4.07/100 g), boiling for 25 min and soaking for 24 h effectively reduced the antinutritional factors without any adverse effect on the nutritional quality.

1 Introduction

In many developing countries, malnutrition is a problem (Egounlety *et al*., 2002). Diseases associated with nutrition, like obesity, diabetes, cancers and coronary heart diseases, are of public health concern worldwide (World Bank, 1994). In view of the consequences of food insecurity in several developing countries, the importance of fruits, nuts and vegetables in human nutrition as sources of vitamins, minerals and dietary fibre (Craig and Beck, 1999; Wargovich, 2000) cannot be overemphasised. Reduced forms of cancer, heart disease, stroke and other chronic diseases have been associated with the daily consumption of fruits, nuts and vegetables (Prior and Cao, 2000; Goldberg, 2003).

Avocado (*Persea americana* Mill) is one of the fruits that are most commonly grown worldwide and belongs to the Lauraceae family (FAO, 1992). Avocado fruit is used as food, medicine and a source of high-quality oil and also has numerous industrial uses (FAO, 1992; Bergh, 1992). Compared to other fruits, avocados are very rich in protein, potassium, magnesium, folic acid, riboflavin, niacin, calcium, thiamine and vitamin E (FAO, 1986).

While there are reports in the literature on the nutritional properties of avocado pulp (CSIR, 1988; Swisher, 1988), there is paucity of data on avocado seeds because they are discarded after the pulp of the fruit has been consumed. Therefore, this work was carried out to highlight the nutritional status of avocado seeds and the processing methods that can reduce antinutritional factors like tannins in avocados.

2 Materials and methods

Mature avocado fruits were purchased from the Oje market, Ibadan, Nigeria. The pulp of each fruit was sliced and the seeds were removed. Seeds of uniform size were randomly picked and used for analysis.

2.1 Sample preparation

The seeds were manually chopped after the raw seed samples were prepared. Part of the chopped raw seeds was ground and used for moisture content determination. The remaining part was oven-dried at 60°C for 10 h and milled in a laboratory-type hammer mill with a 0.25 mm mesh screen into a fine powder. The obtained milled samples were sealed in polyethylene bags and stored at 4°C until needed.

2.1.1 Boiled seed samples

The chopped seeds were placed in boiling water for 10, 15, 20 and 25 min, respectively. Part of the boiled seed samples was ground and used to determine the moisture content while the rest were drained, dried at 60°C for 10 h and milled in a laboratory hammer mill with a 0.25 mm mesh screen into a fine powder. The obtained milled samples were sealed in polyethylene bags and stored at 4°C until needed. The boiled water was also tested.

2.1.2 Water-soaked seed samples

The chopped seeds were soaked in water for 24 h with frequent stirring. At the end of that period, the seeds were drained. Part of the soaked seeds was ground and used for moisture content determination while the remaining part was oven-dried at 60°C for 10 h. The dried seeds were ground in a hammer mill with a 0.25 mm mesh sieve. The milled samples were sealed inside polyethylene bags and stored at 4°C until needed. The soaked water was also tested.

The samples were coded as follows:

- T_1 – raw seed
- T_2 – seed boiled for 10 min
- T_3 – seed boiled for 15 min
- T_4 – seed boiled for 20 min
- T_5 – seed boiled for 25 min
- T_6 – soaked seed.

3 Chemical analyses

The following were analysed:

- proximate composition (AOAC, 1990)
- tryptophan (Spies and Chambers, 1949)
- methionine (Lunder, 1973)
- lysine (Jambunathan *et al*., 1983)
- minerals (AOAC, 1984; Bonire *et al*., 1990)
- vitamins (Morrison, 1975; AOAC, 1984)
- alkaloid (Henry, 1973)
- tannin (Griffiths and Jones, 1977)
- phytic acid (Sudarmadji and Markakis, 1977)
- saponin (Makkar and Becker, 1996)
- oxalate (Libert and Franceshi, 1987).

4 Statistical analysis

The data obtained were subjected to Analysis of Variance (ANOVA) to check for significance differences and the Least Significant Difference (LSD) test was used to determine which sample differed significantly from the others.

5 Results and discussion

5.1 Proximate composition of avocado seeds

The effect of processing methods on the proximate composition of the avocado seeds are shown in Table 1. While the moisture content of the raw seeds was 73.69%, that of the soaked seeds was 83.73%. Boiling and soaking the seeds in water might have softened the cell tissues, thereby increasing the water-absorbing and water-retention capacities of

the seeds due to the increased permeability of the cell membrane to water. Ravindran and Sivakanesan (1996) also reported increases in the moisture content of mango seed kernels during boiling and soaking. The moisture and dry matter levels of any food material is a measure of its longevity or life span. The high moisture content and low dry matter of the avocado seed samples were within the range of 60%–80%, which is expected for fruits and seeds (Akaninwor and Arachie, 2002).

Table 1 Effect of processing methods on proximate composition (on dry matter basis) of *Persea americana* seeds

Sample Treatments	Moisture (%)	Dry Matter (%)	Ash (%)	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	**Carbohydrate (%)	Gross Energy (Kcal/100g)
Raw seed (T_1)	73.69^{a}±0.02	26.30^{a}±0.03	5.21^{a}±0.03	6.34^{a}±0.34	16.81^{a}±0.02	3.97^{a}±0.01	67.68^{a}±0.31	4.49^{a}±0.18
Boiled Seed at 10 minutes (T_2)	74.25^{a}±0.05	25.75^{a}±0.05	4.68^{b}±0.01	15.58^{b}±0.18	28.90^{d}±0.03	3.29^{b}±0.02	47.56^{b}±0.23	5.48^{c}±0.09
Boiled Seed at 15mintes (T_3)	76.79^{b}±0.01	23.21^{b}±0.01	3.77^{c}±0.01	15.23^{cd}±0.18	28.74^{c}±0.01	2.95^{c}±0.01	49.32^{c}±0.17	5.30^{bc}±0.09
Boiled Seed at 20 minutes (T_4)	77.35^{b}±0.15	22.65^{b}±0.15	3.38^{d}±0.02	14.97^{bc}±0.09	28.69^{c}±0.00	2.16^{d}±0.01	50.81^{d}±0.09	5.12^{bc}±0.09
Boiled Seed at 25 minutes (T_5)	78.75^{c}±0.75	21.25^{c}±0.75	2.62^{e}±0.01	14.44^{b}±0.09	28.62^{b}±0.01	1.58^{e}±0.02	52.75^{e}±0.09	4.94^{b}±0.10
Soaked Seed (T_6)	80.73^{c}±0.01	19.27^{c}±0.01	2.25^{f}±0.05	23.54^{e}±0.09	30.83^{e}±0.01	13.76^{f}±0.02	29.66^{f}±0.11	6.01^{d}±0.09

Notes: Means for each attribute followed by the same letter are not significantly different ($p < 0.05$) by least significant difference test (LSD).

± Standard error of the mean.

** Calculated by difference.

The ash content of the raw seeds, which was 5.21%, is more than the values of 1.26% and 1.72% for African pears, *Dacryodes edulis* and mango seed kernels, respectively (Morton, 1987; Obasi and Okolie, 1993). The ash content of raw avocado seeds is an indication that the seeds can be a potential source of minerals important in many of the biochemical reactions and metabolic processes in the body. However, reductions in the ash contents of boiled and soaked seed samples (due mainly to the leaching of soluble inorganic salts into processing water) is not unusual, as similar decreases in the ash content of processed mango seed kernels has been reported by Ravindran and Sivakanesan (1996). The crude protein content of raw avocado seeds was found to be 6.34% and this is in agreement with the observations of Morton (1987) who noted that the crude protein of avocado seed is higher than the pulp.

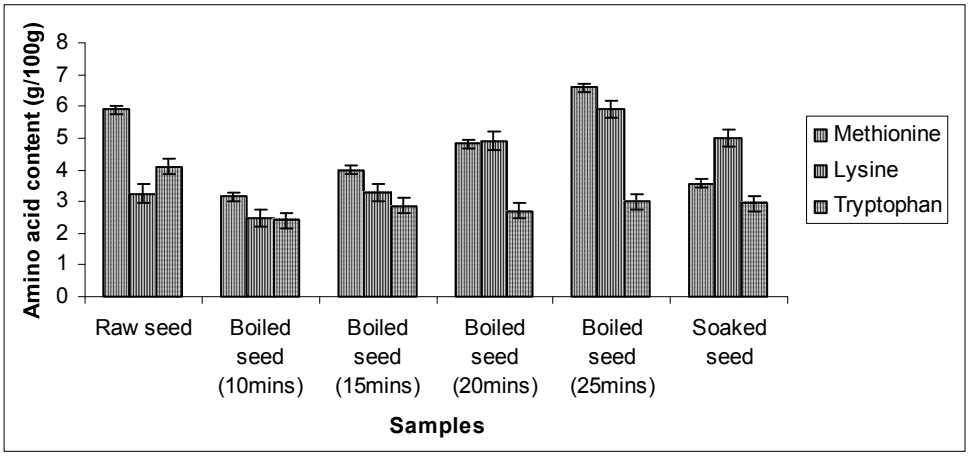
The ether extract content of the raw avocado seeds (16.81%) is within the range of 15%–20.0% reported by Bora *et al.* (2001), but higher than that of pulp (Morton, 1987) and African native pear seeds (Obasi and Okolie, 1993). The high ether extract content of avocado seeds, which is more pronounced after boiling and soaking, is indicative of the fact that the seeds are rich in oil and contain essential fatty acids, which make them a good source of vegetable oil for nutritional and industrial purposes. Similarly, the high ether extract of the seeds makes it a good source of oil-soluble vitamins such as vitamins A, D, E and K. Raw avocado seeds have a fibre content of 3.97%, which is lower than that of the Dacryodes edulis seed (27.3%) (Morton, 1987), but higher than that of mango seed kernels (1.17%–2.63%) (Arogba, 1997; Ravindran and Sivakanesan, 1996). After soaking, the fibre content of the raw avocado seeds increased to 13.76% (Table 1);

thus, soaked avocado seeds may be a good source of dietary fibre for the prevention of nutrition-related diseases. The gross energy of food is the quantity of energy as heat energy resulting from the complete oxidation of a known weight of food. The gross energy values of the raw and processed avocado seed samples were between 4.49–6.01 Kcal/100 g and this may indicate the presence of soluble sugars. Thus, avocado seeds can be exploited in feed formulations as a good source of low energy for ruminants (Enujiugha and Agbede, 2000).

5.2 Lysine, methionine and trytophan contents of avocado seeds

Avocado seeds contain some amounts of essential amino acids like lysine, methionine and tryptophan (Figure 1), but their levels are lower than those of mango seed kernels (Dhingra and Kapoor, 1985). However, avocado seeds can be a good source of essential sulphur-containing amino acids, which is limited in some cereals and legumes.

Figure 1 The effect of processing on the amino acid composition of avocado seeds

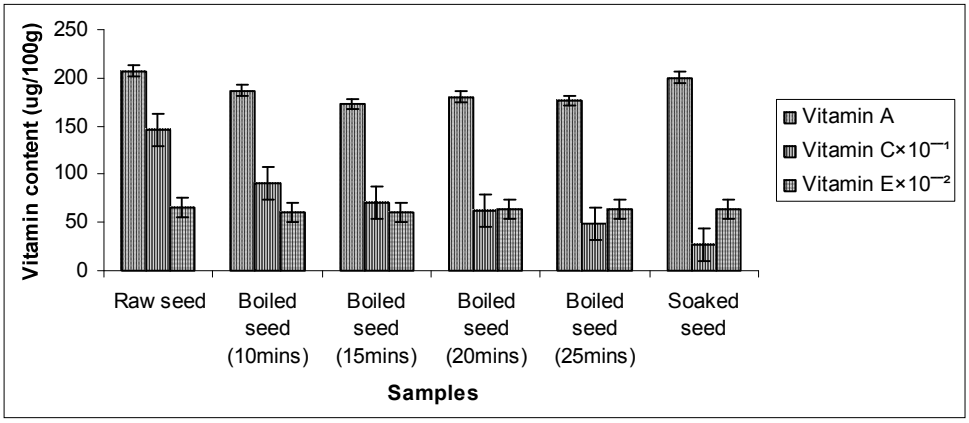


5.3 Vitamin content of avocado seeds

Morton (1987) reported that avocado pulp has vitamin levels of 4.5–21.3 mg/100 g and in this study, the vitamin C of the seeds was found to be 14.63 mg/100 g. Ascorbic acid is a water-soluble and heat-labile vitamin. During the boiling and soaking of the seeds, vitamin C losses were between 38%–67% and 81%, respectively. Vitamin C losses are mostly due to thermal destruction, oxidation and leaching into processing water (Fellows, 2000). The high intake of vitamin C from food has, however, been shown to raise serum HDL cholesterol and lower serum triglyceride concentration (Ness *et al*., 1996). However, with a low level of vitamin C, avocado seeds have higher concentrations of vitamin A (β-carotene equivalent) of between 173.08 to 207 μg/100 g and vitamin E of between 0.61 to 0.65 mg/100 g (Figure 2). Antioxidants such as ascorbic acid, carotenoids and tocopherol have been associated with the prevention of nutritionally associated diseases such as cancer, coronary heart disease and obesity (Larrauri *et al.*, 1996). Vitamins A and E, which are oil-soluble vitamins, are present mostly within the dry matter of the seeds and were not leached into the processing water. While the

antioxidant capacity of fruits and vegetables may vary (Prior and Cao, 2000; Kalt, 2002), it is better to consume a variety of commodities rather than limit consumption to some commodities with a very high antioxidant capacity.

Figure 2 The effect of processing on the vitamin content of avocado seeds



5.4 Mineral content of avocado seeds

The avocado seed samples (T_1 to T_6) have moderately high values of calcium, potassium and sodium, but low values of phosphorus and iron (Figure 3). The mineral content of avocado seeds is, however, higher than that of mango seeds (Morton, 1987). The antinutrients in the seeds (Table 2) can affect the availability of minerals; for example, phytic acid, which is the principal form of phosphorus in many seeds, chelates divalent minerals such as iron, magnesium and calcium and renders these minerals biologically unavailable.

Figure 3 The effect of processing on the mineral content of avocado seeds

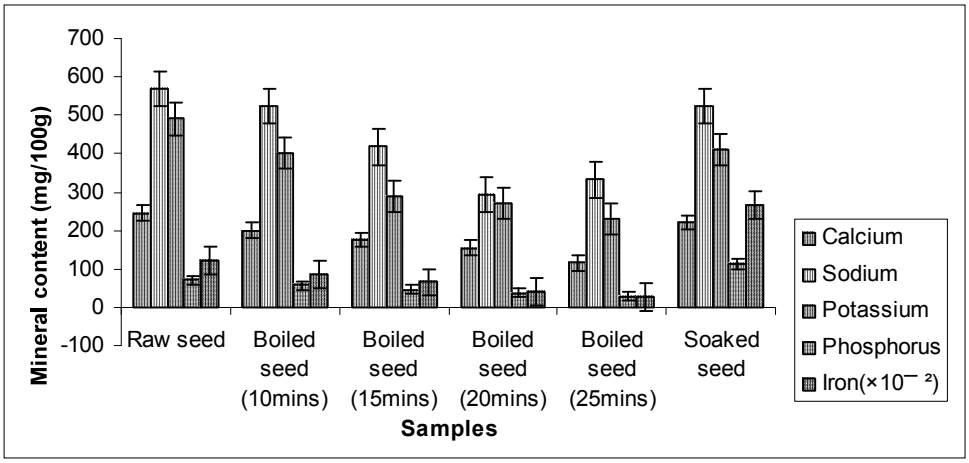


Table 2 Effect of processing on anti-nutritional factors (g/100 g on dry matter basis) in *Persea americana* seeds

Sample Treatment	Alkaloid	Loss (%)	Tannin	Loss (%)	Phytic acid	Loss (%)	Saponin	Loss (%)	Oxalate	Loss (%)
Raw seed (T_1)	$2.05^{c}\pm0.04$	-	$1.29^{a}\pm0.11$	-	$12.87^{a}\pm0.02$	-	$0.92^{c}\pm0.00$	-	$4.07^{a}\pm0.00$	-
Boiled Seed at 10 minutes (T_2)	$1.61^{d}\pm0.03$	21.0	$8.44^{b}\pm0.11$	25.0	$11.35^{b}\pm0.02$	11.0	$0.83^{d}\pm0.00$	9.0	$3.86^{b}\pm0.02$	5.0
Boiled Seed at 15mintes (T_3)	$1.33^{e}\pm0.05$	35.0	$7.89^{c}\pm0.00$	30.0	$9.54^{c}\pm0.03$	25.0	$0.80^{e}\pm0.00$	12.0	$3.57^{c}\pm0.01$	12.0
Boiled Seed at 20 minutes (T_4)	$1.05^{b}\pm0.05$	45.0	$5.37^{d}\pm0.11$	51.0	$7.19^{d}\pm0.02$	44.0	$0.76^{e}\pm0.01$	14.0	$3.12^{d}\pm0.05$	26.0
Boiled Seed at 25 minutes (T_5)	$0.42^{a}\pm0.05$	79.5	$2.74^{e}\pm0.11$	86.0	$5.99^{e}\pm0.02$	53.5	$0.72^{b}\pm0.00$	21.0	$2.77^{e}\pm0.00$	32.0
Soaked Seed (T_6)	$0.32^{a}\pm0.05$	84.4	$3.6^{f}\pm0.11$	68.0	$5.29^{f}\pm0.02$	58.9	$0.48^{a}\pm0.01$	48.0	$2.09^{f}\pm0.01$	49.0

Notes: Means for each attribute followed by the same letter are not significantly different ($p < 0.05$) by least significant difference test (LSD).

± Standard error of the mean.

5.5 Antinutritional factors in avocado seeds

Avocado raw seeds have some antinutritional factors which, when not removed by adequate processing methods, can constitute a potential problem in the use of seeds for animal and human nutrition. With boiling and soaking, however, the antinutritional factors in the seeds were reduced (Table 2). With an initial level of 2.05/100 g of alkaloid, boiling the raw seeds for 25 min and soaking produced 79.5% and 84.4% reductions of alkaloids, respectively. The percentage reductions in tannin, phytic acid and saponin after boiling the seeds for 25 min were 76%, 53.5% and 21%, respectively, and with soaking, the reductions were 68%, 58.9% and 48%, respectively. Udensi *et al.* (2005) reported that boiling for 30 min produced 32% and 40% reductions of tannins and phytic acid in *Mucuna sloanie* (velvet beans). Soaking the seeds for 2 h and cooking them in boiling water, Fasoyiro *et al.* (2005) reported reductions of 32.6% and 52% in the tannin and phytate of *Cajanus cajan* (pigeon peas).

As the values of vitamins A, C and E and some minerals (calcium, potassium, phosphorus and iron) of avocado seeds are close to those of the pulp (CSIR, 1988), with improved processing and breeding methods, it may be possible to produce in the future avocado seeds with improved nutritional content and reduced levels of antinutritional factors.

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