BloEx - Journal
Britain International of
EXACT Sciences Journal
Publish: | January - May - September |
E-ISSN: 2686-1208
P-ISSN: 2686-1216
http://biarjournal.com/index.php/bioex

# Effect of Thermal Processing on Elimination of Antinutritional Factors in Irvingia smithii Almond

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***Abstract:***

*The objective of this work is to identify and eliminate antinutritional factors in the fruit kernel of Irvingia smithii (wild mango tree) from the KISANTU botanical garden (DRC) by thermal effect at different temperatures (T1: sun drying, T2: roasting in an oven at 130° C for 30 minutes, T3: boiling for 45 minutes) as a function of time. It appears from the results of our analyzes that the fruit kernels of Irvingia smithii contain antinutritional factors in low proportions: phytates (536.34mg/100g), oxalates (14.84mg/100g), nitrates (12.71mg/100g, 8), and nitrites (50.15mg/100g,). Saponins were not found in these almonds. Treatment of almonds by boiling for 45 minutes (T2 treatment) proved to be the best eliminator of antinutritional factors (60%) followed by treatment of almonds by roasting (T3) (43%), probably by the dissolution of antinutritional factors in medium aqueous (hydrolysis) and their evaporation by boiling which takes place during cooking. Wild mango (Irvingia smithii) levels of antinutrients are low enough to cause poisoning in their consumers; they have not yet been detected in human tissue or the urine of their consumers. We recommend that the roasting of the almond is done before cooking which is done by boiling, a process which will eliminate almost all the antinutritional factors.*

***Keywords:***
*wild mango; Irvingia smithii; antinutritional factors; thermal effect*

## I. Introduction

Nowadays, non-timber forest products take an important place in cultural and economic development of local population depending on ecosystems (Awono and al., 2009; Vermeulen and al., 2009; Debroux and al., 2007).

Among them, four non-timber forest products are the most commercialized and consumed in central Africa are: Dacryodes edulis fruits, Ricinedendron heudelotti seeds, almonds of Irvingia gabonensis and Irvingia wombulu (Awono and al., 2009; Silou and al., 2004; Vermeulen, 2009).

Irvingia smithii, subject of the present study, is a wild mango tree in the family of Irvingiaceae (Tobe and Raven, 2001) widely distributed in dense humid forests and gallery forest of Africa. Its natural distribution area extends from Nigeria to Angola via the Gulf of Guinea, Cameroon, Gabon, the Central African Republic, the Democratic of Congo and the Congo Brazzaville (Anonyme 1, 2008; Tailfer, 1989).

Its pulp is less consumed such as the mango one, hence the name of the wild mango tree attributed to its tree (Gindo, 2017). But its almond is widely used to season dishes and thicken sauces in the same way as with peanuts and squash (Silou, 2004; Loumouamou et al., 2013; Gindo et al., 2015).

Studies on nutritional quality and chemical composition of Irvingia smithii show that its organic matter contains variable amounts of bioactive substances (proteins, especially lipids and minerals) and toxic and/or antinutritional chemical substances (alkaloids, oxalates, phenols, phytates, cyanides, nitrates, nitrites, etc.) (Drogba, 2010).

In addition, similar studies reveal the presence of low amounts of antinutritional factors in the kernels of wild mangoes of the genus Irvingia: Irvingia gabonensis (Ogungbenenle, 2014; J.E Ayivor et al, 2011; Abena et al., 2013), Irvingia wombolu (Ekpo et al, 2007) and Irvingia smithii (Gindo, 2015). Some of these antinutritional factors could associate with food components and lead to harmful consequences for consumers.

Moreover, the techniques for eliminating antinutritional factors generally involve imbibition in an aqueous medium (hydrolysis) and/or heating (boiling) or simply drying (evaporation) (Simon-Gérard, 1980; Bokanga, 1996; FAO, 2008).

Present study aimed at identifying antinutritional factors in almonds of Irvingia smithii and disposing of them by thermal treatment at different temperature as a function of time.

## II. Material and Methods

### 2.1 Material

Biological material used to carry out the present study consisted of fruits of Irvingia smithii harvested at the Botanical Garden of Kisantu, province of Kongo-Central (DRC), on 24 june 2015.

### 2.2 Methods

**a. Sampling**

The whole fruits were dried using solar energy for two weeks, then crushed in order to recover the almonds which were the subject of analyses.

***Figure 1.*** *Fresh fruits of I. smithii*

***Figure 2.*** *Fruits being dried*


***Figure 3.*** *Almonds of I. smithii*

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Almonds were separated into four groups at a rate of 20 grams per batch to undergo four different treatment modalities:

- T0: 20g almonds that have not undergone any heat treatment (control)
- T1: 20g almonds dried by sun exposure during one week
- T2: 20g almonds boiled for 45 minutes
- T3: 20g almonds roasted at 120°C for 30 minutes


***Figure 4****. Batchs of Irvingia smithii sample*

After drying, the different samples (T0, T1, T2, T3) subsequently underwent grinding using the Moulinex brand PHILIPPS HR2027. Powder obtained has been defatted by soxhlet using ether. Remaining cakes were dried in an oven at 50°C for 24 hours, and stored in hermetically sealed plastic jars before being analyzed.

**b. Chemical Analysis**

Moisture content determination and delipidation have been realized in the Laboratory of Food research and nutritional analysis, Faculty of Sciences, University of Kinshasa (DRC), whereas determination of antinutritional factors has carried out the Mining and geological Research Centre (CRGM) and in the Veterinary Laboratory of Kinshasa (Labovet).

Determination of the water content was carried out using the classic method of drying in an oven (brand MEMMERT model 100-800) at 105°C as described by Vervack (1982) whith an accuracy balance (OHAUS brand).

Phytic acid was measured by colorimetry at 830 nm using a spectrophotometer (HACH DR 2000) by exploiting its ability to form colored solutions with an ammonium molybdate and mercury reagent in a sulfuric acid medium. Solution absorbance is proportional to to the concentration of phytic acid according to the Lambert–Beer law.

Oxalic acid was measured by colorimetry at 420 nm using a spectrophotometer (HACH DR 2000). Its absorbance at this maximum obeys the Lambert–Beer law; thus, it can be dosed, first, by drawing a calibration line from solutions of known concentrations.
Saponins were qualitatively determined by the formation of foam in the filtrate (Trease and Evans, 2002).

Nitrates and nitrites were measured by colorimetry respectively at 500 nm and 585 using a spectrophotometer (HACH DR 2000).

The metallic cadmium reduces the nitrate present in the sample to nitrite in an acid medium.

Nitrite forms with sulphanilic acid an intermediate which is a diazonium salt. The diazonium salt couples with gentisic acid to form an amber-colored solution whose optical density at 500 nm is proportional to the nitrite content and therefore nitrate content. The nitrite ions present in a sample are reduced in an acid medium by iron (II) sulphate to nitrogen monoxide (NO) which combines with the Fe++ ions, forming a complex of greenish color whose absorbance at 585 nm is proportional to the concentration of nitrites presentin the sample (Vervack, 1982; Mbemba et Remacle, 1992; Fouassin et Noirfalèse, 1995 et Lutete, 1994; 21. Samir and al., 2014).

**c. Statistical Analysis**

Means and standard deviations were used to describe the data; while the statistical analysis referred to the analysis of variance using STATISTIX software version 8.0.
The Student's T test, tests of multiple comparison, of LSD, at the 5% threshold allowed to examine the differences observed between the means of the groups (difference between the treatments).

## III. Results and Discussion

### 3.1 Results

Results of the determination of the levels and elimination of the antinutritional factors of different treatments of almond samples *of Irvingia smithii* are given in tables 1 and table 2.

**Table** 1. Residual Antinutritional Factors Content in *Irvingia smithii* Almonds after Thermal Treatment (mg/100g)

| **Treatments/ time** | **Parameters measured (mg/100g)** | | | | |
|---|---|---|---|---|---|
| | **Phytates** | **Oxalates** | **Nitrates** | **Nitrites** | **Saponins** |
| **$T_0$ (Control)** | 536,34±1,43 | 14,84±1,5231 | 12,71±0,3601 | 51,15±1,6519 | - |
| **$T_1$: solar/ 7days** | 391,53±1,313 | 12,15±1,5706 | 8,4±1,1177 | 40,64±1,1903 | - |
| **$T_2$: Ebullition/ 45 minutes** | 240,6±1,745 | 6,34±0,5622 | 4,66±0,5396 | 18,03±0,8703 | - |
| **$T_3$ : toasting at 120°C/ 30 minutes** | 340,54±1,1829 | 8,33±0,5211 | 6,19±0,3231 | 31,53±1,0420 | - |

**Legend:**
$T_0$ : almonds that have not undergone any heat treatment (control)
T1 : almonds dried by sun exposure during one week
T2 : almonds boiled for 45 minutes
T3 : almonds roasted at 120°C for 30 minutes

**Table** 2. Amount of Antinutritional Factors Eliminated due to Thermal Treatment According to the Time

| **Treatment/times** | **Eliminated antinutritional factors (%)** | | | | |
|---|---|---|---|---|---|
| | **Phytates** | **Oxalates** | **Nitrates** | **Nitrites** | **Means** |
| **$T_1$: solar/7j** | 30 | 18 | 34 | 21 | 25,75 |
| **$T_2$: Ebullition/45 minutes** | 66 | 52 | 64 | 65 | 61,75 |
| **$T_3$: Roasting at 120°C/30 minutes** | 37 | 44 | 51 | 39 | 42,75 |

**Legend :**
$T_0$ : almonds that have not undergone any heat treatment (control)
T1 : almonds dried by sun exposure during one week
T2 : almonds boiled for 45 minutes
T3 : almonds roasted at 120°C for 30 minutes

**3.2 Discussion**

Tables 1 and 2 show an overall reduction in the levels of antinutritional factors in almonds having undergone heat treatments at different temperatures (T1, T2, T3) compared to control (T0) not subjected to any heat treatment.

Antinutritional factors content found in the Control (T0) corroborates those found by Gindo et al. (2015) in wild mango kernels of the species *Irvingia smithii* from the DRC.

The analysis of variance of the chemical composition of the wild mango almonds (*Irvingia smithii*) subjected to the thermal effect shows that there is a large significant difference in the elimination of the antinutritional factors between the treatments having been subjected to the thermal effect (T1, T3, and T2).

The LSD multiple comparison t-test at the probability threshold 5% shows these differences in elimination of antinutrients between treatments:

- *for the phytates*: almonds subjected to boiling treatment (T2) recorded a significant elimination of antinutritional factors (66%) (295,54 mg/100g) followed by that of roasted almonds (T3) which eliminated 37% (195,80 mg/100g); sun dried almonds recorded (T1) showed an élimination of 30% (144 ,81 mg/100g).
- *for the nitrites*: an significant elimination (65%) has been recorded for almonds submitted to boiling treatment (T2) (33,12 mg/100g), followed by the roasted almonds (T3) which eliminated 39% (19,62 mg/100g). Sun dried almonds (T1) eliminated 21% (10,51 mg/100g).
- *for the oxalates*: T2 eliminated 52 % (8,51 mg/100g), followed by (T3) with 44% (6,51 mg/100g) and then (T1) that eliminated 18% (soit 2,69 mg/100g).
- *for the nitrates*: a low elimination level has been recorded (34%) by T1 (4.31 mg/100g); roasted almonds (T3) eliminated 51% (6,55 mg/100g); the high elimination (64 %) was recorded by T2 (soit 8,05 mg/100g).

These results show that boiling treatment (T2) is the best eliminator (62% on average) followed by the roasting treatment, T3 (43%).

The dissolution of antinutritional factors in aqueous media (solubilization) which is accompanied by hydrolysis and their evaporation by boiling during cooking would probably be the basis of this significant elimination. The T2 treatment is a combined treatment of hydrolysis and evaporation (Bokanga, 1996; Simon-Gérard, 1980).

## IV. Conclusion

Present study aimed to identifying and eliminating different antinutritional factors present into almond of Irvingia *smithii* fruits from botanical garden of Kisantu, using thermal processing.

Our analyzes show that the fruit kernels of Irvingia smithii do not contain saponin, but contain a low proportion of phytates (536.34 mg /100g), oxalates (14.84 mg/100g), nitrates (12.71 mg/100g,) and nitrites (50.15 mg/100g).

Thermal processing has played an important role in the elimination of antinutritional factors, mostly with T2 (ebullition) that eliminated 62 % of these compounds. This is the best eliminating treatment before T3 (43%) and T1 (26%).

Thanks to the present study, consumers are recommended to proceed first by roasting and pre-grinding of the almonds of wild mango (*Irvingia smithii*) before cooking, as for other seeds rich in protein lipid (peanuts, squash).

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# Annex 1: Basic Datas

*Table 3. Residual antinutritional factors content in Irvingia smithii almonds after thermal treatment* ***(mg/100g)***

| Treatments | Repetitions | Parameters measured in mg/100g | | | | |
|---|---|---|---|---|---|---|
| | | Phytates | Oxalates | Nitrates | Nitrites | Saponins |
| | 1 | 536,71 | 16,51 | 12,55 | 52,02 | absents |
| $T_0$ | 2 | 534,77 | 13,52 | 13,13 | 49,11 | absents |
| | 3 | 537,56 | 14,51 | 12,47 | 51,92 | absents |
| | Average | 536,34 | 14,84 | 12.71 | 51,15 | |
| | 1 | 392,93 | 10,75 | 8,03 | 42,02 | absents |
| $T_1$ | 2 | 390,33 | 13,85 | 7,52 | 39,91 | absents |
| | 3 | 391,33 | 11,86 | 9,66 | 40,01 | absents |
| | Average | 391,53 | 12,15 | 8,4 | 40,64 | |
| | 1 | 242,33 | 6,07 | 4,5 | 19,04 | absents |
| $T_2$ | 2 | 238,84 | 5,97 | 5,27 | 18,03 | absents |
| | 3 | 240,63 | 6,99 | 4,23 | 17,04 | absents |
| | Average | 240,6 | 6,34 | 4,66 | 18,03 | |
| | 1 | 341,53 | 7,83 | 5,92 | 32,4 | absents |
| $T_3$ | 2 | 339,23 | 8,29 | 6,11 | 30,42 | absents |
| | 3 | 340,86 | 8,87 | 6,55 | 31,77 | absents |
| | Average | 340,54 | 8,33 | 6,19 | 31,53 | |
| | | | | | | |
| | | 532,74 | 15,51 | 13.51 | 53,01 | absents |

**Legend :**

$T_0$ : almonds that have not undergone any heat treatment (control)

$T_1$ : almonds dried by sun exposure during one week

$T_2$ : almonds boiled for 45 minutes

$T_3$ : almonds roasted at 120°C for 30 minutes

# Annex 2 : Statistical analysis

**Phytic acid**

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Statistix 8.0                                          04/04/2016,
11:18:14

Randomized Complete Block AOV Table for parametre

Source       DF        SS        MS          F         P
repetitio     2        13       6.6
Traitemen     3    136526   45508.7    78014.9    0.0000
Error         6         3       0.6
Total        11    136543
```

Grand Mean 376.67  CV 0.20

**Tukey's 1 Degree of Freedom Test for Nonadditivity**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Nonadditivity | 1 | 0.37075 | 0.37075 | 0.59 | 0.4763 |
| Remainder | 5 | 3.12925 | 0.62585 | | |

Relative Efficiency, RCB 2.73

**Means of parameter for Treatment**

| Treatment | Mean |
|---|---|
| T0 | 536.34 |
| T1 | 391.53 |
| T2 | 240.60 |
| T3 | 340.54 |

Observations per Mean 3
Standard Error of a Mean 0.4410
Std Error (Diff of 2 Means) 0.6236

Statistix 8.0 04/04/2016, 11:21:51

**LSD All-Pairwise Comparisons Test of parameter for Treatment**

| Treatement | Mean | Homogeneous Groups |
|---|---|---|
| T0 | 536.34 | A |
| T1 | 391.53 | B |
| T3 | 340.54 | C |
| T2 | 240.60 | D |

Alpha 0.05  Standard Error for Compar6son 0.6236
Critical T Value 2.447  Critical Value for Comparison 1.5259
Error term used: repetitio*Traitemen, 6 DF
***All 4 means are significantly different from one another.***

## Oxalates

Statistix 8.0 03/04/2016, 13:24:41

**Randomized Complete Block AOV Table for parameter**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| repetitio | 2 | 0.500 | 0.2500 | | |
| traitemen | 3 | 133.583 | 44.5278 | 43.32 | 0.0002 |
| Error | 6 | 6.167 | 1.0278 | | |
| Total | 11 | 140.250 | | | |

Grand Mean 9.7500  CV 10.40

**Tukey's 1 Degree of Freedom Test for Nonadditivity**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Nonadditivity | 1 | 0.05271 | 0.05271 | 0.04 | 0.8437 |
| Remainder | 5 | 6.11395 | 1.22279 | | |

Relative Efficiency, RCB 0.82

**Means of parameter for treatment**

| treatment | Mean |
|---|---|
| T0 | 14.833 |
| T1 | 12.553 |
| T2 | 6.347 |
| T3 | 8.337 |
| Observations per Mean | 3 |
| Standard Error of a Mean | 0.5853 |
| Std Error (Diff of 2 Means) | 0.8278 |

Statistix 8.0 03/04/2016, 13:26:18

**LSD All-Pairwise Comparisons Test of parameter for treatment**

| treatment | Mean | Homogeneous Groups |
|---|---|---|
| T0 | 14.833 | A |
| T1 | 12.553 | B |
| T3 | 8.337 | C |
| T2 | 6.347 | D |

Alpha 0.05 Standard Error for Comparison 0.8278
Critical T Value 2.447 Critical Value for Comparison 2.0255
Error term used: repetitio*traitemen, 6 DF
***There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.***

## Nitrates

Statistix 8.0 03/04/2016, 13:28:13

**Randomized Complete Block AOV Table for parameter**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| repetitio | 2 | 2.167 | 1.0833 | | |
| traitemen | 3 | 112.000 | 37.3333 | 448.00 | 0.0000 |
| Error | 6 | 0.500 | 0.0833 | | |
| Total | 11 | 114.667 | | | |

Grand Mean 7.6667 CV 3.77

**Tukey's 1 Degree of Freedom Test for Nonadditivity**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Nonadditivity | 1 | 0.00549 | 0.00549 | 0.06 | 0.8230 |
| Remainder | 5 | 0.49451 | 0.09890 | | |

Relative Efficiency, RCB 3.02

**Means of parameter for treatment**

| traitemen | Mean |
|---|---|
| T0 | 12.713 |
| T1 | 8.373 |
| T2 | 4.663 |
| T3 | 6.197 |
| Observations per Mean | 3 |
| Standard Error of a Mean | 0.1667 |

Std Error (Diff of 2 Means) 0.2357

Statistix 8.0 03/04/2016, 13:29:11

**LSD All-Pairwise Comparisons Test of parameter for treatment**

| treatment | Mean | Homogeneous Groups |
|---|---|---|
| T0 | 12.713 | A |
| T1 | 8.373 | B |
| T3 | 6.197 | C |
| T2 | 4.663 | D |

Alpha 0.05 Standard Error for Comparison 0.2357
Critical T Value 2.447 Critical Value for Comparison 0.5767
Error term used: repetitio*traitemen, 6 DF
***All 4 means are significantly different from one another.***

## Nitrites

Statistix 8.0 03/04/2016, 13:31:23

**Randomized Complete Block AOV Table for parameter**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| repetitio | 2 | 4.17 | 2.083 | | |
| traitemen | 3 | 1800.33 | 600.111 | 3086.29 | 0.0000 |
| Error | 6 | 1.17 | 0.194 | | |
| Total | 11 | 1805.67 | | | |

Grand Mean 35.167 CV 1.25

**Tukey's 1 Degree of Freedom Test for Nonadditivity**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Nonadditivity | 1 | 0.12640 | 0.12640 | 0.61 | 0.4710 |
| Remainder | 5 | 1.04027 | 0.20805 | | |

Relative Efficiency, RCB 2.63

**Means of parameter for treatment**

| traitemen | Mean |
|---|---|
| T0 | 51.153 |
| T1 | 40.643 |
| T2 | 18.000 |
| T3 | 31.530 |

Observations per Mean 3
Standard Error of a Mean 0.2546
Std Error (Diff of 2 Means) 0.3600

Statistix 8.0 03/04/2016, 13:32:12

**LSD All-Pairwise Comparisons Test of parameter for treatment**

| **treatment** | **Mean** | **Homogeneous Groups** |
|---|---|---|
| T0 | 51.153 | A |
| T1 | 40.643 | B |
| T3 | 31.530 | C |
| T2 | 18.000 | D |

Alpha 0.05 Standard Error for Comparison 0.3600
Critical T Value 2.447 Critical Value for Comparison 0.8810
Error term used: repetitio*traitemen, 6 DF
***All 4 means are significantly different from one another.***