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Technological Development of Irvingia Gabonensis (Péké) Kernels: Trial Production of Seasoning Products

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Abstract

This study explored the potential of Irvingia gabonensis kernels, a local resource in the Republic of Congo, for the production of seasoning fats and powders. The kernels, which have a low water content (2.86%) and a high oil content (39.2%), were processed into seasoning products. The manufacturing process consisted of three main stages: oil extraction, formulation according to mixing plans, and drying at 60˚C. In total, six samples of fats and six samples of powders were produced. A sensory evaluation was carried out on the seasoning powders. The results revealed a general acceptability of the products, with variations in preferences for aroma, colour, taste and flavour, which appear to be linked to variations in formulation, particularly the salt/sodium glutamate ratio. This study demonstrates the potential of Irvingia gabonensis for the development of innovative food products, thereby helping to diversify lipid sources and improve food security in the Republic of Congo. It also highlights the interest of future studies in oil characterisation, statistical analysis of sensory results and fat evaluation.

Keywords

Irvingia Gabonensis, Sensory Evaluation, Nutritional Value, Almonds, Characterisation, Blending Plan

1. Introduction

The Republic of Congo, with its humid tropical climate and vast arable land, has

considerable agricultural potential. However, only a tiny fraction of this land is exploited, mainly by farmers with limited resources. This under-exploitation leads to dependence on food imports, compromising food security and the diversification of sources of healthy lipids for the Congolese population.

According to GUOT data for the first half of 2024 [1], the Congo spends around 195.68 billion CFA francs per six-month period on imports of basic necessities, over 70% of which are foodstuffs.

Dietary surveys reveal excessive consumption of carbohydrates to the detriment of proteins and fats, with an average fat intake well below the nutritional recommendations, even in sports environments [2]. Faced with this situation, it is crucial to make the most of local resources.

Irvingia gabonensis, or wild mango, is a species endemic to the dense forests of Africa, renowned for its traditional uses in medicine and cooking [3]. Apart from its use as a simple thickener thanks to its mucilaginous substances, its kernels are a concentrated source of interesting nutrients. They have a high lipid content, dominated by saturated fatty acids, mainly myristic acid (50.23% to 53.97%) and lauric acid (30.16% to 35.53%), giving the oil good thermal and oxidative stability [4]. Studies have also identified other beneficial components such as dietary fibre (5.3%), protein (8.9%) and various minerals [5]. Medicinally, various studies have explored the properties of Irvingia gabonensis almond extracts, suggesting potential effects on weight management, blood sugar regulation and improvement of the blood lipid profile [6]. These properties make it particularly interesting to develop this fine for functional or improved food applications.

The aim of this study is to develop food products from the oil and cake of Irvingia gabonensis, with a view to enhancing the value of this local plant. The key stages of this research include the extraction of the oil, the formulation of seasoning products by experimental design, and the sensory evaluation of the products obtained, specifically the powders in this phase of the study.

2. Materials and Methods

2.1. Plant Material

The main plant material for our study was kernels extracted from the fruit of Irvingia gabonensis, collected in Sibiti, in the Lékoumou department of the Republic of Congo.

Figure 1 and **Figure 2** below show the fresh and dried then ground kernels of Irvingia gabonensis, respectively.

Additional ingredients were used in the formulation of the seasoning products: garlic (*Allium sativum*), spring onion (*Allium fistulosum*), onion (*Allium cepa*), nutmeg (*Myristica fragrans*), black pepper (*Piper nigrum*), sodium glutamate and cooking salt.

2.2. Methods

The methodology used for the production of seasonings consists of different pro-

cessing phases, illustrated by the diagram below.

Figure 1. Fresh kernels of *I. gabonensis*.

Figure 2. Crushed kernels of *I. gabonensis*.

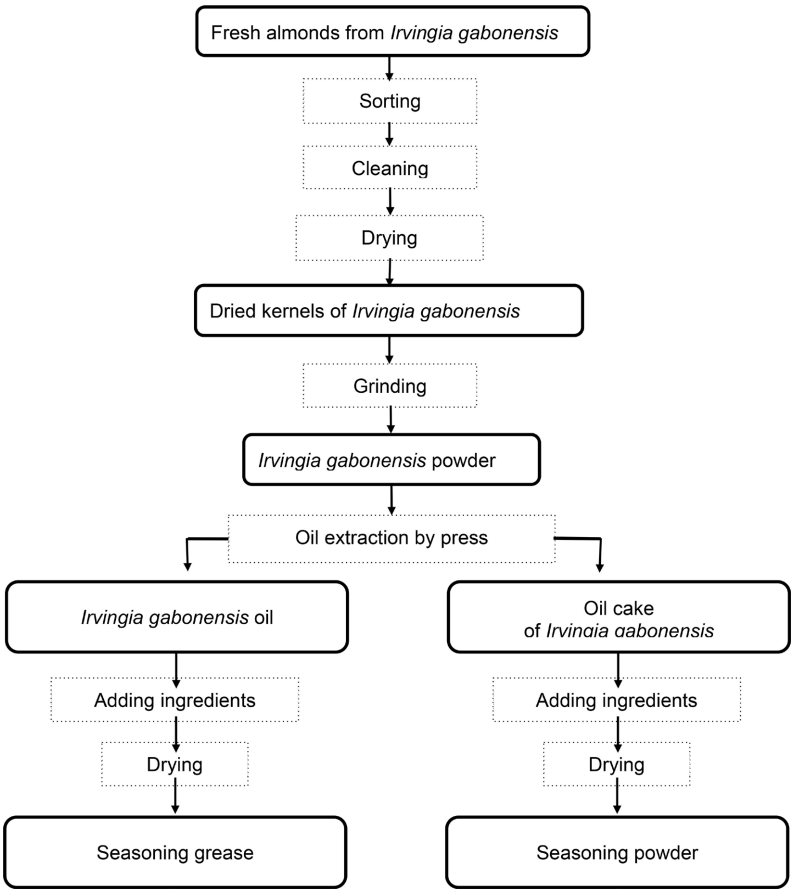

Figure 3. Production diagram for *Irvingia gabonensis* based seasoning products.

2.2.1. Drying of Almonds

The fresh fruit was mechanically crushed using a hammer. The kernels obtained were separated manually, sorted and cleaned to remove any impurities, before being dried in an Indelab oven at 60˚C for about 4 h. Moisture content was obtained in accordance with the protocol defined in AOAC standard 950.01-1950 [7] **Figure 3**.

2.2.2. Oil Extraction from Irvingia

The completely dry samples were ground in an electric cook work grinder. The oil contained in the kernels was extracted by pressing in accordance with the protocol used by Matouba *et al.* 2013 [8]. The powder obtained after grinding was heated to 110˚C for 20 minutes in an autoclave under a pressure of 1 bar. The result obtained was deoiled using a hydraulic press with a pressure of 5 tonnes.

2.2.3. Formulation of Seasoning Products

The design of the seasoning products, fats and powders, was optimised using a design of experiments to study the effect of varying certain key ingredients. We used an approach based on the principles of mixing designs for two variable components: salt (sodium chloride) and sodium glutamate, while keeping the quantities of the other ingredients constant. This methodology is particularly suitable when the quality of the final product depends on the relative proportions of its components, such as oils, spices and other ingredients [9]. In our case, we chose to explore the impact of the ratio between salt and sodium glutamate on sensory characteristics, as these are major taste modulators. The plan made it possible to systematically explore six formulations by varying the quantities of salt and sodium glutamate according to a predefined matrix (**Table 1** and **Table 2**). For each formulation, the quantity of oil for the fats or cake for the powders was set at 35 g. The quantities of the other spices (onion, garlic, spring onion, nutmeg, black pepper) were also fixed. Only the quantities of salt and sodium glutamate varied, for a combined total of 25 g per formulation. **Table 1** and **Table 2** show the exact proportions of ingredients for each formulation.

Table 1. Formulation of different seasoning fat samples.

Ingredients (g)	E1	E2	E3	E4	E5	E6
Oil	35	35	35	35	35	35
Salt	25	20	15	10	5	0
Onion	5	5	5	5	5	5
Garlic	5	5	5	5	5	5
Chives	5	5	5	5	5	5
Nutmeg	1	1	1	1	1	1
Black pepper	1	1	1	1	1	1
Sodium glutamate	0	5	10	15	20	25

E = Sample.

Table 2. Formulation of different seasoning powder samples.

Ingredients (g)	E1	E2	E3	E4	E5	E6
Oil cakes	35	35	35	35	35	35
Salt	25	20	15	10	5	0
Onion	5	5	5	5	5	5
Garlic	5	5	5	5	5	5
Chives	5	5	5	5	5	5
Nutmeg	1	1	1	1	1	1
Black pepper	1	1	1	1	1	1
Sodium glutamate	0	5	10	15	20	25

E = Sample.

2.2.4. Production Processes

Process for the production of seasoning fats from Irvingia gabonensis kernels

The seasoning fats were formulated from oil extracted from Irvingia gabonensis kernels. The kernels, previously dried and ground, were subjected to oil extraction by mechanical pressure, as described in Section 2.2.2. The spices and other ingredients needed to make up the fats were purchased from the Total market in Brazzaville. Once in the laboratory, the ingredients were sorted, washed and then ground separately using an electric blender, a hand grinder and a mortar. Six samples of seasoning fat were prepared according to a mixing plan (Table 1). The blends obtained were subjected to drying kinetics before being finalized. The resulting fats were stored in a refrigerator at 4˚C.

Process for the production of seasoning powders from Irvingia gabonensis kernels

The seasoning powders were formulated from Irvingia gabonensis kernel meal. The oilcake was obtained after extracting the oil by mechanically pressing the dried and ground kernels. The ingredients used in the formulation of the fats were also used for the powders. Six samples of seasoning powder were prepared according to the mixing plan described above (Table 2). The mixtures obtained were subjected to drying kinetics until ready-to-use powders were obtained.

The resulting powders were stored in a dry place, away from light and air, to prevent any moisture build-up.

2.2.5. Drying Kinetics of Seasoning Products

The resulting seasoning powders and fats, packaged in glass jars, were oven-dried at 60˚C for 7 hours. This meticulous drying process resulted in ready-to-use fats and powders, stored as defined in their production processes. The water and volatile substances content was obtained in accordance with the protocol defined by AOAC standard 950.01-1950 [7].

2.2.6. Sensory Evaluation of Seasoning Powders

Sensory analysis is a broad discipline whose primary aim is to ensure the profita-

bility of a food product by minimising its failure on the market. The aim of this technique is to improve, classify or describe the properties of food products in a rigorous and objective way by tasters [9]. To evaluate the organoleptic characteristics of *I. gabonensis* almond seasoning powders and identify the most popular formulation, a hedonic test was carried out. Consumers were asked to give subjective scores indicating the level of pleasure they experienced when eating the dishes.

The tests were carried out on omelettes prepared with the different powder samples and a control prepared without them. Eggs from laying hens were chosen as the tasting dish because they are easy to prepare and the taste is particularly appreciated by the Congolese.

That said, in order to take part in the sensory evaluation, the tasters had to be regular consumers of eggs, in order to best appreciate the variations in taste. A total of 8 untrained panellists with different backgrounds took part in the tasting. The sensory evaluations were carried out on the basis of pre-established tasting sheets using a rating system based on scale of 1 to 5, where 1 indicates "poor", 2 represents "bad", 3 denotes "average", 4 means "good", and 5 "very good" [10].

The characteristics chosen were smell, taste, flavour and colour.

3. Results and Discussion

3.1. Results

3.1.1. Water and Oil Content of Irvingia Gabonensis Kernels

Table 3 below shows the water and oil content obtained after processing the kernels of Irvingia gabonensis.

Table 3. Water and oil content of *Irvingia gabonensis* kernels.

Water content (%)	2.86 ± 0.10
Oil content (%)	39.2 ± 0.03

3.1.2. Drying Kinetics of Seasoning Products

Figure 4 and Figure 5 below show the drying kinetics curves for manufactured seasoning products. They illustrate the loss of mass of the samples as a function of the drying time at 60˚C.

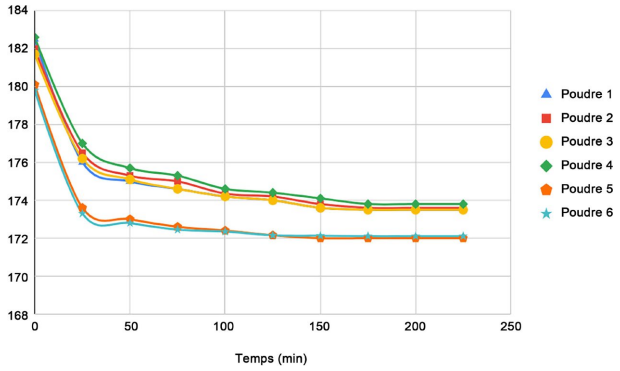

Figure 4. Drying curve for seasoning fats at 60˚C.

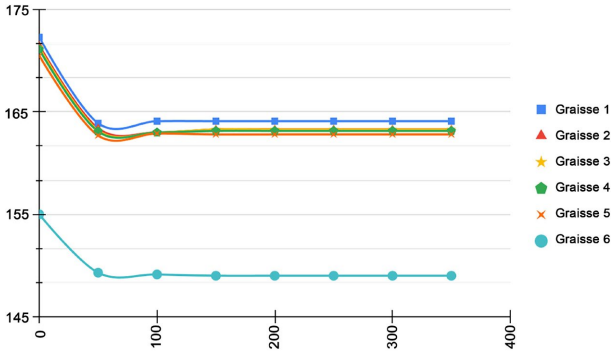

Figure 5. Drying curve for seasoning powders at 60˚C.

3.1.3. Sensory Evaluation of Seasoning Powders

The average results obtained during the sensory evaluation are shown in **Table 4** below.

Table 4. Average results obtained in the sensory evaluation of seasoning powders.

Parameters	E1	E2	E3	E4	E5	E6
Aroma	2.5	2.7	3	3.8	3.8	3.8
Colour	3.7	3.5	3.3	4.5	3.7	4
Taste	4	3.5	3.2	3.5	3.8	3.5
Taste	3	3.5	2.7	3.5	3.3	3.7

E = Sample.

The results of the sensory evaluation of the seasoning powders revealed a general acceptability of the powders manufactured, with average scores of over 3 for most attributes and samples, corresponding to an "Average" to "Very good" perception on the hedonic scale.

Variations were observed between samples for all the attributes assessed.

For colour, the scores ranged from 3.3 (Sample 3) to 4.5 (Sample 4). Sample 4 had the highest score, while Sample 3 had the lowest. The other samples had intermediate scores.

The aroma scores of the powders produced ranged from 2.5 to a high of 3.8. Samples 4, 5 and 6 obtained the highest scores, while Sample 1 received the lowest, suggesting a potential influence of formulation on aromatic intensity.

For taste, the highest score (4) was obtained by sample number 1 followed by sample 5 (3.8). The rest of the samples obtained a score of 3.5, with the exception of sample 3 which only scored 3.2. These variations could indicate an effect of the salt/glutamate ratio on taste perception. Sample 1, the richest in salt and without glutamate, scored best for pure taste, while samples with more glutamate (4, 5, 6) tended to score better for aroma and overall flavour.

The results for flavour were relatively similar, with an average of 3.28. Sample 3 obtained the lowest score (2.7), while samples 2 and 4 obtained the highest (3.5).

The radar graph below shows the data obtained during the sensory evaluation.

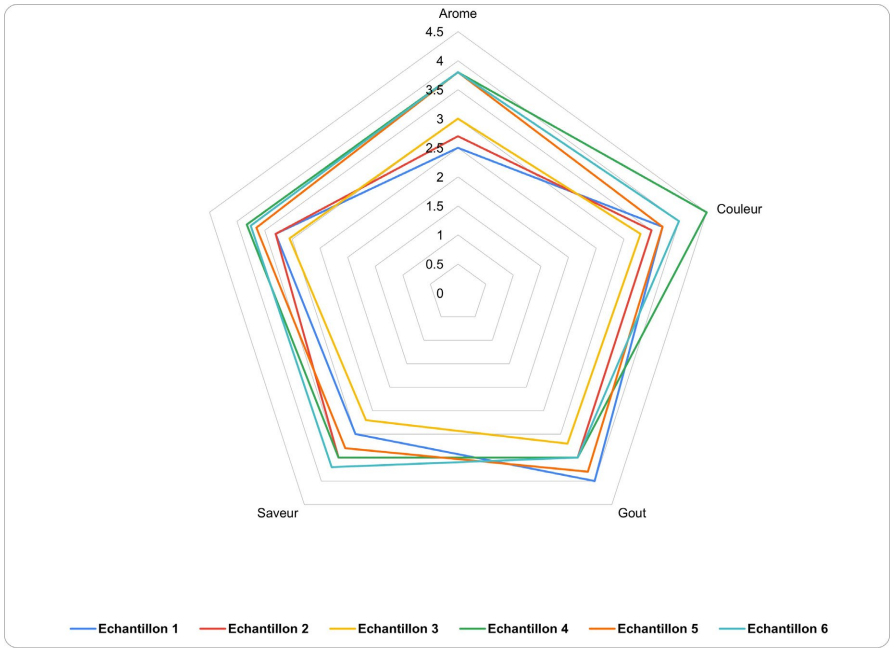

Figure 6. Sensory evaluation of seasoning powders.

3.2. Discussion

3.2.1. Water Content

The moisture content of the Irvingia gabonensis kernels studied was evaluated at an average of 2.78%. This value is relatively low compared to those obtained by Ejiofor *et al.* 1987 (11.90%) [11], Ibezim 2015 (8.28%) [12] and Ezeabara and Ezeani 2016 (11.54%) [13]. This can be justified by the fact that the seeds were stored for about three months at room temperature before being analysed, resulting in natural drying.

However, the moisture content obtained is within the same range as that found by Eka 1980 (2.10%) [14] as well as Elah 2010 [15] and Ogunsina *et al.* 2012 [16], who both obtained 2.55%. These authors report having bought the analysed kernels in state markets, which makes the hypothesis of natural drying plausible.

As the moisture content of fresh seeds generally varies between 10% and 14%, they need to be dried before being harvested to ensure better preservation.

3.2.2. Lipid Content

Analysis of Irvingia gabonensis kernels revealed an average lipid content of 39.2% ± 0.5%. This result is within the range of values reported by Silou *et al.* (2004) [17] and Matos *et al.* (2009) [18], who obtained 36.75% and 34.55% respectively. The higher value obtained in our study (39.2%) could be explained by the force applied during pressure extraction and by the efficiency of the equipment used.

It is important to note that this 39.2% oil content, obtained by pressing, is probably lower than the actual content. Pressure extraction is generally less efficient than other methods, such as extraction using organic solvents (Soxhlet). Statistical studies often show a difference of at least 20% between these two methods. For example, I. A. Amoukou *et al.* (2013) [19] obtained an oil content of 28.05% for

Sesamum indicum L. with manual pressing, compared with 50.20% with solvent extraction, a difference of around 22%.

The results of organic solvent extractions on Irvingia gabonensis obtained by E. Dahouenon-Ahoussi *et al.* (2012) (65.45% ± 2.53%) [4], Idowu *et al.* (2013) (67.69%) [20] and Ibezim (2015) (69.34%) [12] confirm this hypothesis.

The oil content obtained by pressing in our study is slightly higher than that of some common oilseed varieties, such as groundnuts (37.9% to 56.3%) [21] and palm oil (18%) [22].

3.2.3. Drying Kinetics for Seasoning Products

The drying kinetics curves (**Figure 4** and **Figure 5**) show a gradual reduction in the water and volatile substance content of the fats and seasoning powders over the 7 hours of drying at 60˚C. There was a reduction in drying of around 8 g for the powders and 15 g for the fats. This difference between fats and powders can be explained by the entrainment of part of the oil in the form of vapour in addition to the release of water orchestrated in the powders. This drying is crucial for the stability and preservation of finished products, limiting the risks of microbiological or chemical deterioration.

Visual analysis of the finished products revealed differences in colour: the fats had a more or less dark green hue, while the powders had a pale brown colour. These colour variations can be attributed to the differences in composition between the fats (oil-based) and the powders (cake-based), as well as to the Maillard reactions that occur during drying.

The dark green colour of the fats can also be justified by the addition of different pigments, such as chlorophyll pigments from ingredients such as spring onions, garlic and black pepper. As the oil is liquid at the time of formulation, it allows better homogenisation and stronger adhesion of the colour.

3.2.4. Sensory Evaluation of Seasoning Powders

The sensory evaluation of the seasoning powders revealed a general acceptability of the products, with above-average scores for all samples. Variations in average scores were observed between formulations for each attribute, suggesting an influence of composition.

In terms of colour, sample 4 received the highest score (4.5), while sample 3 obtained the lowest (3.3). These differences may be due to variations in the concentrations of the ingredients or to the drying conditions, with a possible influence of the Maillard reaction leading to a more or less intense brown colouration. The Maillard reaction is a complex chemical reaction that occurs mainly between amino acids and reducing sugars in the presence of heat. Although it is classically associated with high temperatures, often in excess of 120˚C, it is well established that this reaction can also occur at lower temperatures, such as those used during oven drying. The work carried out by Bouquelet, S. (2016) reports that, at 60˚C for 10 minutes, approximately 1% of the amino acids are blocked in a carbohydrate-amino acid complex [23].

The aroma of the powders was also well perceived, with samples 4, 5 and 6 receiving the highest scores. Sample 1 received the lowest score, suggesting a possible inadequacy of its formulation in terms of aromatic balance.

In terms of taste, sample 1 was judged the tastiest, followed closely by sample 5. Sample 3 obtained the lowest score, which could indicate an imbalance in the proportions of the ingredients or a possible alteration in the taste compounds during the drying process.

The flavour of the powders was generally appreciated, with relatively homogeneous scores. Samples 2 and 4 received the highest scores, while sample 3 received the lowest. These results suggest that the formulations of samples 2 and 4 achieved an optimal flavour balance, while sample 3 may require adjustment to improve its flavour profile.

This study shows that the sample most appreciated was sample 4 (**Figure 6**), followed by sample 6 with mean values of 3.82 and 3.75 respectively. This choice can be justified by the balance of the concentrations of sodium glutamate and NaCl known to improve the overall perception of the flavours and palatability of foods [24], as well as by the contribution of the aromatic compounds formed during the potential maillard reactions mentioned above.

4. Conclusions

The results of this study demonstrated the potential of Irvingia gabonensis kernels for the production of high-quality fats and seasoning powders. The low water content of the kernels and their high oil content make them an interesting raw material for the production of stable, lipid-rich food products. Sensory evaluation has identified the formulations most appreciated by consumers, paving the way for larger-scale production, subject to further study.

The drying kinetics revealed a gradual reduction in the water content of the products, which is essential for their preservation. The differences in colour observed between fats and powders can be attributed to their different compositions and to potential Maillard reactions.

This study is helping to diversify lipid sources and improve food security in the Republic of Congo. It also opens up prospects for the development of new food products based on Irvingia gabonensis, such as edible oils, bakery products and dietary supplements.

However, it should be noted that the present study has a number of limitations which, by way of prospects, pave the way for further work, particularly in the areas of characterisation of Irvingia gabonensis oil, sensory evaluation of seasoning fats, statistical processing of evaluation data and optimisation of the manufacturing process.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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