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Assessment, Quality and Sensory Evaluation of Crude Oil of *Polygala multiflora* Poiret in Burkina Faso

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Abstract

Polygala multiflora Poiret is an oleaginous plant in Burkina Faso, but most of its quality characteristics remain unexplored. This work aimed to evaluate the chemical and sensory quality of *Polygala multiflora* Poiret crude oil. Chemical parameters were determined using AOAC standards. The sensory analysis of the samples was carried out using three tests (descriptive and hedonic classification). Principal component analysis (PCA) was used to establish the relationship between the panelists' evaluation of the attributes and the type of oil extracted. The results showed that *P. multiflora* seed oil is mainly produced by women using a mechanical extraction process. The chemical analysis of the extracted oil showed a refractive index (1.45 ± 0.02), free fatty acids (1.97% ± 0.2% ac. oleic), acidity index (6.93 ± 0.14 mg KOH/g), saponification index (186.3 ± 9.31 mg KOH/g), iodine index (40.37 ± 0.5 gI2/100 g) and peroxide index (1.58 ± 0.05 Meq O_2/kg). The descriptive sensory attributes showed that the crushed seed oil had the highest appreciation percentage value. The hedonic test showed that the highest percentage value of the attribute "like it" was associated with whole seed oil. The results of the Principal Component Analysis (PCA) showed the variability of the sensory quality depending on the type of oil extracted.

Keywords

P. Multiflora, Seeds Oil, Chemical Properties, Sensory Profile, Burkina Faso

1. Introduction

In Burkina Faso, there are local oilseed trees with significant potential that are currently underutilized. Promoting these trees could generate substantial income for both rural and urban communities [1]. During the 2019 - 2020 agricultural campaign, oilseed production was primarily dominated by cotton (724,237 tons), peanuts (396,129 tons), sesame (374,703 tons), and soybeans (51,708 tons) [2]. The seeds from these oilseeds are processed into oils that are widely consumed by the population.

A quantity of approximately 86,000 tons of edible vegetable oils is produced each year. The annual demand for edible oils is estimated at 150,000 tons, with a growth rate of 4%. The deficit in vegetable oils is filled by imports, mainly palm oil from the Ivory Coast and Asia, of around 75,000 t of edible oils. A value of more than 14.6 billion FCFA [3].

The diet for most rural households is low in fat, which considerably reduces the energy and fat-soluble vitamin intake of the population. Artisanal edible oils occupy a preponderant place in the diet of the population [4]. Significant sources of available vegetable oils are not exploited or known. Productions from fats such as oils and kinds of butter used in food, cosmetics, and medicine; represent real opportunities for Burkina Faso to improve its gross domestic product through exports [5].

Burkina Faso, like most West African countries, is heavily dependent on imports at more than 50% to meet the oil needs of its population. Despite this, market needs remain at a low level. This results in pressure on prices [6]. Furthermore, imported oils are not always of good nutritional or hygienic quality and can be sources of public health problems. The oilseed sector is, therefore, strategic for Burkina Faso. However, insufficient oilseed production significantly limits the country's domestic oil production.

Therefore, the need to diversify the supply of seeds for crushing is imperative for securing the sustainable supply of oil to consumers. Among the oilseed plants with high potential, *P. multiflora* Poiret presented an important source of oil that can be explored for nutritional assessment. It is a plant species of the *Polygalaceae* family native to West Africa [7] which has been less studied.

The seeds of *P. multiflora* have an important potential to develop oil production in Burkina Faso, which could place it among the main producing and exporting countries. The quality of oil has not been consistently a priority, but currently, there is a renewed interest in the quality.

However, research work on the quality criteria of these seeds, their properties, and the nutritional value of the extracted oil is rare, or even absent. The extraction process and several accompanying parameters can influence the quality, stability, and purity of oil. The enhancement and improvement of extracted oil of *P. multiflora* require studying its chemical quality and sensory properties which must comply with international standards. This study aimed to assess the quality sensory properties of *P. multiflora* oil to valorize it as an oleaginous source.

2. Material and Methods

2.1. Study Design and Setting

The study consisted of a survey of producers, processors, and traders of seeds and products of *P. multiflora* Poiret, in the localities of Sassema (10˚24'26.2"N, 4˚33'44.7"W) and Ounoungou (12˚32'N, 2˚12'E). The figure shows the location of the study sites. The survey questionnaire was designed with the Sphinx Plus²-V4.5 software. The data was filled in using survey sheets. The respondents were producers, processors, and traders of *P. multiflora* Poiret seeds.

The survey focused on the socio-demographic data of the producers, the uses and socio-economic importance of *P. multiflora* Poiret products, and the control of oil production. A total of 44 producers of *P. multiflora* Poiret seed and oil were randomly selected for the survey. The main techniques used to collect data and information were interviews and field visits. The interviewees were reference persons able to provide concrete details.

2.1.1. Collection of Socio-Demographic Data

Sociodemographic data were collected using a questionnaire covering gender, age, occupation and educational level.

2.1.2. Evaluation of Forms of Use and Socio-Economic Importance of *P. multiflora*

A questionnaire was used to collect data from respondents on the number of producers, forms of seed use and consumption, annual production, quantity consumed, and quantities of seed and oil marketed.

2.1.3. Diagnostic of the Extraction Process of Oil

The different steps of the main oil extraction process were followed and analyzed.

2.2. Sampling and Preparation

The biological samples consisted of *P. multiflora* Poiret seeds collected from *P. multiflora* Poiret seed producers in the East-Central region of Burkina Faso.

A total of 100 samples of *P. multiflora* Poiret seeds (2 kg/sample), including 50 samples in the village of Sassema and 50 in Ounoungou, were collected, placed in amber bags, and then transported to the laboratory. Sampling was randomized 50/50 to ensure that the geographic distribution of producers is adequately represented.

They were dried in the laboratory at room temperature (25˚C~30˚C).

Upon arrival at the laboratory, the seed samples were carefully sorted to remove foreign matter and packed in plastic bags. Part of the samples was reduced to ground material with a particle size of 1 mm, obtained after grinding the seeds with a grinder and stored in airtight glass jars protected from light while awaiting biochemical analysis.

2.3. Oil Extraction Process

The fat was extracted from a mass of *P. multiflora* seed powder with hexane using the Soxhlet method for 10 hours according to the standard method [8].

2.4. Analysis of Chemical Parameters of Extracted Oil

The refractive index of seed oil and free fatty acid value were determined by the standard method [8]. The oxidative stability was determined following the AOAC standard [9]. The acid, saponification, peroxide, and iodine indices were analyzed by AFNOR standards method [8].

2.5. Diagnostic of Oil Production

The process of 4 types of oil produced was carried out to monitor the different steps. The central process flow chart was used to obtain the 4 types of oil extracted. The 4 oil samples obtained for the sensory test were respectively: crushed seed oil extracted by press (A), whole seed oil extracted by press (B), boiled seed oil (C), and roasted seed oil extracted by hand (D).

2.6. Sensory Analysis

2.6.1. Ethical Considerations

The methodology and data collection instruments were validated by the Ethics Committee for Health Research (CERS) of Burkina Faso, consultation no. 2024-06-198. Informed consent and the favorable opinion of the participants were mandatory for ethical compliance. An information sheet was used to explain the purpose, importance, and scope of the study. A consent form was then given to the tasters to obtain their informed consent by signature. The participants were assured that the confidentiality of the information to be collected would be respected. A hygiene check was carried out beforehand to ensure the safety of the samples to be tested.

2.6.2. Analysis of the Sensory Profile and Hedonic Appreciation

The organoleptic analysis of the different samples of *P. multiflora* Poiret seed oil was carried out according to the standard method [10]. A total of 04 oil samples were evaluated by the tasters. The sensory evaluation of the freshly prepared oil samples was carried out under controlled room conditions to ensure accurate and reliable results.

The samples were: crushed seed oil extracted by press (A), whole seed oil extracted by press (B), boiled seed oil (C), and roasted seed oil extracted by hand (D). The evaluation focused on multiple acceptability of color, appearance, consistency, smell, aroma, taste, rancidity, and texture. A 5-point hedonic descriptive scale was used for scoring, ranging from 1 (like it a lot) to 5 (dislike it), allowing panelists to provide accurate and detailed feedback. The 30 panelists selected for the sensory evaluation had no known allergies to the tested oil. Before the sensory test, the selected panelists underwent a preparatory session to familiarize them with the descriptive profile of the attributes. This session gave them a clear understanding of how to evaluate and rate the attributes. However, to avoid bias, the panelists were not informed about the coding of the samples, thus ensuring that their ratings were blind and unbiased. The samples were coded according to the standardized three-digit code table [11]. The room conditions during the sensory evaluation were careful to minimize any external factors that might influence the panelists' perceptions. The analysis of the hedonic profile was carried out using the preference test according to the method described by Watts *et al.* [12]. The ranking was carried out according to the method described by Cochran and Cox [11].

2.7. Data Analysis

All data from the different activities were entered, processed, and analysed in the Excel 2020 spreadsheet. Results were expressed as mean. Qualitative and quantitative data from the survey were entered and processed using Sphinx Plus^2-V4.5 software to determine means, correlations, and significant differences. The difference between the results of the different variables was determined by analysis of variance (ANOVA) using the Chi2 test at a significance level of $p < 0.05$. The sensory analysis data were entered in EXCEL and processed with SPSS software and XLSTAT 2016.02.27444 software using the ANOVA test at the probability threshold. To visualize the relationships between the products and their attributes, PCA was performed with 4 products and 8 attributes.

3. Results and Discussion

3.1. Data of the Survey

3.1.1. Socio-Demographic Characteristics of the Stakeholders

The socio-demographic data of the actors interviewed in the two localities (Sassema and Ounoungou) are presented in **Table 1**.

The population surveyed was predominantly female, 80.85% of whom were married. The producers were divided into four age groups, with the 45 - 54 age group in the majority (46.80%). Most of the female producers were farmers (68.10%) and uneducated (74.47%).

3.1.2. Forms of Use and Socio-Economic Importance of *P. multiflora* Poiret Products

The survey data on the use of seeds and oil of *P. multiflora* Poiret are presented in **Table 2**. The data obtained from this survey allowed us to identify a potentially growing interest in the plant.

The survey revealed an annual production of 7.2 and 6.9 tons by 25 and 22 producers respectively in Sassema and Ounoungou. The plant was mainly exploited for its seeds (95%) and secondarily for its stems and leaves (5%). The leaves and stems were dried, bagged and sold by women in local markets and used to prepare decoctions and infusions for therapeutic treatments. The seeds were consumed as a seasoning for sauces (90%). The quantities of seeds marketed were estimated at 2.8 and 2.2 tonnes per year for the Sassema and Ounoungou zones respectively. The quantities of oil sold were 253 and 217 liters respectively. The average quantities of seeds consumed as condiments were 0.5 and 0.12 tons per year for the two production areas.

Table 1. Socio-demographic data of respondents.

Socio-demographic characteristics		Areas				Total frequency number	
		Sassema		Ounoungou			
		N	P (%)	N	P (%)	N	P (%)
Gender	Female	21	100	23	100	44	100
	Male	00	00	00	00	00	00
Marital status	Married	21	100	23	100	44	100
	Single	0	0	0	0	0	0
Occupation	Farmers	15	34.1	14	31.8	29	65.9
	Traders/sellers	6	13.8	9	20.5	15	34.1
Age	≤35	2	4.5	0	0	2	4.5
	36 - 44	5	11.4	4	9.1	9	20.5
	45 - 54	3	6.8	5	11.4	8	18.2
	55 - 64	8	18.2	6	13.6	14	31.8
	≥ 65	3	6.8	8	18.2	11	25
Educational level	Out of school	16	36.4	20	45.5	36	81.8
	Literated	0	0	2	4.5	2	4.5
	Primary school	2	4.5	1	2.3	3	6.8
	Junior high school	3	6.8	0	0	3	6.8

Legend: N= number; **P%** = Percentage.

Table 2. Production, use and marketing of products.

Variables	Areas	
	Sassema	Ounoungou
Number of producers	21	23
Forms of exploitation	Seeds (95%), stems and leaves (5%)	
Forms of seed consumption	sauce ingredients (90%), therapeutic care (10%)	
Seeds production (t/year)	7.2	6.9
Quantity of seeds sold (t/an)	2.8	2.2
Quantity of seeds consumed as ingredients (t/an)	0.5	0.12
Quantity of extracted oil marketed (L/an)	253	217

The results of the present study corroborate those of Nadembega *et al.* [13], who pointed out in her work that the plant parts used by *P. multiflora* Poiret are the leaves, stems, and seeds. The seeds are used to extract oil, as a paste in sauce, and mixed with millet as an energy drink. According to the respondents, the leaves and stems are used as a decoction to treat certain diseases such as malaria and jaundice and to reduce miscarriages. Compared to the production of other oilseeds, the quantities of *P. multiflora* seeds produced in these two locations were significantly lower than the average production statistics for the last 10 years for peanuts (292,614 tons) and sesame (21,487 tonnes), but also close to the production of soybeans (7315 tons) [6]. The economic interest of *P. multiflora* Poiret was comparable to that found by Keita [14] for the exploitation of oilseeds, in particular *Jatropha curcas*. However, the economic benefit is significantly lower than that of sesame seed for a production of 25,000 tons at a selling price of 300 FCFA/kg, representing a total resource of 11 million euros [6]. These data demonstrate the nutritional and economic importance of the herbal product of *Polygala multiflora* Poiret in these two localities in Burkina Faso.

According to market viability and scalability, the *P. multiflora* oil demand could be grow due to the annual demand for edible oils which is estimated to 150,000 tons in Burkina Faso, with a growth rate of 4% [2].

In Burkina Faso, widely produced and consumed oils extracted from cottonseed, groundnut, sesame, and shea kernel oil. Approximately 86,000 tons of edible vegetable oils are produced each year.

3.2. Assessment of Oil Establishment

By monitoring the different steps of oil processing, it was possible to construct the artisanal production diagram for *Polygala multiflora* Poiret oil. The flow chart for the extraction of oil from *P. multiflora* seeds is shown in **Figure 1**.

It was shown that the flow chart of the oil production process could influence its sensory characteristics. The production of the oil was carried out in the following 8 steps by the artisanal companies:

Sorting-Hulling

The seeds are sorted and hulled by hand. During this stage, impurities are removed in order to optimize the quality of the production.

For sorting, a plastic bag is spread out on the floor of the workshop and the seeds to be sorted are poured into it. Operators sitting on the floor sort the seeds by removing the husks.

Cleaning

This step consisted of winnowing, desanding, and washing the seeds to remove impurities. The cleaned seeds were separated from impurities (sand, pebbles, wood debris, stones) and collected in a container.

Drying

This operation consisted of exposing the seeds to the sun on a clean surface. The seeds were spread out in the drying area for a few days (3 to 5) until the almonds dried properly.

Roasting

This was done in a pot heated by a wood fire. The seeds were visually monitored during this process. The heated seeds were continuously stirred by rotating them. Roasting stops when a specific odor is released. It increases the crude lipid content, crude protein, ash, water and oil absorption capacity, and gelling temperature.

Grinding-Kneading

It consisted of grinding the product obtained after roasting. The roasted seeds were ground in a wooden mortar and mixed with water to obtain a paste. The resulting paste was left to cool before extraction.

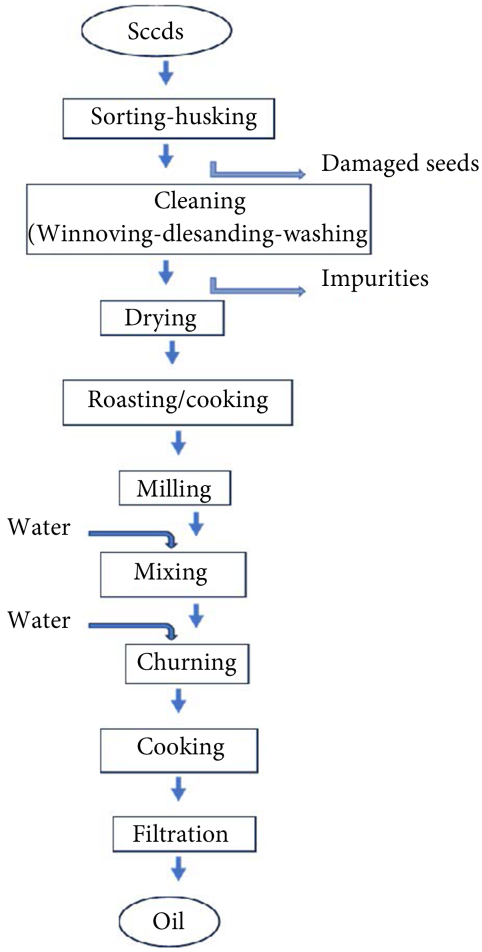


Figure 1. Process central flowchart for extraction of oil from *P. multiflora* seeds.

Pressing

The oil was extracted using a press. The seeds were crushed between the screw and the press cylinder. The oil comes out through the spaces between the circular rings, the cake comes out at the end of the press in the form of scales and they are collected in basins.

Filtration

Oil filtration was carried out on nylon fabrics to retain residues and certain contaminants. It was carried out by transfer through a thin cloth into a storage container.

Storage/ Packaging

Oil filtration was carried out on nylon fabrics to retain residues and certain contaminants. It was carried out by transfer through a thin cloth into a storage container.

Figure 1 demonstrates the main steps of oil extraction but for industrial applications, the process comprises two fundamental stages: preparation of the seeds (crushing), followed by separation of the oil fraction from the other solid and liquid components refinery method.

3.3. Chemical Characteristics of Extracted Oil

The chemical properties of the oil due to the process could affect its sensory profile. The chemical characteristics of the extracted oil from *P. multiflora* seeds are presented in Table 3. The extracted oil showed mean values of 1.45 ± 0.02 at 120˚C, 2.11 ± 0.03 h, and 1.97% ± 0.2% for refractive index, oxidative stability, and free fatty acid respectively. The results showed that the acid value, which is an index of free fatty acid content due to enzymatic activity in the samples, was 6.93 ± 0.14 (mg/KOH).

Table 3. Chemical parameters of extracted oil.

Parameters	Mean Value
Refraction index (at 120˚C)	1.45 ± 0.02
Oxidative stability (h)	2.11 ± 0.03
Free fatty acid (as oleic %)	1.97 ± 0.2
Acid value (mg KOH/g)	6.93 ± 0.14
Iodine value (gI_2/100g)	40.37 ± 0.5
Saponification value (mg KOH/g)	186.3 ± 9.31
Peroxide value (Meq O_2/kg)	1.58 ± 0.05
Ester index (mg KOH/g)	179.37 ± 12.98

The iodine value is a measure of the degree of unsaturation of vegetable oils and an indicator of their susceptibility to oxidation. The iodine value of *P. multiflora* was found to be 40.37 ± 0.5 as I2/100 g oil. The saponification value obtained from this work indicated that the oil contained 186.3 ± 9.31 mg KOH/g. The peroxide value is an indicator of the amount of primary oxidation products and oxidative stability in the oil product. The peroxide and ester index values of the extracted oil were found to be 1.58 ± 0.05 (Meq O_2/kg) and 179.37 ± 12.98 (mg KOH/g) respectively.

P. multiflora Poiret oil presented a refractive index (1.45 ± 0.02) close to that obtained with chia seed oil from Mexico (1.47) by Segura-Campos *et al.* [15], *Griffonia simplicifolia* oil (1.48) by Novidzro *et al.* [16], cottonseed oil (1.470 - 1.473) by Aïssi *et al.* [17] at the same temperature. However, the value of the index is within the range established by Codex Alimentarius 210 [18].

A previous study showed that the refractive index depends on the analysis temperature and the unsaturation content of the fatty acids [15]. The authors found that high analysis temperatures had low refractive index values and that high unsaturation content was associated with high refractive index values. The refractive index is considered a criterion for the purity of an oil. This index is proportional to the molecular weight of the fatty acids and their degree of unsaturation.

In terms of oxidation stability, an induction time of 2.11 ± 0.03 h was found for the solvent-extracted seed oil, which is close to the value of the chia seed oil tested (2.4 h) reported by Meléndez-Martínez *et al.* [19]. The value found in this study was lower than that reported by Gharby *et al.* [20], who found induction times of 13 and 9 h for cold-pressed and solvent-extracted Nigella seed oils, respectively. Cheikh-Rouhou *et al.* [21] reported a higher induction time of 12 h for *Nigella* oil from Tunisia.

Oxidative stability is an important parameter for estimating the sensitivity of vegetable oils to oxidation and consequently their shelf life [22]. The oxidative stability of the oil depends on the composition, concentrations, and activity of the reaction substrates and antioxidants. To minimize the use of food additives, oxidative stability can potentially be improved by preserving or enhancing the endogenous oxidation control systems of foods [23].

The free fatty acid content of the oil was 1.97% ± 0.2%, reflecting endogenous enzymatic hydrolysis of triacylglycerides. Our results were lower than those reported for solvent-extracted Nigella seed oil (2.3%) by Gharby *et al.* [20] in Morocco. According to Sultan *et al.* [24], enzymatic hydrolysis reactions of triacylglycerides and saponification reactions are responsible for the formation of free fatty acids (FFA) in vegetable oils. The determination of free fatty acids is particularly important for industrial purposes because this component can modify the organoleptic or physicochemical properties of the oil.

The iodine index was 40.37 ± 0.5 g I2/100 g. Compared to other common oils, it was lower than that of soybean oil (120 - 143), sesame oil (118 - 120), and peanut oil (85 - 90) [25]. It was found to be lower than the iodine value of linseed oil (187 gI_2/100 g oil) [26]. Low iodine lipids have fewer unsaturated fatty acid structures and greater oil stability. The iodine index of the oil obtained from these *P. multiflora* Poiret seeds confirms its nutritional potential. However, further studies are needed to evaluate its anti-nutrient content.

The acid value of 6.93 ± 0.14 mg/KOH of *P. multiflora* Poiret seed oil was higher than that of chia oil (1.64 mg KOH/g) obtained by Patil and Nawab [27] using the pressure extraction method.

The saponification index value obtained by the hexane extraction method was 186.3 ± 9.31 mg KOH/g. This value is comparable to the saponification index of common oils such as soybean (189 - 195), groundnut (187 - 196) and cottonseed (189 - 198) [28] (FAO/WHO, 2001).

The higher saponification index indicates the presence of high triacylglycerol content [29].

The peroxide index was 1.58 ± 0.05 Meq O_2/kg, a value close to that of Argentine chia seed oil (1.97) obtained by Uzunova *et al.* [23], but lower than the 10 Meq O_2/kg that characterizes most conventional oils [28].

Peroxides are unstable and break down into minor carbonyl oxidation products and are responsible for unfavorable oil flavors. In fact, peroxide index values below 10 Meq O_2/kg are generally considered an acceptable level of oxidation [30]. The ester index of *P. multiflora* Poiret seed oil was 179.37 ± 12.98. This value was comparable to that of oil extracted from *Afzelia Africana* almonds from Côte d'Ivoire (179.11 ± 0.10) [31].

P. multiflora oil regarding global standards for edible oils, the chemical composition of extracted oil is in line with the limits established by the Food Codex [18]. No anti-nutritional factors were detected in the analyzed oils.

3.4. Sensory Profile of Extracted Oil Samples

The mean values of the descriptive sensory attributes for each product are shown in **Figures 2-10**. The interactions between products and panelists for all sensory attributes were not significant ($p > 0.05$), indicating that the oil samples tested were perceived similarly by the panelists. Positive attributes were associated with the intensity of perception as light yellow, beautiful, liquid, good, pleasant, melting, and not rancid for color, appearance, consistency, smell, aroma, taste, texture, melting, and rancidity. In contrast, dark, not nice, solid, not good, not pleasant, not melting, and very rancid were associated with negative attributes.

Sensory evaluation is used because it is the most effective method of assessing the qualitative differences between oils, differences that cannot be detected by physico-chemical analysis.

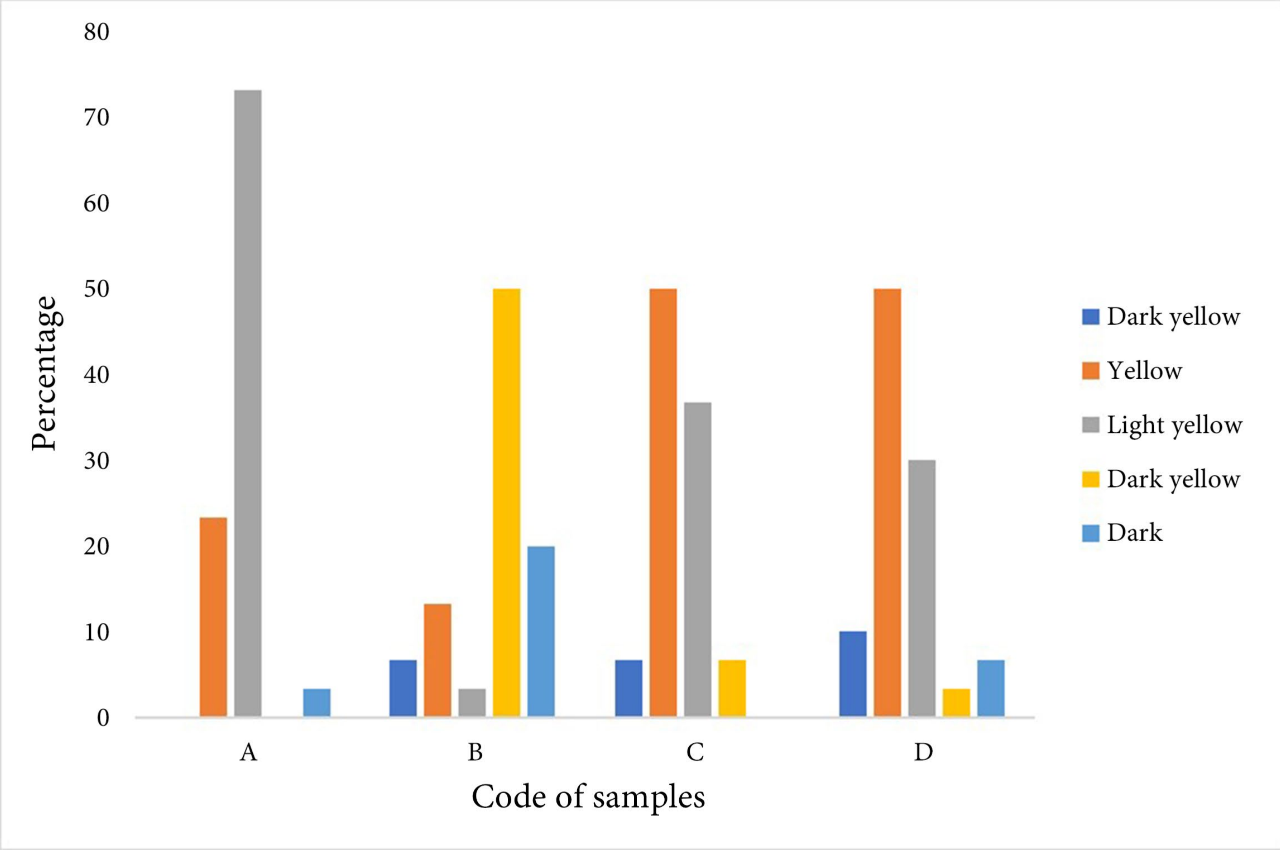
Color

The results of the color description of the oils are shown in **Figure 2**. Overall, there was no significant difference ($p > 0.05$) in the color perception of the panelists. Of the 30 tasters, 73.3% perceived the pressed crushed seed oil as light yellow. In contrast, 50% attributed a dark yellow color to the pressed whole seed oil.

In addition, 50% of the tasters described the color as yellow, both for the boiled seed oil and for the hand-extracted roasted seed oil. The color is associated with the quality of *P. multiflora* seed oil and ranges from light yellow to dark, depending on the concentration of chlorophyll and carotene in the plant. Chlorophylls are responsible for the yellow-green color, while carotene gives a color between yellow and red. The level of these substances is linked to genetic factors, production conditions, and the stage of ripeness of the seeds. The color of the oil is one of the factors that determine consumer acceptance and is very important in determining its subsequent use [32].

Appearance

The results of the visual description of the oils are shown in **Figure 3**. The statistical analysis did not show a significant difference ($p > 0.05$) in the way the panelists evaluated the oils. Regarding the appearance of the oils, 56.7% and 50% of the tasters associated the attribute "beautiful" with the crushed seed oil and the roasted seed oil, respectively. On the other hand, 46.7% of the tasters considered the appearance of the boiled seed oil to be less attractive. However, 40% of the tasters considered the appearance of the hand-extracted boiled seed oil to be very beautiful. The appearance was judged differently according to the type of extraction process.



Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 2. Results of color appreciation.

It could sometimes vary due to the presence of different metabolites. Siddiq *et al.* [33] reported that continuous processes and practices for oil extraction could deteriorate the stability and appearance of the oil.

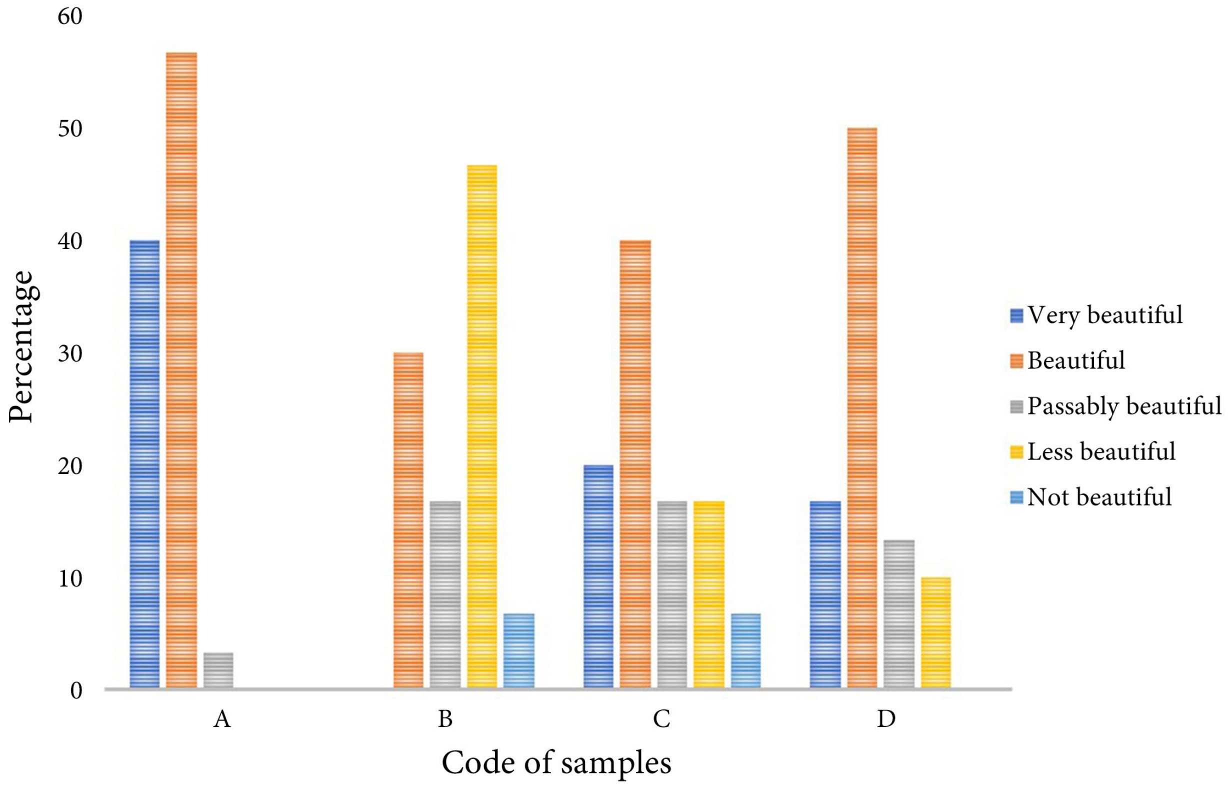
Consistency

Appreciation of oil consistency was assessed and the results are shown in **Figure 4**. There was no significant difference ($p > 0.05$) between the tasters' evaluations. In terms of oil attributes, the very liquid consistency was attributed by 76.7% of tasters to crushed seed and whole seed oil extracted by the press, respectively. The semi-liquid consistency was attributed to boiled seed oil extracted by hand (46.7%) and roasted seed oil (33.3%). The difference in consistency ranking in this study could be related to the technical process of oil extraction.

Consistency is one of the essential parameters required to determine the quality and stability of the food system [34].

Smell

The oil smell was rated and the results are shown in **Figure 5**. There was no significant difference ($p > 0.05$) between the panelists' ratings. Regarding the odor of the oils, crushed seed oil and roasted seed oil were rated quite good by 40% and 30% of the panelists respectively. A good smell was attributed to whole seed oil (33.3%)



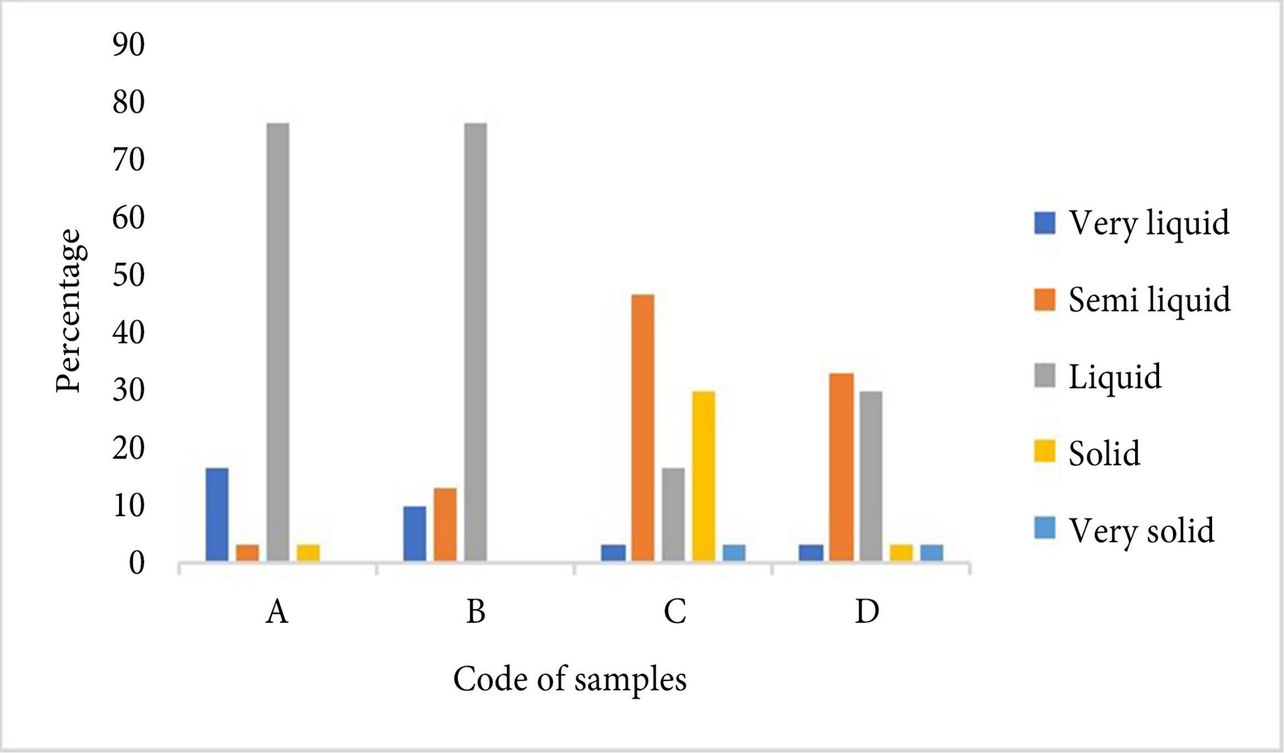
Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 3. Results of appearance appreciation.

and a less good one to boiled seed oil (33.3%). Thus, less than 40% of tasters liked the smell of whole-seed oil. The smell of food is a reaction when volatile compounds from the food enter the nasal cavity and are perceived by the olfactory system [35].

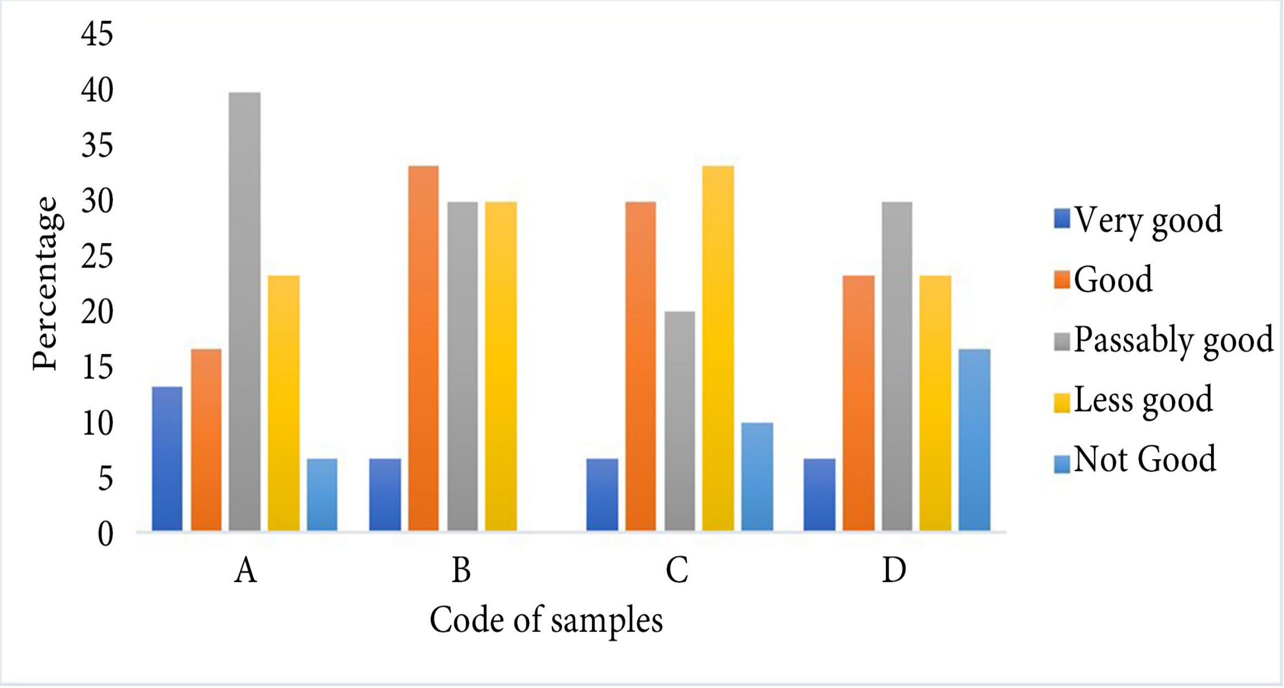
Aroma

The sensory evaluation of the aroma was described and the results are shown in **Figure 6**. No significant difference ($p > 0.05$) was found in the type of evaluation made by the panelists. 53.3% and 43.3% of the tasters, respectively, associated good attributes with whole seed oil and extracted boiled seed oil. The same good rating was given to crushed and roasted seeds by 36.7% and 30% of the panelists respectively. The difference in the percentage of attribution to aroma evaluation in the 4 types of samples may be due to the chemical composition influenced by the extraction process. Aroma is essential in the food industry as it can enhance the taste and appeal of food products. Oil aroma is the sum of the sensory perceptions generated when the various chemical compounds transported with the air during inhalation and exhalation reach the olfactory receptors. The aroma is made up of volatile low molecular weight chemical compounds. The aroma oil is strongly correlated with its quality level and nutritional value [36].



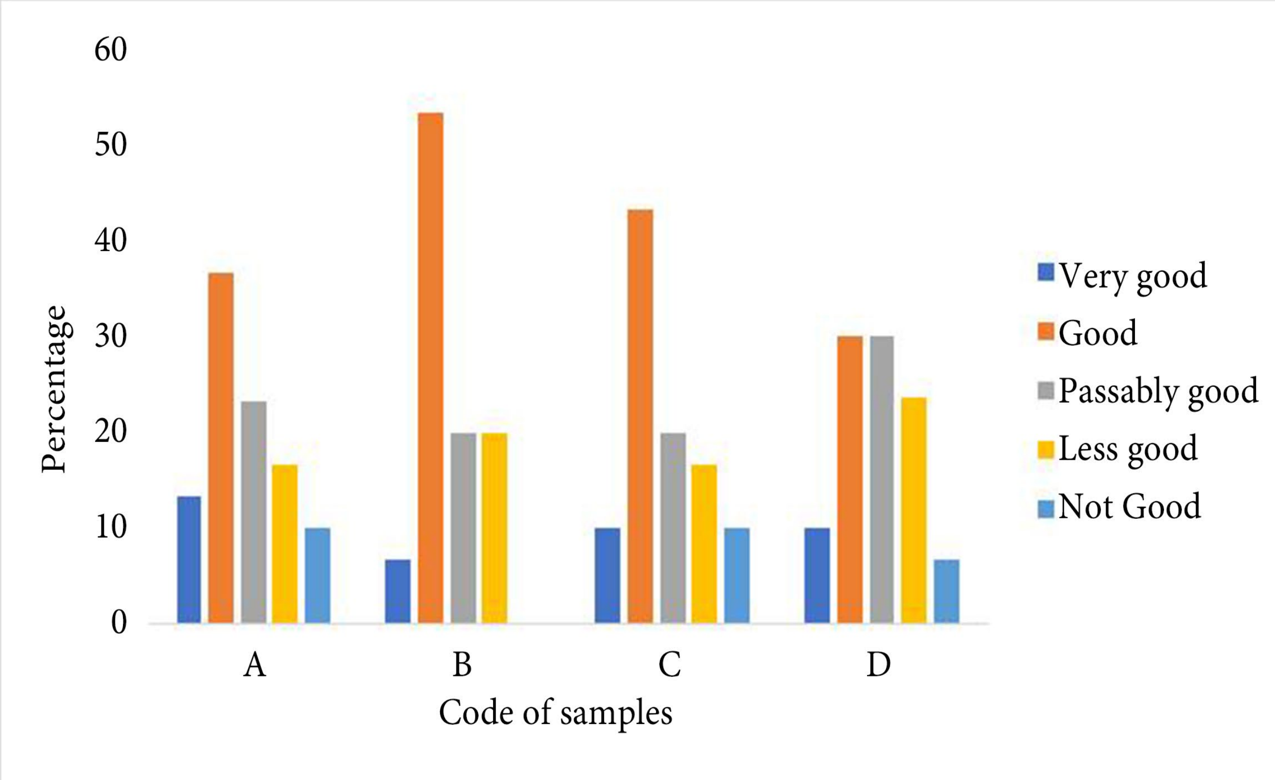
Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 4. Results of consistency appreciation.



Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 5. Results of smell appreciation.



Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 6. Results of aroma appreciation.

Taste

The results of the taste analysis are shown in **Figure 7**. The same type of appreciation ($p > 0.05$) was found in all the panelists. The crushed seed oil received a pleasant attribute from 50% of the tasters, followed by 36.7% for the whole seed oil and the roasted seed oil. The percentage of palatability in this study varied according to the technical process used to obtain the oil. It could be influenced by consistency and texture. This assertion is supported by Clark [37] who found that taste perception during eating is modified by the mechanical properties of food texture, represented by viscosity for liquid and pasty foods. Taste is the sensation perceived when the taste receptors are stimulated. Taste is produced by volatile low molecular weight chemical compounds. The palatability of crushed seed oil could be due to certain compounds such as glycosides, depending on genetic factors, the ripening stage of the seeds, and the technological processes of oil extraction [32].

Texture

The results of the texture test, shown in **Figure 8**, showed that 43.3% of panelists attributed the melting quality to crushed seed oil, followed by roasted seed oil (30%) and boiled seed oil (26.7%). Fairly melting texture was attributed to whole seed oil (23.3%). The textures found in the 4 oil types in this study varied according to the extraction process. Texture is an important attribute in determining consumer acceptance of food [32]. According to Clark [37], texture is related to mechanical properties represented by viscosity for liquid and pasty foods.

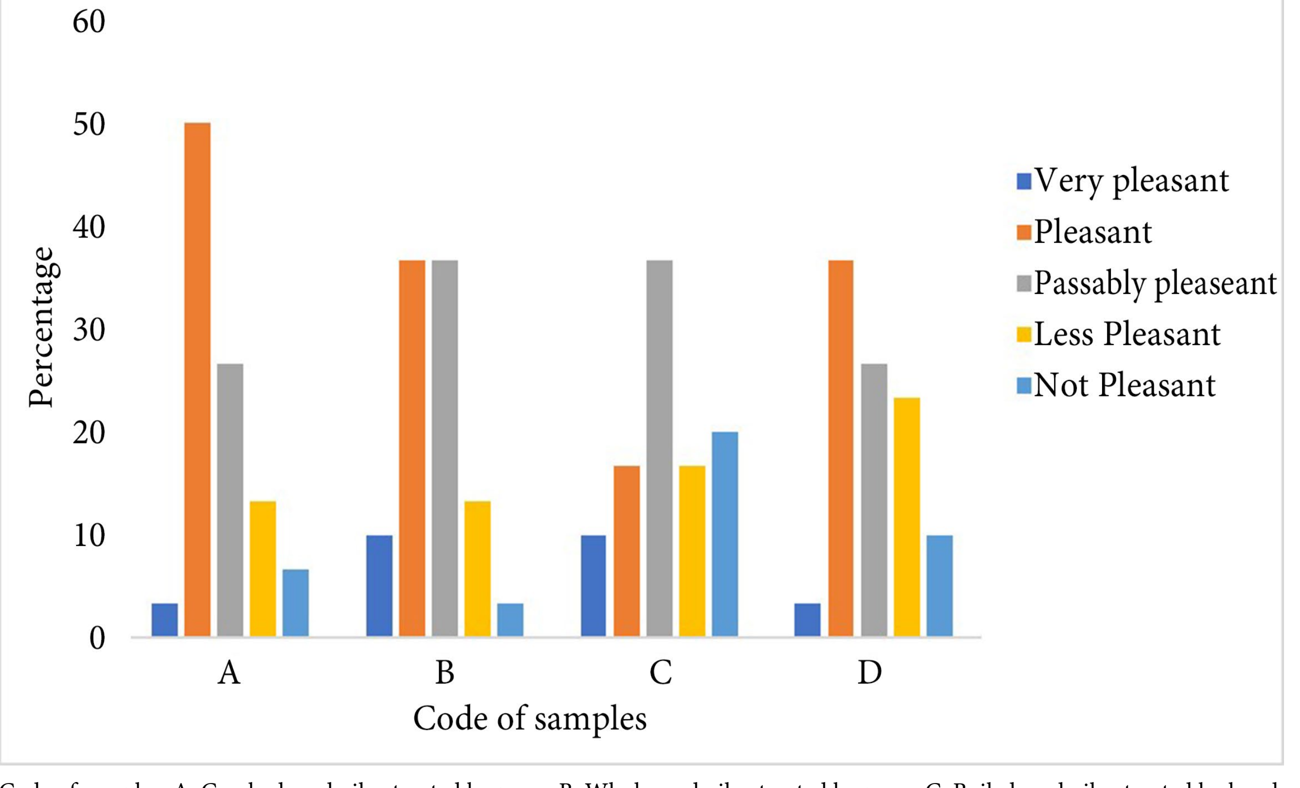
Rancidity

Statistical analysis of the data revealed no significant ($p > 0.05$) differences between the types of rancidity rated by the panelists (**Figure 9**). The highest percentage value of the tasters' assessment was obtained for crushed seed oil (46.7%), followed by boiled seed oil (40%), roasted seed oil (36.7%), and whole seed oil (30%). In terms of rancidity, the very rancid description was the most representative of the crushed oil obtained. The difference in the degree of rancidity in this study could be related to the maturity of the seeds, the chemical compounds and the technical extraction process. The present results are in agreement with the findings of Yahya *et al.* [38] who reported that the degree of rancidity was significantly improved by the extraction method. They also added that the high peroxide content affects the rancidity.

Hedonic Profile and Ranking of Oils Produced from the Seeds of *P. multiflora* Poiret

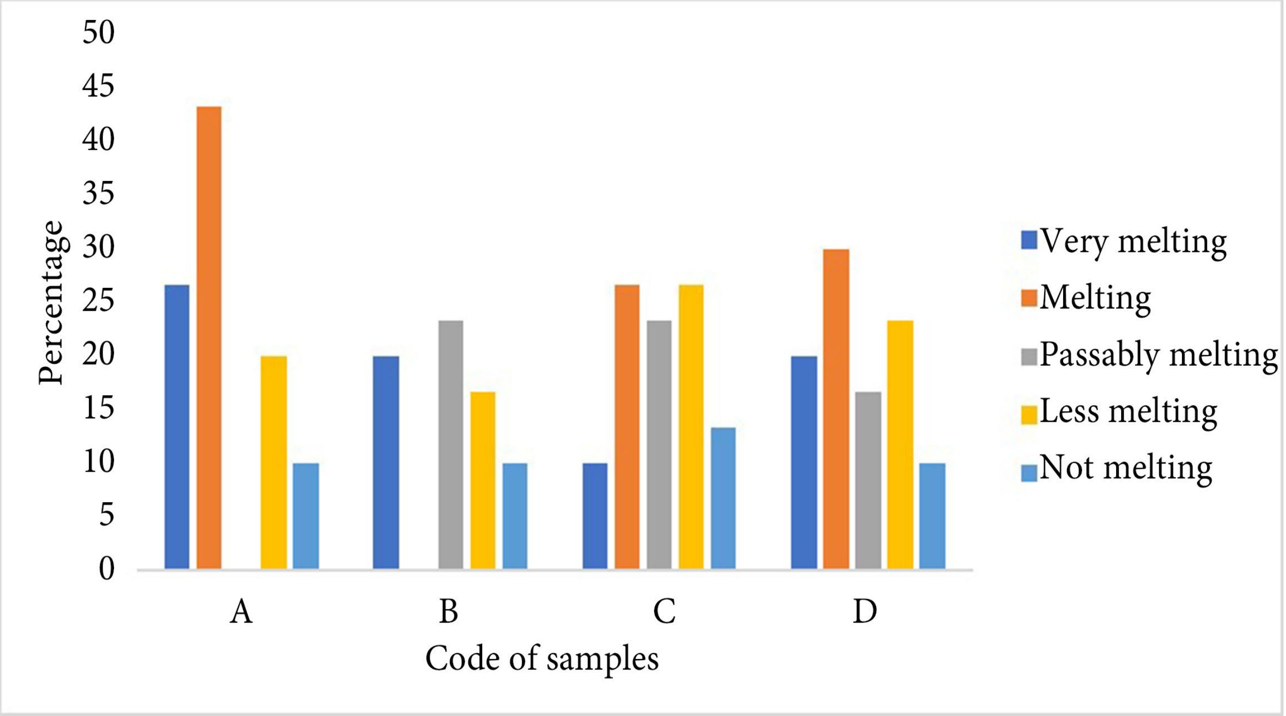
1. Hedonic profile

The results of the hedonic profile test are shown in **Figure 10**. The main features of the scale are that each category is associated with a verbal descriptor ranging from "like it very much" to "do not like it at all". The highest percentage of "like it"



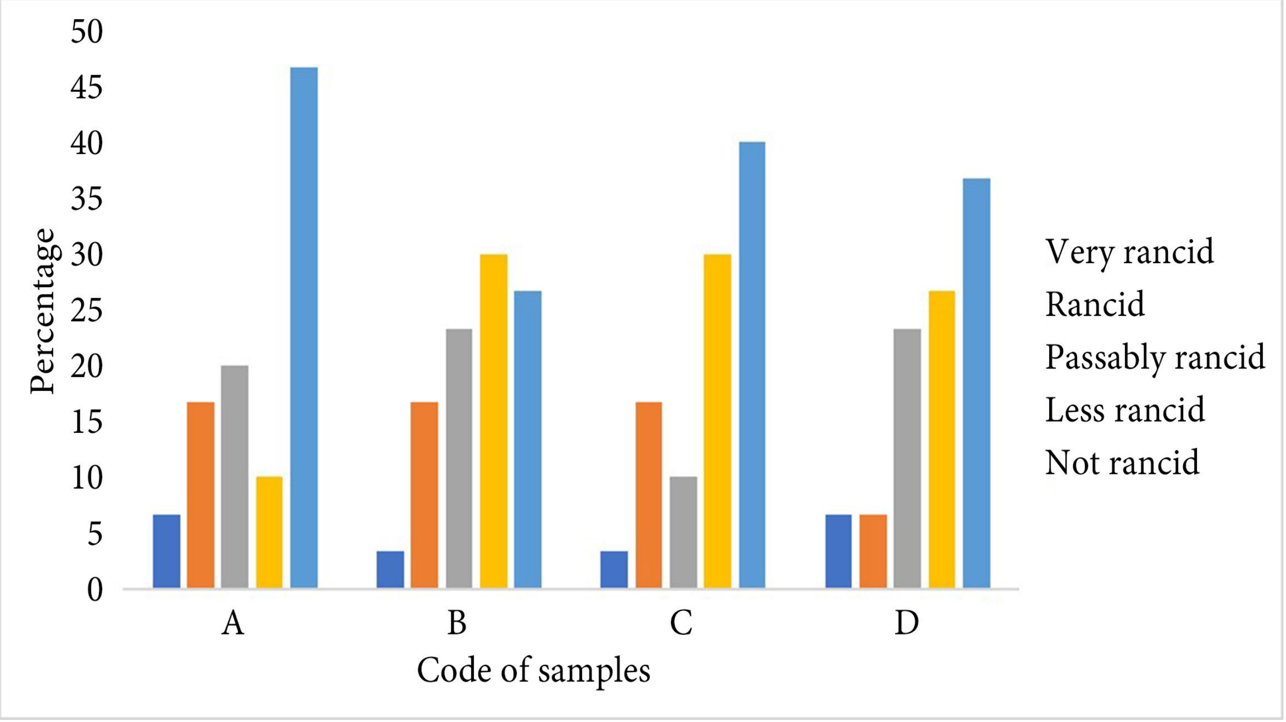
Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 7. Results of taste appreciation.



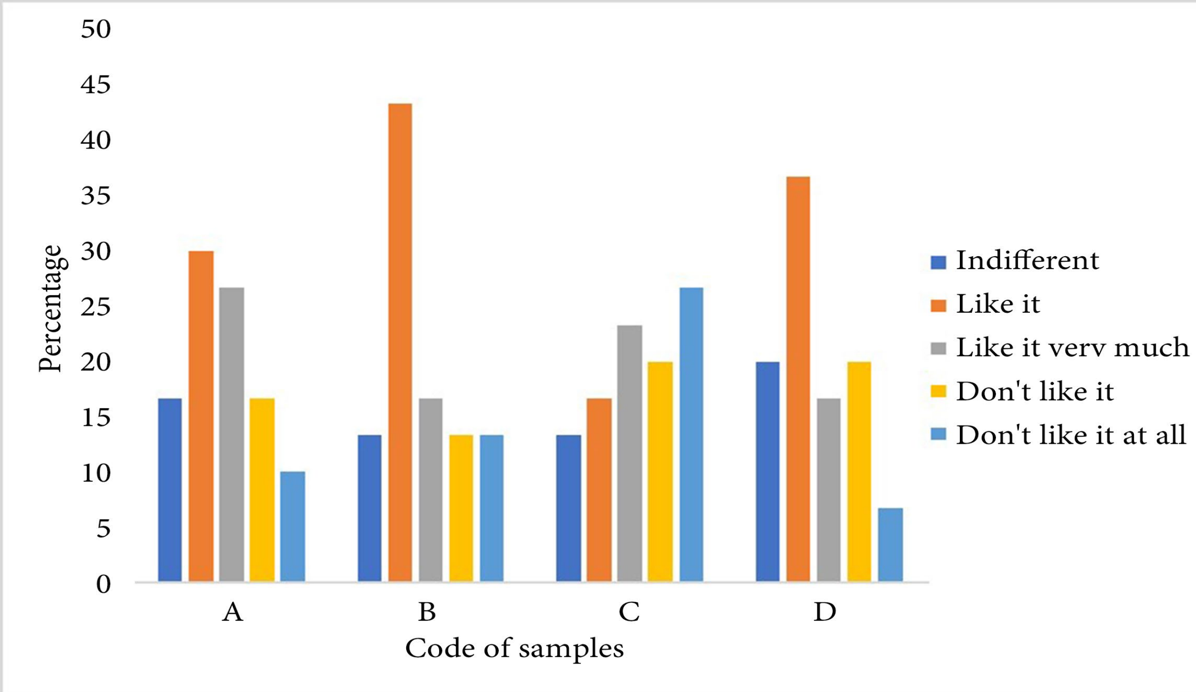
A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 8. Results of texture appreciation.



Code of samples: A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 9. Results of rancidity appreciation.



A: Crushed seed oil extracted by press; B: Whole seed oil extracted by press; C: Boiled seed oil extracted by hand; D: Roasted seed oil extracted by hand.

Figure 10. Hedonic profile of the 4 oil samples.

was associated with whole seed oil (43.3%), followed by roasted seed oil (36.7%), crushed seed oil (30%), and boiled seed oil (16.7%). According to Lawless and Heymann [39] (2013), the hedonic scale assumes that participants' preferences and their responses can be categorized into likes and dislikes. The hedonic profile is important for the marketing of food products. This assertion should be emphasized with Bakhtiary [40], who assumed that sensory qualities are often more important marketing points for the majority of consumers than nutritional value.

2. Ranking of profile of produced oils

Based on the hedonic profile, the ranking test was performed on 4 types of oil extracted from *P. multiflora* seeds. Thirty respondents ranked the sensory attributes of the oil. The results of the data processing using ANOVA showed that the brand had a significant effect on all sensory attributes. **Figure 11** shows the results of ranking tests for 4 types of extracted oil. The crushed seed oil has the highest mean value for all attributes. It is in first place, followed by whole seed oil, boiled seed oil in third place, and roasted seed oil. These results allow us to manage the quality of the oil for marketing. The ranking test determines which products are most favored by consumers, which is the main purpose of product marketing [41].

3.5. Analyze of Principal Component of Sensory Parameters

The results of the PCA of the sensory parameters of the 4 oils produced are shown in **Figure 12**. To visualize the relationships between the products and their

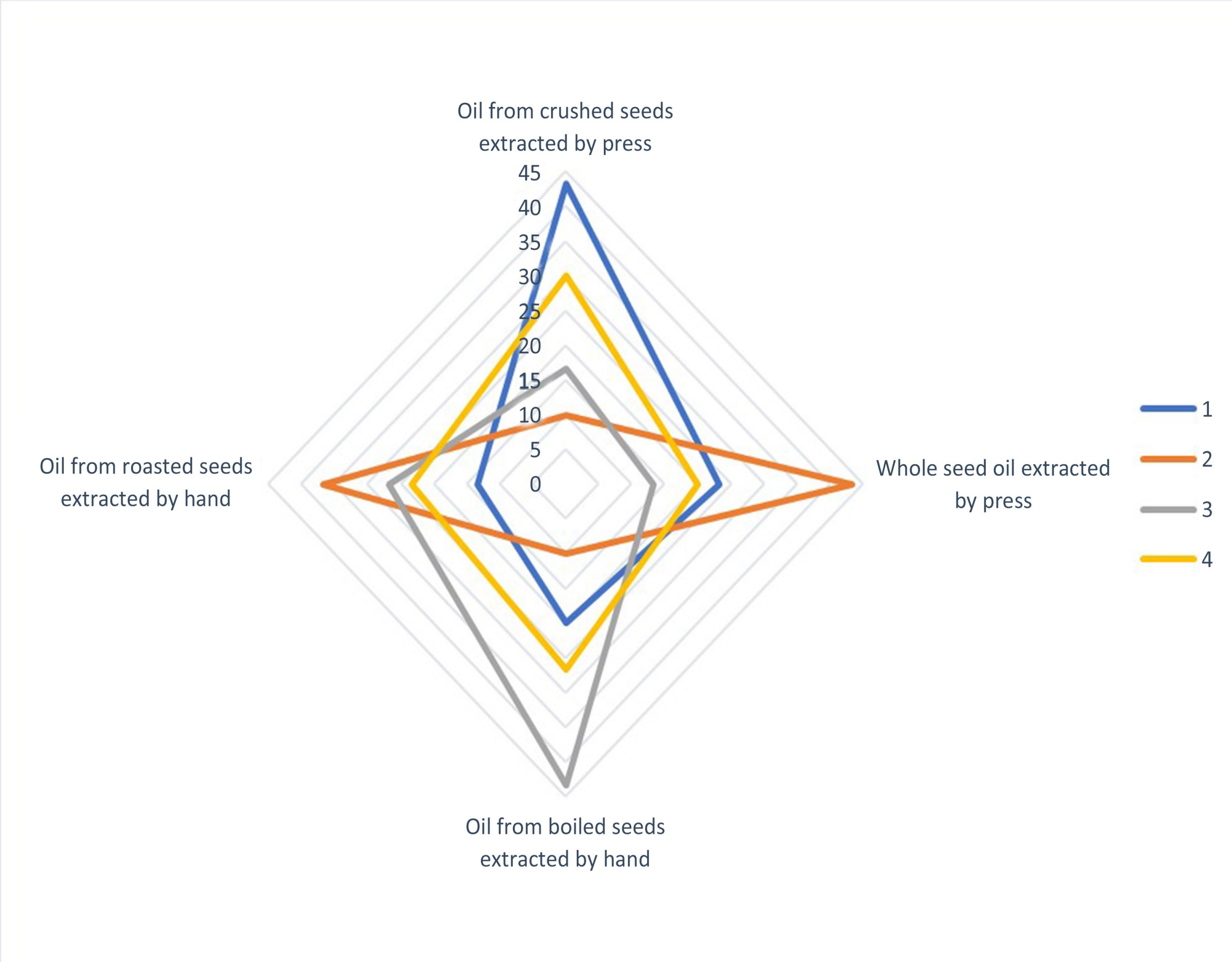


Figure 11. Ranking of the 4 oil samples.

attributes, the PCA was performed with 4 products and 8 attributes that showed statistical significance ($p < 0.05$).

Attributes were weighted in the PCA process by transforming the original dataset, generating a new set of data. Each attribute in the new dataset offers insights into the relationship between the original attributes, considering the highest percentage of explained variance from the original dataset. PCA differences are perceptible to human sensory thresholds, especially for tasting and visual evaluation

The PCA biplot explained 95.06% (F1: 71.54%, F2: 23.53%) of the total variation (**Figure 12**). The F1 dimension mainly accounted for the attributes of oil texture, taste, rancidity, aroma, and odor. The crushed and whole seed oil samples had high (positive) sensory scores for these attributes. In the opposite (negative) direction were the attributes of color, appearance, and consistency for the samples of boiled seed oil and roasted seed oil.

There is a strong correlation between the type of oil and the attributes. The sensory analysis of the scoring test confirms that the criteria of color, appearance,

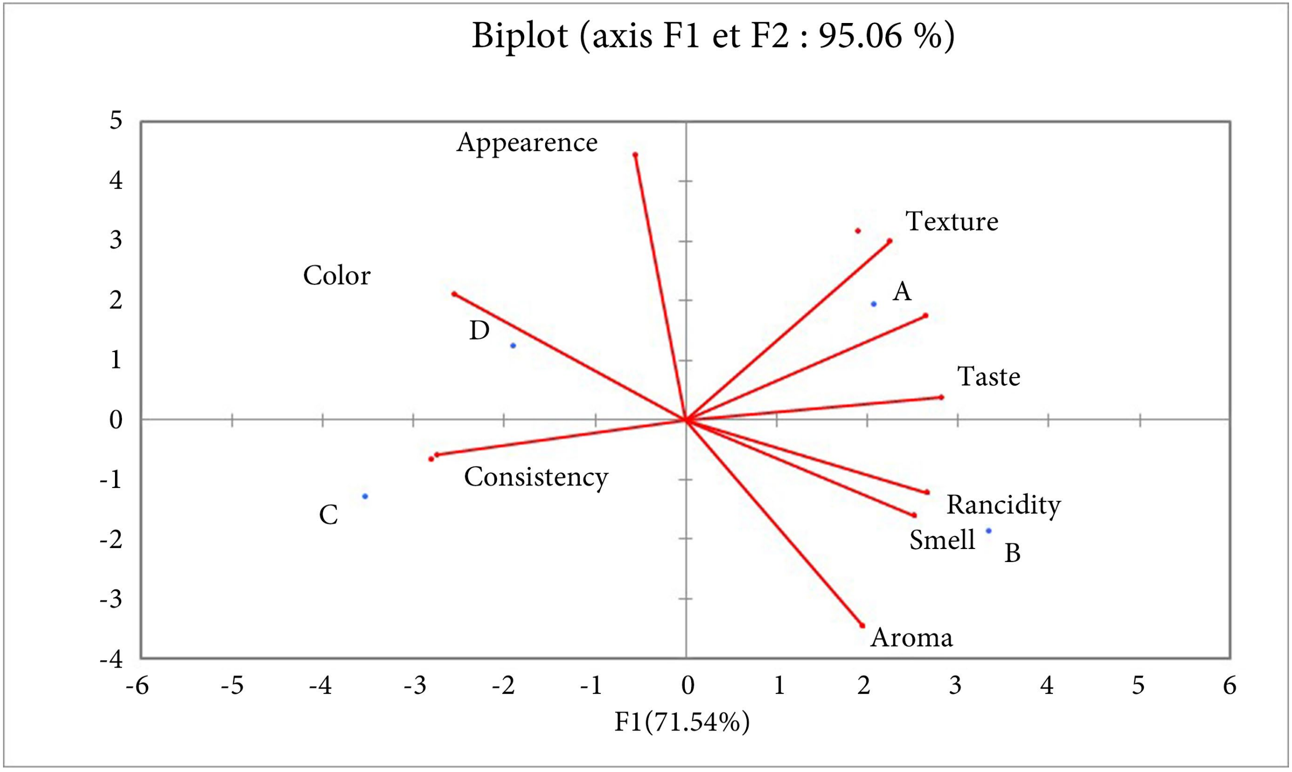


Figure 12. PCA biplot of the sensory analysis of the oils tested.

aspect, odor, aroma, taste, texture, and rancidity are significant parameters in the acceptance of the oils produced. The evaluation of the sensory quality varied according to the type of oil extracted. Panelists appreciated the taste and texture of crushed seed oil.

The tasters appreciated the appearance and color of the whole seed oil. For the roasted seed oil, the most accepted parameters were rancidity, odor, and aroma. The panelists appreciated only the consistency of the boiled seed oil.

The present study showed that the quality, nutritional, and sensory characteristics of *P. multiflora* seed oil are related to its chemical composition, which is the result of a complex interaction between several environmental, agronomic, and technological factors. This observation is in line with the assertion of Faci *et al.* [42], who considered that cultivar, growing area, environmental conditions, soil, tree age, irrigation, fruit ripening, harvesting time, fruit storage, and processing system are the important factors influencing the composition of the oil. Principal Component Analysis demonstrated variations in sensory attributes across four oil types. The study highlights the potential of *P. multiflora* seed oil as a valuable resource for edible and non-edible applications.

4. Conclusion

The results showed that the seed oil of *P. multiflora* plays an important role in the qualitative and sensory characteristics. The crushed seed oil showed the best sensory and chemical results. The data from this study on the use of *P.*

multiflora Poiret oil justify the growing interest in this plant. The sensory analysis results showed an acceptable and appreciated oil, even if it still needs to be refined to meet the criteria for edible oils sold on the market. Many other oleaginous varieties of plants as *Polygala senegambica Chodat, Polygala vulgaris, Polygala tenuifolia* are unexplored in terms of quality characteristics and more effort should be made to evaluate them. So the small sample size of 44 producers constitutes a limitation to assume completely the conclusion. However, the results obtained in this study provide a comprehensive analysis of *P. multiflora* oil's chemical and sensory characteristics, demonstrating its potential importance in Burkina Faso's oilseed industry. Finally, the results allow us to conclude that *P. multiflora Poiret* oil is an excellent candidate for valorization and could contribute to the diversification of oil sources in Burkina Faso.

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Conflicts of Interest

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

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