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Extraction and Physicochemical Characterization of Oil from Seeds of Wild Plant *Vitellaria paradoxa* C.F. Gaerten from Ethiopia

[1]Birhanu Bayissa Gicha and [2]Teshome Soromessa

[1]School of Natural Resources Management and Environmental Sciences, Haramaya University, P.O. Box 138 Dire Dawa, Ethiopia
[2]Environmental Science Program, Addis Ababa University, P.O. Box 1176 Addis Ababa, Ethiopia

ABSTRACT

Oil from wild plants of Shea tree was analyzed to establish its physico-chemical characteristics and evaluate its applications for food and industrial purposes. The results of analysis indicated that the oil contains color, melting point, specific gravity (at 20^0C), refractive index (40^0C), acid (mg KOH/g), peroxide (me peroxide oxygen/Kg), iodine (Wij's g/100g sample) and saponification (mg KOH/g) values ranged between Yellow orange-white yellow, 42-43^0C, 0.914±005-0.915±001,1.482±0.003-1.482±0.001, 2.28±0.23-12.29±0.04, 39.13±0.12-53.63±0.09, 2.25±001-14.13±001 and 177.32±0.03 -178.63±1.01 for n-hexane solvent and traditional extracts respectively. Values for iodine, acid and peroxide were significantly different ($P<0.05$), but melting point, specific gravity, refractive index and saponification values were not significantly different ($P<0.05$). Poor post-harvest handling practices may be responsible for the increase in the values of the parameters in the traditionally extracted Shea oil. The results favorably showed that the oil extracts can be utilizable for food, cosmetic and pharmaceutical application both locally and at industrial scale with proper extraction and post-harvest handling practices.
KEY WORDS: *Analysis, Extracts, Gambella, Physicochemical, Shea oil*

INTRODUCTION

In Africa, the contribution of edible wild plants and their potential in overcoming prevailing food problems are enormous [1]. Shea tree (*Vitellaria pradoxa* C.F.Gaerten), which belongs to the Sapotaceae family of tropical trees and shrubs, is a wild fruit tree with multiple benefits within the order Ebenales and class Magnoliopsida, has two subspecies: *nilotica* and *paradoxa* [2]. Geographically, *nilotica* subspecies occupies Southern Sudan, Ethiopia, Uganda and northeast Zaire while the *paradoxa* subspecies extends from Senegal eastwards to the Central African Republic [2, 3]. The two subspecies differ in their physical appearance and fat content within their nuts. The tree prefers dry and sandy clay soils with [4] annual rainfall range averages from 600-1,500 mm [5].

Shea butter/oil, fat obtained from nuts of Shea tree has multiple applications as cooking oil, replacer of cocoa butter in chocolate industry and application in cosmetics industry [6]. Beside this, the plant has been employed to heal many diseases traditionally including joint pains, wounds, infections, constipation, stomachache and eye problems [4, 7-10].

In Ethiopia, Shea tree exclusively occurs naturally in Gambella Regional State, south-western part of Ethiopia at 6° 30' - 8° 30' N and 33 00' - 35° 45' E covering a total area of 3,203,280 ha [11]. It occurs predominantly in Abobo, Gog and Fugnido districts, which are on the average of 98 km apart from each other [11].

Like other African countries, Shea tree is an important traditional source of fruits, beverages, nuts and edible oil in Gambella Regional State of Ethiopia. Physicochemical characteristics variations in Shea oil samples obtained from different areas have been reported which attributes are of environmental, farming practices and post-harvest handling characteristics [12, 13]. Use of Shea oil for food and other industrial application is greatly influenced by its physicochemical properties. Characterization of Shea oil is therefore one step to evaluate the significance of the oil for a given purpose and promoting the product in international market.

In Ethiopia, there were no efforts made to characterize the product and less emphasis is given to the plant and its products by research institutions. Hence, this study aims at analyzing the physicochemical characteristics of Shea oil which will used to provide data used to evaluate the suitability of the oil for a given purpose in the national and international markets.

Corresponding author: Birhanu Bayissa Gicha, School of Natural Resources Management and Environmental Sciences, Haramaya University, P.O. Box 138 Dire Dawa, Ethiopia. Email: ibs430@hotmail.com.

MATERIALS AND METHODS

Sample collection and preparation: Samples of fruit and oil for this study were collected from Gambella Regional State, Gog district, Fugnido Kebele where Shea tree is predominantly found. Shea tree fruits were collected from Fugnido Kebele and stored in ice box, transported to laboratory. The kernels were cleaned and dried by spreading them on the ground for 6 days. To ensure minimum moisture content, dehusked dry kernels were further dried in drying cabinet for three hours at 70 °C. The dry nuts were grinded using mortar and pestle and were put in drying cabinet for further analysis.

In order to extract oil from the crushed nuts, a soxhlet apparatus using analytical grade hexane (n- hexane) was applied for 5 hours at 60 ^{0}C. After extraction, the kernel were collected and concentrated using rotary evaporator at a temperature of 50^{O}C for one hour, stored in the bottle for further analysis. The physical and chemical parameters including refractive index, specific gravity, peroxide value, saponification value, iodine value and acid value were determined according to the standard methods of AOAC [14]. The yield was calculated using the following equation by evaporating the oil over water bath for 30 min at 70˚C;

Oil content (%) = $\frac{Weight\ of\ the\ Oil}{Weight\ of\ the\ Sample} X\ 100$

To determine the color, the samples were correlated using color charts. Melting point was determined according to the methods employed by [15].

Data Analysis: One way analysis of variance (ANOVA) was employed to study the variation in physico-chemical properties among the two differently extracted Shea oil samples. Significant difference was observed at 5% probability ($P < 0.05$).

RESULTS AND DISCUSSION

Application of oil for a given purpose including for nutritional, pharmaceutical and cosmetics requires prior analysis of the physicochemical characteristics. In this research, the physicochemical properties of Shea oil extracted by two different methods were given in Table 1.

Table 1 Physiochemical characteristics

Parameters	Traditionally extracted	n–hexane solvent extracted
Color	White yellow	Yellow-orange
Oil yield (%)	_	45.60
Melting point (^{0}C)	43	42
Specific gravity at 20^{0}C	0.915 ±001	0.914 ±005
Refractive index at 40^{0}C	1.482±0.001	1.482±0.003
Acid value (mg KOH/g)	12.29 ±0.04	2.28 ±0.23
Iodine value (Wij's g/100g sample)	53.63 ±0.09	39.13 ±0.12
Peroxide value (me peroxide oxygen/Kg)	14.13±001	2.25±001
Saponification value (mg KOH/g)	178.63±1.01	177.32±0.03

Figure 1 Traditionally extracted Shea oil

Figure 2 Solvent extracted Shea oil

The color exhibited by Shea oil obtained by traditional method was white yellow (Fig 1) while that exhibited by n-hexane solvent extract was yellow-orange (Fig 2). Observed color change may be as a result of per oxidation, pigmentation, contamination or polymerization of triglycerides which is also case for Shea oil obtained traditionally [16]. The oil content for Shea oil is 45.60 % that falls within ranges of 20% to 60% what have been reported [12]. Oil yield of Shea oil is considered good for industrial applications, as 30% oil yield is reported to be suitable for commercial use [15].

The melting points of the samples ranged between 42 – 43°C (Table 1). The Shea oil exhibited a relatively higher melting point in comparison to cocoa and palm oil that ranges between 32 - 36 and 25 - 30°C respectively [17]. Previous studies have reported the melting point for Shea oil in the ranges of 32 - 42°C [17]. Extracts of Shea oil samples exhibited a specific gravity ranging between 0.914±005 - 0.915±001 (Table 1) with no significant variation ($P< 0.05$) among the two samples. The specific gravity of 0.915±005 falls in the range what has been reported [18] and is a recommended value for any cooking oil [19]. The refractive index ranged between 1.482±0.001-1.482±0.003 (Table 9), and the value is within the ranges of nut family oils of 1.45 -1.49 [20 - 22].

The acid value was ranged between 2.28±0.23 and 12.29±0.04 mgKOH/kg and the value was highest for traditional extract. At $P< 0.05$, a significant variation was noticed between n-hexane solvent extract and traditional extracts of Shea oil samples. High acid value, low quality indicator, can be the result of poor post-harvest handling practices, hydrolysis of triglycerides in the Shea oil due to extraction processes and poor storage condition of the oil [23]. This value is exhibited by many edible vegetable oils [24].

The peroxide value of Shea oil sample under this study was ranged between 2.25±001 and 14.13±001 meq/Kg and the values significantly vary ($P< 0.05$) (Table 1). Acid value for n-hexane solvent extract is below the tolerable limit for application in the cosmetic and pharmaceutical industry [24-26]. The relatively high peroxide value of traditional Shea oil extract may be due to atmospheric oxygen and light being absorbed by the Shea oil during storage and processing, thereby producing intermediate oxidation products [27, 28].

The iodine value exhibited by the two processing methods fell in the range of 39.13±0.12- 53.63±0.09 I_2g/100g and the values vary significantly ($P< 0.05$). This increase in the iodine value of oil is attributed to high degree of unsaturation and presence of peroxides which is also true for traditionally extracted Shea oil [29, 30]. The value is lower than other vegetable oils indicating that it is non-drying oil [31, 32].

The saponification value was in the range of 178.63±1.01-177.32±0.03 mgKOH/g with the values for traditional extract greater than n-hexane solvent extract. Significant variation was not observed among the two extracts ($P< 0.05$). The saponification value is lower than values for soya bean, peanut, cotton, sun flower and olive [26, 33].

CONCLUSION

The physicochemical characteristics of Shea oil samples fells within limits of other edible vegetable oils making it a good raw material for food, cosmetics and other industrial applications. The result also showed that, there is significant variation in iodine value, acid value and peroxide value among the two Shea oil samples which is related to post harvest handling practices. No significant difference is observed in saponification value, melting point, specific gravity and refractive index among the two samples. To ensure higher quality Shea oil, it is recommended to have improved post harvest handling and extraction practices.

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