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Full Length Research Paper

Proximate analysis of the resins and leaves of *Boswellia sacra*

Ahmed Al-Harrasi*, Ahmed Al-Rawahi, Javid Hussain, Najeeb Ur Rehman, Liaqat Ali and Hidayat Hussain

Department of Biological Sciences and Chemistry, University of Nizwa, P. O. Box 33, Postal Code 616, Birkat Al Mauz, Nizwa, Sultanate of Oman.

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The analysis of the proximate composition of the leaves and various grades of resins obtained from *Boswellia sacra* was performed using standard methods of AOAC. The resins and leaves analyzed in this study were found to have the following ranges of the proximate composition: moisture (5.41 to 11.54%), dry matter (88.45 to 94.58%), alcohol soluble extractive (14.09 to 64.84%), ash (1.02 to 6.66%), crude fats (6.90 to 85.36%), nitrogen (0.04 to 0.18%), proteins (0.25 to 1.14%), carbohydrates (13.30 to 74.15%), and energy value (360.80 to 822.53 kcal/100 g). The leaves of *B. sacra* were found to have higher concentration of ash, fiber, and carbohydrates, but low in fats, energy value, and alcohol extractives as compared to the resins. Unlike leaves, all the resins were found to be excellent source of lipids and consequently higher in energy.

Key words: Frankincense, proximate analysis, *Boswellia sacra*, moisture analyzer, Kjeldahl.

INTRODUCTION

Plant based products; essential oils, plant extracts, natural resins and their preparations have a wide range of applications mainly in pharmaceutical industry, food technology, aroma and cosmetic industries. Frankincense or olibanum is a natural oleo-gum-resin obtained from the incisions made in the bark of the trees of genus *Boswellia* (family Burseraceae) (Mertens et al., 2009). It has a long history of use and is considered as one of the oldest fragrant and medicinal resins known throughout the world (Culioli et al., 2003). This resin has been used for variety of therapeutic purposes (Marinetz et al., 1988), including cancer (Shao et al., 1998), inflammation (Singh and Atal, 1986), arthritis (Sharma et al., 1989), asthma (Gupta et al., 1998), psoriasis (Chopra et al., 1956), colitis (Gupta et al., 2001), Crohn’s diseases (Gerhardt et al., 2001), and hyperlipidemia (Pandey et al., 2005). Due to these enormous therapeutic applications, it can accurately be described as a panacea (used for everything from cold to cancer). Frankincense trees are found in Oman, Somalia, Ethiopia, Yemen, the Southern Arabian Peninsula, and India (Marshall, 2003; Culioli et al., 2003; Baser et al., 2003; Hamm et al., 2005). Dhofar region in southern Oman is the source of *Boswellia sacra* Flueckiger (Coppi et al., 2010), the sacred frankincense, also called LUBAN in the local language. In folklore, frankincense from *B. sacra* is used to stimulate digestion, to expel congested phlegm, to combat halitosis, and to strengthen the teeth and gum. It is also used for other ceremonial and traditional purposes (Culioli et al., 2003).

Considering the high medicinal importance of this precious resin as well as its frequent use in many food recipes, the present study aimed at evaluating the proximate composition (moisture, ash, fats, crude fiber, proteins, carbohydrates and energy value) of various grades of resin as well as the leaves of *B. sacra*. To the best of our knowledge, this is the first proximate analysis of *Boswellia* species.

MATERIALS AND METHODS

Sample collection and identification

Frankincense has been classified into six grades on the basis of its

*Corresponding author. E-mail: aharrasi@unizwa.edu.om. Tel: +968-92828487. Fax: +968-25443400.

Table 1. Collection details of the selected samples of resins and leaves of *B. sacra*.

Frankincense samples	Codes	Place of collection in sultanate of Oman
Royal Hougari white	RHW	Hougar mountain, Salalah
Super Hougari green	SHG	Hougar mountain, Salalah
Hougari regular	HR	Hougar mountain, Salalah
Hougari yellow	HY	Hougar mountain, Salalah
Shabi Frankincense	SF	Oyoon, Salalah, Oman
Leaves (*Boswella sacra)*	FL	Oyoon, Salalah, Oman

degree of excellence. The size, color and hardness of the resin lumps differ significantly from one grade to another. The samples of various grades of frankincense as well as the leaves were collected from the *B. sacra* tree in Wadi Ofool which belongs to the Shazri type. Some of the frankincense samples were collected from different locations in Dhofar and were supplied by a trustful Dhofari partner (Dr. Saleh Al-Amri). Four samples of Hougari frankincense resins namely; Royal Hougari white (RHW), super Hougari green (SHG), Hougari yellow (HY) and Hougari regular (RH) were collected from Wadi Hougar. Shabi Frankincense (SF) resin was collected from Wadi Magsyl. All these samples were authenticated by Dr. Mustafa Mansi (botanist), Department of Biological Sciences and Chemistry, University of Nizwa, the Sultanate of Oman. All the samples were collected in April and May by the corresponding author and his team, and the details of these collections are summarized in Table 1.

Sample preparation

All the samples of resins and leaves were kept under subdued light for drying prior to proximate analysis. The dried matter thus obtained was ground to a fine powder and stored at room temperature in air-tight containers prior to further analysis.

Proximate analysis

All the collected samples (SHG, SF, RHW, RH, HY and FL) were analyzed using the methods reported by the Association of Official Analytical Chemists (AOAC, 2000). Nitrogen estimation was carried out by the micro-Kjeldahl (Kjel Flex K-360) method (Pearson, 1976) and the crude protein was subsequently calculated by multiplying the nitrogen content by a factor of 6.25.

The moisture content was determined by moisture analyser (KERN MLS_N) and also by a manual drying method in a WiseVen oven (WOF-105, Version 1.4.3) at 105℃ for 6 h (AOAC, 20 00), and both the values were compared. Ash content was obtained by dry ashing in Wise Therm muffle furnace (FP-03, Version 1.4.4) at 550℃ for 3 h. Crude lipid was quantified using the soxhlet apparatus and *n*-hexane as a solvent by the reported method (AOAC, 2003). Crude fiber was estimated by acid-base digestion with 1.25% H_2SO_4 (v/v) and 1.25% NaOH (w/v) solutions (Hussain et al., 2010a).

Total carbohydrates were calculated by the difference, and the total energy values were calculated by multiplying the amount of proteins and carbohydrates by a factor of 4 and lipid by the factor of 9 K cal/100g (Al-Farsi et al., 2007). The alcohol soluble extractives were extracted with 90% ethanol (100 mL) by the reported method (Falodun and Irabor, 2008). All the analyses were done in triplicate.

Statistical analysis

The results were calculated for three independent determinations with their mean, standard error and correlation matrix. Statistical analysis was performed using Statistic Analysis System SAS 9 (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The texture, taste, appearance and stability of foods depend on the amount of water they contain. As the moisture content depends on the environmental conditions such as humidity and temperature in growing period, harvest time, climate as well as storage conditions, knowing this is necessary to predict the behavior of foods during processing. Thus it is important for food scientists to be able to reliably measure moisture contents of the various food materials. Among the analyzed samples, SF grade resin was found to contain the lowest moisture content (5.41, and 6.25% by moisture analyzer and by dry oven method, respectively), whereas the highest moisture content was found to be present in RHW (11.54 and 10.73% by moisture analyzer, and by oven dry method respectively) (Table 2 and Figure 1). SHG and RHW grade resins were found to contain comparatively higher values of moisture content and were significantly different ($P \leq 0.05$) from the other species. However, no significant difference was observed between the values of moisture content analyzed by both methods ($P \leq 0.05$). The other grades of the resin showed moisture values comparable to those reported for different cultivars ranging from 6.1 to 8.9% (Onwuliri and Obu, 2002; Trugo et al., 2000), and to the values described for the Indian wild legume seeds varied from 5.7 to 8.5% (Vadivel and Janardhanan, 2005).

The crude fats (lipid content) were found to be the highest in the SHG grade (85.36%), followed by HR (77.38%), HY (76.94%), RHW (76.47%), SF (71.58%), and FL (6.90%) in the decreasing order (Table 2 and Figure 1). This higher value (85.36%) of SHG grade resin was significantly different ($P \leq 0.05$); however the other grades of the resin (SF, HY, HR and RHW) showed close similarity in lipid content except those for the *B. sacra* leaves. The lipid content in various grades of resin was higher than those described for soybean seeds, an important oil seed, with values ranging from 18.3 to 21.5% (Vasconcelos et al., 1997), melon seed varieties (40.86 to 45.21%) in Nigeria (Abiodun and Adeleke,

Table 2. Proximate values of the selected resins and leaves of *B. sacra* (in percentages).

Parameter	FL ± S.E	SF ± S.E	HY ± S.E	HR ± S.E	SHG ± S.E	RHW ± S.E
Moisture (moisture analyzer)	7.93 ± 0.05[bc]	5.41± 0.005[c]	9.88 ± 0.06[b]	6.61 ± 0.062[c]	11.36 ± 0.09[a]	11.54 ± 0.007[a]
Moisture (dry oven method)	7.47 ± 0.10[c]	6.25 ± 0.06[c]	8.90 ± 0.02[b]	7.13 ± 0.032[c]	10.65 ± 0.06[a]	10.73 ± 0.005[a]
Dry matter	91.97 ± 0.01[ab]	94.58 ± 0.005[a]	90.10 ± 0.06[ab]	93.38 ± 0.062[a]	88.63 ± 0.09[b]	88.45 ± 0.007[b]
Alcohol soluble extractive	14.09 ± 0.01[cd]	56.72 ± 0.04[b]	57.37 ± 0.07[b]	58.20 ± 0.020[b]	64.84 ± 0.01[a]	47.88 ± 0.007[ab]
Ash	6.66 ± 0.03[a]	1.64 ± 0.04[bc]	1.51 ± 0.01[bc]	1.60 ± 0.041[bc]	1.02 ± 0.01[bc]	1.54 ± 0.01[bc]
Crude fats	6.90 ± 0.09[de]	71.58 ± 0.06[b]	76.94 ± 0.05[b]	77.38 ± 0.069[b]	85.36 ± 0.06[a]	76.47 ± 0.092[b]
Crude fiber	6.90 ± 0.00[4a]	1.25 ± 0.005[cd]	0.05 ± 0.002[d]	0.17 ± 0.001[d]	0.07± 0.001[d]	0.04 ± 0.002[d]
Nitrogen	0.07 ± 0.000[4c]	0.11 ± 0.002[ab]	0.07 ± 0.001[c]	0.18 ± 0.004[a]	0.04 ± 0.002[c]	0.10± 0.001[ab]
Proteins (N×6.25)	0.49 ± 0.003[b]	0.71 ± 0.01[ab]	0.49 ± 0.007[b]	1.14 ± 0.026[a]	0.25 ± 0.01[c]	0.67 ±0.011[ab]
Carbohydrates	74.15 ± 0.06[a]	24.79 ± 0.05[bc]	20.98± 0.06[c]	19.68 ± 0.09[d]	13.30 ± 0.05[de]	21.25 ± 0.093[c]
Energy value (Kcal/100g)	360.80 ± 0.60[de]	746.31 ± 0.42[bc]	778.42 ± 0.22[b]	779.78 ± 0.43[b]	822.53 ± 0.35[a]	776.005 ± 0.43[b]

Data are means ± standard error of triplicate determinations on dry weight basis. [a-e]Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test. The results were analyzed using Statistic Analysis System (SAS 9.1). Values given are mean ± standard error.

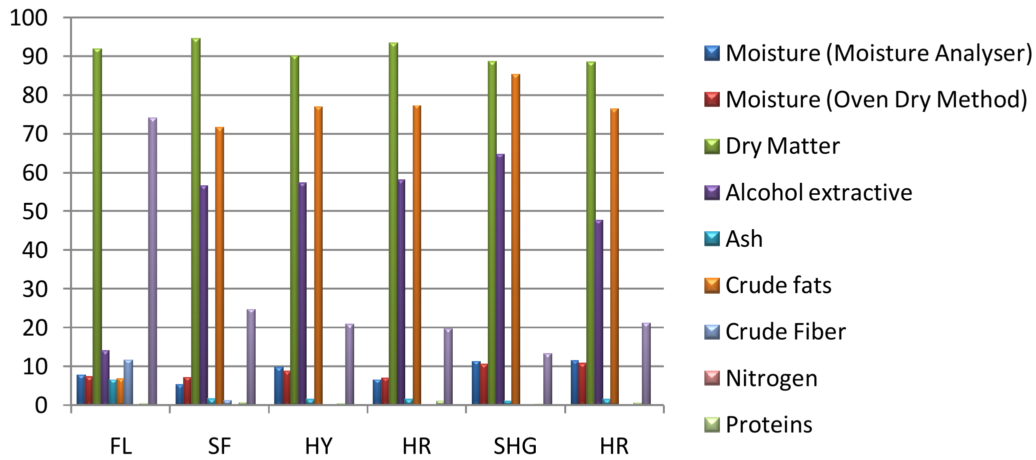

Figure 1. Graphical presentation of the various parameters of the resin and leaves in percentage.

2010), wild growing mushrooms (0.4 to 27.5%) in Europe (Kalac, 2009), wild legume seeds (0.7 to 29.6%) in Northeastern Brazil (Carvalho et al., 2011) and some vegetables (8.3 to 27.0%) consumed in Nigeria, and Republic of Niger (Ifon and Bassir, 1980). Based on these observations the frankincense samples can thus be considered as an excellent source of dietary oil and in turn can be considered as a source of stored energy.

Carbohydrates are one of the most important components in many foods, and the digestible carbohydrates are considered as an important source of energy. The carbohydrate content of analyzed samples suggested that the leaves of *B. sacra* have the highest amount of carbohydrates (74.15%), with significant difference (P ≤ 0.05), followed by various grades of the resin in the decreasing order of SF (24.79%), RHW (21.25%), HY (20.98%), HR (19.68%), and SHG (13.30%) respectively (Table 2 and Figure 1).

However, the two grades of the resin; HY and RHW showed non-significant difference (P ≤ 0.05). The contribution of the carbohydrates to the energy in a food ration recommended by WHO (1990) is from 55 to 75%. Although the range of carbohydrates of various grades of resin was lower than the reported WHO value, however, the leaves of *B. sacra* fall in the acceptable range set by WHO. Thus the leaves of *B. sacra* can be used as a source of energy contribution in a food ration. This comparative study of the carbohydrate value (74.15%) of the leaves of *B. sacra* indicated a close agreement with what has been reported for the medicinally important plants; *Otostegia limbata* (78.81%) and *Lavandula angustifolia* (73.06%), which are being used in various folk medicines for the curing of wounds and treatment of ophthalmia and also as antiasthmatic, antiseptic, antispasmodic, digestive and expectorant (Adnan et al., 2010).

The ash content, which is an index of mineral contents in biota, was high in the leaves of *B. sacra* (6.66%), as compared to the frankincense samples (Table 2 and Figure 1). The ash content in the leaves of *B. sacra* was significantly higher than the resins, whereas, no significant difference was observed among the various grades of the resin (P ≤ 0.05). The ash content in the leaves revealed comparable results with the previously analyzed medicinal plants, *Ammonum sulbulatum* (6.97%) and *Rhazya stricta* (6.21%) reported by Hussain et al. (2009, 2010b).

The high fiber contents in the diet increases digestibility, but on the other hand high level of fibers can also produce intestinal irritation, and ultimately decreases the utilization of the nutrients (Oyenuga and Fetuga, 1975). The leaves of *B. sacra* (FL) had the highest value of fibers (6.90%), followed by the resin of SF grade (1.25%), while the other grades of the resin had comparatively lower concentration of the fiber (Table 2). The leaves were thus significantly different (P ≤ 0.05) from the other grades of the resin due to high value in crude fiber, but there was no significant difference in the crude fiber values of the various grades of the resin except that of SF (1.25%).

The protein content of the leaves and the various grades of the resin was calculated on the basis of the available nitrogen using Kjeldahl method and was observed in the range of 0.25 to 1.14% with HR grade of the resin having the highest value which was significantly different (P ≤ 0.05) from other frankincense samples (Table 2). The other grades of the resin as well as the leaves showed relatively low protein content with non-significant difference. The daily recommended proteins for men and women underlined by WHO (1990) are from 14.5 to 53.3% of ration. Based on this fact, the resin of the various grades, as well as the leaves of the plant *B. sacra* was considered as poor sources of proteins.

The extractive potency of the selected samples in alcohol was also determined and the results are tabulated in Table 2. SHG grade resin was found to be significantly higher in extractive potency than the remaining frankincense samples (P ≤ 0.05). Low level of extractive potency was observed in the leaves of *B. sacra*. No significant difference was observed in the remaining four frankincense samples.

According to the results of the energy calculations, based on the carbohydrates, fats, and protein content, the highest value was found in the SHG grade of the resin (822.53 kcal/100g), while the leaves of *B. sacra* were found to contain the lowest energy value (360.80 kcal/100 g). The energy value of the resin of SHG grade was significantly different from other frankincense samples. However, no significant difference was observed in the remaining grades HY, HR and RHW (P ≤ 0.05). The energy value in the leaves of *B. sacra* (360.80 kcal/100 g) was comparatively higher than the reported values of some Nigerian leafy vegetables (248.8 to 307.1 kcal/100g) (Isong et al., 1999), some Ghanian green leafy vegetables like *Corchorus tridens* (283.1 kcal/100g) and sweet potato leaves (288.3 kcal/100g) (Asibey-Berko and Tayie, 1999).

However, it was found to be in close proximity to the commonly consumed vegetables like *Luffa acutangula* (358.94 kcal/100 g) and *Cucurbita moschata* (359.18 kcal/100g) (Hussain et al., 2010a).

Looking at the correlation analysis of the selected parameters, it is evident that similar parameters have high significant correlation while the inter-parameter correlation is either nonsignificant or less significant and the various parameters are moderately related (Table 3). Moisture (moisture analyzer) with moisture (manual or the dry oven method); ash with crude fiber and carbohydrates; nitrogen with proteins; alcohol extractive with crude fats and energy value, and crude fats with energy value showed the significant correlation.

Dry matter showed nonsignificant correlation with moisture (analyzed both by moisture analyzer and by the dry oven method). In the same way, ash with alcohol soluble extractives, crude fats, and energy value; crude fiber with alcohol extractive, crude fats and energy value; alcohol soluble extractives and crude fats with carbohydrates, and carbohydrates with energy value showed nonsignificant correlation, whereas the remaining parameters showed less or moderate correlation (Table 3).

Two-way ANOVA analysis without replication was conducted to know the sum, average and variance of the nutrient parameters of the selected frankincense samples. While taking proximate parameters as factors, for almost all the samples, there was no or less

Table 3. Correlation matrix of nutrient parameters.

Parameter	Moisture (M. analyzer)	Moisture (manual)	Ash	Crude fiber	Nitrogen	Proteins	Alcohol extract	Crude fats	Dry matter	Carbonhydrates	Energy value
Moisture (M. analyzer)	1										
Moisture (dry oven method)	0.948	1									
Ash	-0.229	-0.419	1								
Crude fiber	-0.239	-0.41	0.993	1							
Nitrogen	-0.595	-0.566	-0.142	-0.203	1						
Proteins	-0.594	-0.566	-0.14	-0.202	0.999	1					
Alcohol extract	0.131	0.309	-0.97	-0.95	0.109	0.107	1				
Crude fats	0.262	0.44	-0.997	-0.993	0.139	0.1383	0.971	1			
Dry matter	-0.999	-0.945	0.217	0.227	0.6	0.598	-0.118	-0.249	1		
Carbohydrates	-0.261	-0.44	0.996	0.991	-0.138	-0.137	-0.9736	-0.999	0.248	1	
Energy value	0.258	0.436	-0.998	-0.995	0.146	0.145	0.969	0.999	-0.246	-0.999	1

Table 4. Summary of the anova analysis (two-factor without replication).

Summary	Count	Sum	Average	Variance
FL	11	582.364	52.942	11385.7
SF	11	1010.4	91.854	48216.63
HY	11	1044.767	94.978	52465.78
HR	11	1045.301	95.027	52731.57
SHG	11	1098.092	99.826	58671.52
HR	11	1034.727	94.066	52152.03
Moisture (moisture analyzer)	6	52	8.792	6.460
Moisture (dry oven method)	6	52	8.690	2.804
Ash	6	14	2.333	4.543
Crude Fiber	6	13	2.230	22.075
Nitrogen	6	0.6	0.100	0.0023
Proteins	6	3	0.631	0.089
Alcohol soluble extractives	6	299	49.854	336.179
Crude fats	6	394	65.777	851.370
Dry matter	6	547	91.191	6.436
Carbohydrates	6	174.	29.029	502.894
Energy value	6	4263	710.644	29965

interdependency (Table 4).

Conclusion

Due to the high importance and frequent use of frankincense in medicine, pharmaceutics, and food industries (Gerhardt et al., 2001), it is necessary to assure the constant quality of the traded frankincense resin and its respective products by developing specific criteria. This study indicated that there was no significant difference among the five grades of frankincense in terms of the analysed parameters except the leaves of *B. sacra*.

This study further indicated that leaves are considered as the source of minerals, being abundant in ash content, whereas the five grades of frankincense were found to be excellent source of lipids and hence the energy value. These promising results are encouraging to do further investigations to explore this vast field of interest for the scientific community.

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