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Characterization of Hachi (*Camelus dromedarius*) fat extracted from the hump

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ABSTRACT

In this work, the characteristics of fat from the hump of young camels (Hachi) were evaluated. The physicochemical properties of the fat were as follows: melting point, 45 °C; saponification value, 202.3 mg KOH/g oil; refractive index (60 °C), 1.468; unsaponifiable matter, 1.37%; free fatty acids (as the percentage of oleic acid), 0.96%; and peroxide value, 3.37 mequiv. O_2/kg oil. High-resolution ^{1}H nuclear magnetic resonance (^{1}H NMR) was used for the direct determination of the iodine value of Hachi fat (62.74 g/100 g oil). The Hachi fat was composed primarily of oleic acid (33.35%), followed by palmitic acid (26.16%), stearic acid (10.07%), palmitelaidic acid (9.56%) and myristic acid (8.83%). The thermal properties were assessed by thermogravimetry (TG) and derivative thermogravimetry (DTG). The results of the present analytical study showed that Hachi fat could be used in food products and as an important source of biological materials.

1. Introduction

The use of animal fats by humans may well predate civilization. As the depot fats in animals are readily visible during the butchering of a slaughtered animal, are easily harvested, and are available without the need for plant domestication or the adoption of established agriculture, it is probable that animal fats were the first lipids employed as industrial and edible lipids by humans. Lipids support multiple biological functions in the body. They serve as the structural building material of all cell and organelle membranes. Lipids are the most efficient fuel for living organisms, containing more than twice the energy content of carbohydrates and proteins on a weight basis.

Animal depot lipids are used in culinary applications. These lipids are sometimes consumed directly, but they are more often used in such applications as baking, cooking, and deep-fat frying (Hein, Henning, & Isengard, 1998). Animal-derived lipids are also used in industrial applications, primarily in soap production (Dugan, 1987), as an energy and nutrient source in animal feeds (Ruth et al., 2010), in lubricants (Kramer, Lok, & Krug 2001), as biodiesel (Cengiz & Sehmus, 2009), and as a source of industrial fatty acids. For example, tallow is used as a food in spreads, as a frying oil, as an energy-rich component of animal feed and the oleochemical industry. Tallow derivatives are used in personal care products, cosmetics, and emulsifiers (Gunstone, 2004).

Camels are a fundamental pillar of the national economy and food security in many countries in the world, especially in Asia and Africa. These animals play a critical role in providing human foods, especially meat, milk and fat.

Camel fats, especially the fat in the hump, are used to prepare many dishes in different countries in Asia and North Africa. Camel hump fat is used for the production of a cocoa butter analog (Shekarchizadeh, Kadivar, Ghaziaskar, & Rezayat, 2009), for making high-quality semi-dry and dry sausages, and for frying purposes by Bedouin tribes in the Arabian desert, because it can reach high temperatures without smoking. Additionally, it is used to prepare various Saudi Arabian dishes, such as albulgman, which is the most common meal of desert inhabitants.

In the present study, the fatty acid composition, physicochemical properties (iodine value, free fatty acid content, saponification value, amount of unsaponifiable matter, kinematic viscosity, refractive index and peroxide value), thermal profile, IR spectrum, and ^{1}H NMR spectrum of Hachi (young camel) fat were determined. Tallow was used for comparison. The findings of this study are important locally and internationally for evaluating whether Hachi fat may be exploited as a source of fat for nutritional, industrial and pharmaceutical applications.

2. Materials and methods

2.1. Sample preparation

Hachi (young camel) fat, taken from the hump, was collected from a retail butcher's shop in Riyadh, Saudi Arabia. The fat was

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melted by slowly heating to 60–70 °C and then separated from the solid residue. The transparent liquid layer was filtered at reduced pressure, and the white extracted fat was stored at −20 °C during the experimental period. Three batches of hump fat were collected and used for analysis.

2.2. Analytical methods

Analysis was carried out in triplicate. The values of different parameters were expressed as the mean ± standard deviation (±S.D.).

2.2.1. Analysis of the fatty acid composition

The fatty acid methyl ester (FAME) composition was determined by conversion of the fat into FAME by adding 1 ml of n-hexane to 40 mg of fat, followed by the addition of 200 µl of sodium methoxide (2 M). The mixture was heated in a bath at 50 °C for approximately 10 s, and then 200 µl of HCl (2 N) was added. The top layer (1 µl) was injected into a gas chromatography system (Nehdi, 2011a).

2.2.2. Gas chromatography (GC) conditions

The FAMEs obtained by the transesterification reaction were analyzed by gas chromatography using a Shimadzu GC-2014 instrument equipped with a flame ionization detector (FID) and a non-polar Rtx-1 capillary column (0.25 mm internal diameter, 30 m length and 0.25 µm film thickness (Shimadzu corp., Tokyo, Japan)) to obtain the individual FAME peaks. The detector temperature was 275 °C. The column temperature was held at 150 °C for 1 min and then increased to 180 °C at a rate of 15 °C/min. The column temperature was then increased to 210 °C at a rate of 1 °C/min and held at 210 °C for 4 min. Helium was used as a carrier gas with a flow rate of 1.41 ml/min. The total run time was 60 min. The FAME peaks were identified by comparing their retention times with those of FAMEs from conventional oils and pure FAME standards (Supelco, USA). The identities of the FAME peaks were confirmed by gas chromatography–mass spectrometry using a Shimadzu GCMS-QP2010 Ultra instrument operating under conditions similar to those used for the GC-FID.

The relative percentages of the individual fatty acids were calculated based on the ratios of the peak areas of the fatty acid species to the total peak area of all the fatty acids in the fat sample.

2.2.3. Chemical analysis of the Hachi fat

ISO (International Organization for Standardisation) standards were used for the determination of the peroxide value (ISO 3960), acidity (percentage of free fatty acids calculated as the percentage of oleic acid) (ISO 660), saponification value (ISO 3657) and amount of unsaponified matter (ISO 3596) of Hachi fat.

2.2.4. Physical analysis of Hachi fat

The refractive index of the Hachi fat was determined using an ABBe 60 (Bellingham + Stanley Limited, England) refractometer. The thermal characteristics of the Hachi fat were measured in a dynamic air atmosphere using a TGA-50 thermogravimetric analyzer (Shimadzu, Japan). The airflow rate was 100 ml/min. The Hachi fat samples (approximately 5 mg) were weighed in open aluminum pans. The sample pan was then placed inside the calorimeter. The temperature was increased from 25 to 600 °C at a rate of 10 °C/min.

The melting point for the hachi fat was determined by the capillary tube method using an automatic melting point meter (KSP1, Kruss, Hamburg, Germany) melting point meter.

2.2.5. Infrared analysis

The FTIR spectrum was recorded on a Bruker Tensor 27 FTIR spectrometer equipped with an ATR sampling accessory with a removable ZnSe crystal. The spectrum was collected from 64 scans with a spectral resolution of 4 cm^{-1}. The average spectrum from triplicate analysis in the range 4000–400 cm^{-1} was treated chemometrically using Opus 6.5 Software (Bruker, Germany).

2.2.6. Iodine value determination

The degree of unsaturation of Hachi triglycerides was determined using ^{1}H NMR spectroscopy. Spectral data were recorded on a Varian Mercury-300 spectrometer operating at 300 MHz at room temperature. The sample used for the ^{1}H NMR analysis was approximately 10% fat in 0.7 ml of $CDCl_3$ containing a very small amount of TMS as an internal reference in a 5 mm NMR tube. Using the ^{1}H NMR (Fig. 3), the iodine value was calculated based on the average molecular weight and the absolute number of double bonds (Nehdi, Sbihi, Tan, & Al-Resayes, 2013). For an unknown sample, the average molecular weight must be determined prior to the ^{1}H NMR analysis to minimize error. In the following equations, the letters A–G (Fig. 3) represent the areas of the respective ^{1}H NMR signals:

$$\text{Area per proton} = B/4 \tag{1}$$

$$\begin{aligned}\text{Average mol. wt} = {} & 15.034G/3/(1) + 14.026(C + D + E + F \\ & + H)/2/(1) + 173.100B/4/(1) \\ & + 26.016(A - B/4)/2/(1)\end{aligned} \tag{2}$$

$$\begin{aligned}\text{Iodine value} = {} & 253.8(A - B/4)/2/100 \\ & \times \text{average ml. wt.}(253.8 \\ & = \text{mol. wt of iodine})\end{aligned} \tag{3}$$

3. Results and discussion

3.1. Fatty acid composition

The fatty acid composition (%) of the studied Hachi fat is summarized in Table 1. The most important acids were oleic (C18:1; 33.35%), palmitic (C16:0; 26.16%), stearic (C18:0; 10.07%), palmitelaidic (C16:1n-7; 9.56%) and myristic (C14:0; 8.83%) acid, which together accounted for approximately 88% of the total fatty acids (Fig. 1). According to the National Cholesterol Education Program/American Heart Association, C16:0 and C18:0 fatty acids are the most healthful saturated fatty acids derived from natural sources (Hayes, 2002). Oleic acid is very important in nerve cell construction (Taner Sara oğlu, Zengin, Akin, & Akt-msek, 2012). It can be metabolized into a set of compounds related to prostaglandins that have important roles at the vessel level and in blood coagulation. Oleic fatty acid also has a fundamental role in the prevention of cardiovascular diseases (Nehdi, 2011b). Moreover, various reports have suggested that lauric and myristic acids have preventative effects on prostatic hyperplasia development because of their 5α-reductase inhibitory activity (Veeresh Babu, Veeresh, Patil, & Warke, 2009).

3.2. Physicochemical properties

The physicochemical properties of the studied Hachi fat are summarized in Table 2.

3.2.1. Iodine value

The iodine value (62.74 g/100 g fat) of Hachi fat was low due to its high content of saturated fatty acids but still relatively high