Spectroscopic Investigation of the Cashew Nut Kernel (*Anacardium occidentale*)

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Abstract: Fourier transform infrared and Fourier transform Raman spectra of the kernel of the cashew nut (*Anacardium occidentale*) are presented. Based on the correlations with the infrared spectra of its individual components and other compounds already published, assignments of the observed bands have been done. The infrared spectrum is shown to be very similar to that of triolein, a triglyceride of oleic acid — a characteristic useful in reducing the low-density lipoprotein (LDL) cholesterol level of the person consuming it.

Keywords: Cashew, FTIR, FT Raman, triolein.

INTRODUCTION

Native to arid north-eastern Brazil, the cashew was taken around the world by the Portuguese and Spanish who planted the trees in their colonies. Of all nuts, it is second only to the almond in commercial importance [1]. Cashew nuts form an important part of every day meal in several countries in the world. Though, it can add taste to ice creams, sweets, chocolates, dishes etc., people enjoy most when they eat plain, roasted cashew.

As nuts are typically high in fat — reported to be 46% in the case of the cashew nut [2] — these are traditionally avoided in an attempt to lower blood cholesterol and the risk of coronary heart disease. However, there is increasing evidence the diets that include nuts like the cashew may be a deterrent in controlling cardiovascular ailments [3, 4]. It is indicated [5] that the cashew nut contains appreciable amounts of tocopherols, squalene and phytosterols, all of which elicit cardio-protective qualities. In order to throw light on the beneficial factor of the cashew nut, in the present work a Fourier transform infrared spectrum, along with a Fourier transform Raman spectrum, of the cashew nut kernel are presented and analyzed, which reveal specific functional groups attributed to different vibrational bands present in the spectrum.

MATERIALS AND METHODS

Cashew nuts were collected from Meghalaya, a north-eastern region of India. These were placed on burning charcoal for two-three minutes. The thick shell at first became red and wet with 'cardol' — a thick caustic oil that can cause blisters. Then the shell split and was easily removed. The cashew kernels were crushed to powder in an agate mortar. The FTIR spectrum of the powdered sample was recorded in a Perkin-Elmer Spectrum RX1 FT-IR system, taking KBR pellet as the sample. The resolution was 4.0 cm^{-1}. FT Raman spectrum of the powdered sample was recorded in a Spectra-physics spectrometer equipped with a Nd: YAG laser, having an exciting line of 1064 nm and a power output of 2.5 watts, and a liquid nitrogen-cooled Ge detector.

RESULTS AND DISCUSSION

The FTIR and FT Raman spectra of the sample are shown in Figs. (**1**) and (**2**), respectively, and the wavenumbers of the observed bands together with their assignments are presented in Table **1**. Heavy luminescence masks most of the peaks in the FT Raman spectrum; only three of them have been indicated in Fig. (**2**). In the FTIR spectrum, the broad medium strong band at 3411 cm^{-1} at first look gives the impression that it is due to the OH stretching vibration only, but a closer look reveals the existence of a doublet at a separation of approximately 70 cm^{-1}. This band is almost totally overlapped by OH vibrations and overtones of lower bands. To these two vibrations in the near infrared, we could assign N-H asymmetric stretching and symmetric stretching, respectively [6]. The same assignment has been given to the virtually similar relative intensity pattern observed in the Fourier transform infrared spectrum of riboflavin [7]. The band at 2999 cm^{-1}, similar to the one observed at 3006 cm^{-1} in the infrared spectrum of oleic acid [8], could be the CH stretching related to =C-H bonding, or a combination band (= 1651+1342 cm^{-1}). C-H asymmetric and symmetric stretching vibrations, representing aliphatic CH_2, could be attributed to the very strong band at 2911 cm^{-1}(the corresponding Raman frequency also at 2911 cm^{-1}) and its doublet at 2842 cm^{-1}, respectively [6], while CH_2 scissors deformation vibration [9, 10] could be assigned to the medium strong one at 1460 cm^{-1} (the corresponding Raman peak appearing at 1450 cm^{-1}). C=O stretching vibration of the carboxylic groups (methyl esters and triglycerides) could be attributed [11] to the very strong band at 1746 cm^{-1}. C=O stretch of fatty acids could be attributed to the band at 1705 cm^{-1} — as has been done in the spectroscopic evaluation of the surface quality of apple [12] — while the 1676 cm^{-1} band is likely to be a combination one (= 1161 + 518 cm^{-1}). The

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Table 1. Vibrational Frequencies from the FTIR and FT Raman Spectra of the Cashew Nut Kernel and their Assignments

Frequency (cm^{-1})		Assignment
FTIR	FT Raman	
3411		OH stretch & NH stretch
2999		=C-H stretch/combination band
2911	2911	CH_2 symmetric stretch
2842		CH_2 symmetric stretch
1746		C=O stretch
1705		C=O stretch
1676		Combination band
1538		Combination tone/C=C stretch
1514		Combination tone/C=N stretch
1460	1450	CH_2 scissors deformation
1376		CH_2 wagging
1342		CH_2 wagging
1317	1327	CH_2 wagging
1290-1040		C=C-C-O
1024		C-O stretch
856		OH stretch
721		CH_2 rock
577		C-H out of plane bending/difference band
518		C-H out of plane bending/difference band
444		P=O/difference band
415		P=O/difference band

bands at 1538 (= 1023 + 518) and 1514 (= 1096 + 415) cm^{-1} are either combination bands, or due to C=C and C=N stretching vibrations, respectively [7]. CH_2 wagging vibration could be assigned [6] to the bands at 1376, 1342 and 1317 cm^{-1} (the Raman band manifesting at 1327 cm^{-1}). In the infrared spectrum of oleic acid in the region 1290 – 1040 cm^{-1}, instead of the so-called progressional bands of fatty acids like palmitic acid, a broad band — assigned as C-C stretching — has been observed with some structure [10]. The observed difference could be due to C=C bonding. In Fig. (**1**), a strong band at 1160 cm^{-1} is observed to be flanked by weaker bands at 1234 and 1097 cm^{-1}, as has been observed in the spectrum of triolein, a triglyceride of oleic acid [13, 14]. The triolein molecule is formed by the reaction of three molecules of oleic acid with one of glycerol. So, the mass of the right hand side of C-C bond is increased, leading to a decrease in the frequency of this vibration. This implies that the formation process of the molecule should be very similar to that of triolein. Such characteristics can make the cashew nut a candidate to prevent against LDL cholesterol. The band at 1024 cm^{-1} could involve stretching of the C-O bond, as carbohydrates have many bands in this region [6]. The weak band at 856 cm^{-1} is proposed to be characteristic of the O-O linkage in hydroperoxides, even though its lack of intensity limits its usefulness [15]. The band at 721 cm^{-1}, similar to the one observed in the spectrum of fatty acids and triglycerides, could be assigned to the CH_2 rocking mode [9]. Assignment of vibrations to the weak bands at low frequencies is difficult and somewhat tentative; still, the bands at 577 and 518 cm^{-1} could be assigned as C-H out of plane bending [7, 16]. Similarly, one could, perhaps, assign P=O vibration [17] to the bands at 444 and 415 cm^{-1}, as phosphorus is a major elemental component of the cashew nut kernel [2]. These four bands could be assigned as difference bands also (= 1746 – 1160, 1538 – 1023, 1538 – 1096 and 1651 – 1234, respectively).

CONCLUSION

Through infrared spectroscopy, complemented in few cases by Raman spectroscopy, a satisfactory vibrational band assignment of the cashew nut kernel has been done. The vibrational band analysis conclusively establishes that the formation process of the molecule is very similar to that of triolein, a triglyceride of oleic acid. This result, contrary to the popular belief about 'dietary fat', should encourage its con-

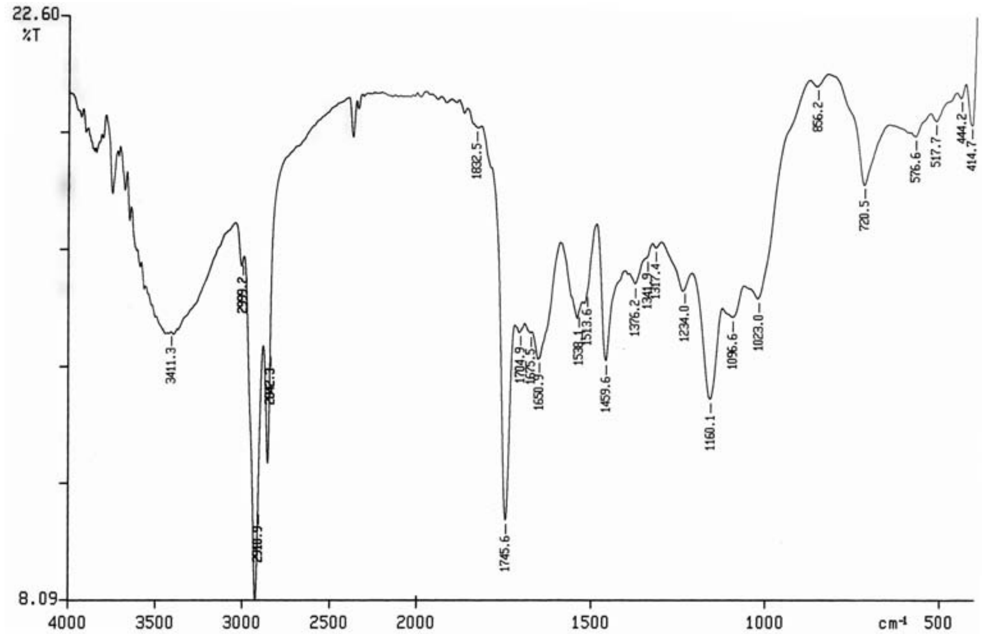

Fig. (1). FTIR spectrum of the cashew nut kernel.

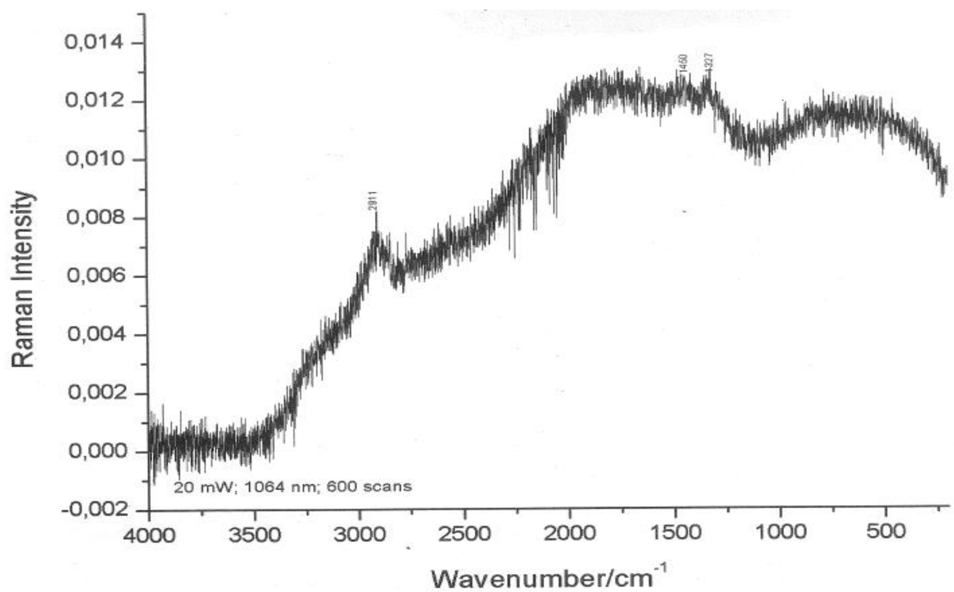

Fig. (2). FT Raman spectrum of the cashew nut kernel.

sumption to decrease the LDL cholesterol level, instead! Though no beneficial effect on the total cholesterol and LDL cholesterol concentrations has been observed in a recent clinical trial on cashew nuts, it has been ascribed to the low TC and LDL-C concentrations of the subjects at the baseline [18].

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