RHEOLOGICAL CHARACTERIZATION OF ANDIROBA OIL IN COMPARISON WITH OTHER CONVENTIONAL AND ALTERNATIVE VEGETABLE SOURCES

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ABSTRACT

Evaluating the rheological behavior of vegetable oils is important to define their application in industry. Thus, the objective of this study is to evaluate and characterize the rheological behavior of andiroba oil and compare it with other conventional (sunflower and soybean) and alternative (baru) vegetable sources. The vegetable oils presented Newtonian behavior at 20 °C and the viscosity values varied from 61.5 mPa.s to 81.9 mPa.s. The conventional oils showed lower viscosity values, while the andiroba and baru oils were more viscous. The results suggest that there is a relationship between the viscosity and the fatty acid composition of these oils. The viscosity of oil extracted from andiroba seeds did not differ from the other oils and may be a promising alternative for food industries.

Key words: vegetable oils, rheological properties, viscosity

INTRODUCTION

Rheology is the science that studies the flow of fluids and the deformation of solids as a function of applied mechanical forces (1). The study of the rheological behavior of a fluid is of great importance for its characterization and application, being necessary for quality control and simulation of processes in the food industry that involve the transfer of mass, heat, and amount of motion, such as in the development of equipment projects (2,3). Furthermore, the viscosity of an edible oil affects its absorption during frying (4) and is considered an important indicator of food texture (5).

Thus, the rheological characterization of vegetable oils from alternative sources, such as andiroba and baru, is essential for application by industries, since the flow behavior of these fluids has a great influence on their stability and processing, and can provide important information about their appearance, texture, and quality of the product.

Andiroba (*Carapa guianensis*) is a species native to the Amazon, while baru (*Dipteryx alata*) is a tree native to the Brazilian Cerrado, and the oils extracted from their seeds have nutritional and medicinal properties, ecological value, and wide use in the pharmaceutical and cosmetic industries (6,7). These oils from alternative sources have potential applications in the food sector since there is a trend on the part of consumers to seek a healthier lifestyle (8).

OBJECTIVE

To evaluate and characterize the rheological behavior of refined vegetable oils from alternative (andiroba and baru) and conventional (sunflower and soybean) sources.

MATERIALS AND METHODS

Materials

The refined andiroba and baru oils were purchased from Mundo dos Óleos (Brasília-DF), and the soybean and sunflower oils were obtained from local commerce in the city of Viçosa-MG.

Rheological Properties

The evaluation of rheological properties was determined using a HAAKE MARS oscillatory dynamic rheometer (Modular Advanced Rheometer System, Thermo Electron Corp., Germany) equipped with a thermostatic bath (Phoenix 2C30P, Thermo Electron Corp., Germany) at 20 °C using a coaxial cylinder sensor (DG41). The flow curves of the vegetable oils were obtained by applying a shear rate ranging from 0.01 to 200 s^{-1} for 120 s.

Newton's model was fitted to the experimental data:

$$\tau = \eta\gamma \quad \text{(Equation 1)}$$

Where τ is the shear stress (Pa), η is the viscosity (Pa.s) and γ is the shear rate (s^{-1}).

The results were evaluated by analysis of variance (ANOVA), followed by Tukey's test of means at 5% probability.

RESULT AND DISCUSSION

The flow curves (Figure 1) indicate Newtonian behavior for all refined vegetable oils (andiroba, baru, sunflower, and soybean), obeying Newton's first law (Equation 1), in which there is a linear relationship between shear stress and strain rate (5,9). The coefficient of determination was close to or equal to 1.00 for all oils, i.e. Newton's model adequately describes the flow behavior of these vegetable oils. This behavior is commonly found in several vegetable oils (2, 10-12).

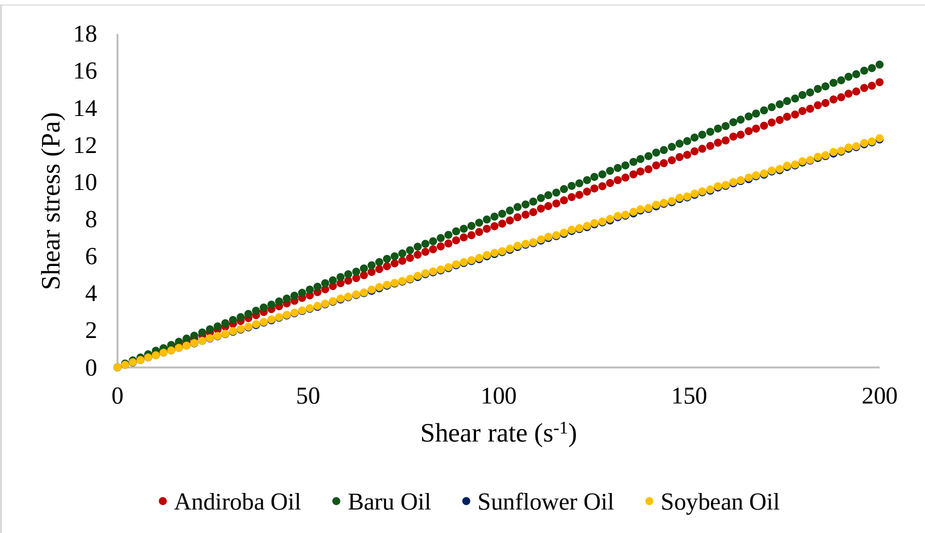

Figure 1. Flow curves for andiroba, baru, sunflower and soybean oils.

The viscosity is given by the slope of the shear stress curve as a function of the strain rate. Table 1 shows the average viscosity of vegetable oils at a temperature of 20 °C. The viscosity values were similar for sunflower (61.5 mPa.s) and soybean (61.9 mPa.s) oils. This result was also observed in other studies (2,10,13). The viscosity of conventional oils was significantly lower than that of baru oil ($p < 0.05$), which had a value of 81.9 mPa.s. However, the viscosity of andiroba oil (76.9 mPa.s) was statically equal to all oils ($p > 0.05$). The viscosity values obtained in this study are close to those found in the literature, at 20 °C to 25 °C, for soybean (59.0 mPa.s), corn (67.6 mPa.s), sunflower (58.3 mPa.s), rice (73.8 mPa. s), cotton (67.7 mPa.s), olive (79.7 mPa.s), canola (73.1 mPa.s), or some oils from vegetable sources unconventional, such as mustard (71.02 mPa.s), hazelnut (63.00 mPa.s), and macadamia (58.30 mPa.s) (2,13-15). Pineli et al. (16) determined the viscosity of baru oil at 20°C and the value found (76.8 mPa.s) was lower than that of our study. This difference can be attributed to climatic issues, soil type, genetic aspects, agricultural practices and oil extraction conditions that can influence its chemical composition. The viscosity at 20°C for refined andiroba oil was not found in the literature.

Table 1. Viscosity of andiroba, baru, sunflower, and soybean oils at 20 °C.

Oil	Viscosity (mPa.s)	R^2
Andiroba	$76{,}9 \pm 0{,}57^{ab}$	1,0000
Baru	$81{,}9 \pm 0{,}21^{a}$	1,0000
Sunflower	$61{,}5 \pm 0{,}31^{b}$	0,9999
Soybean	$61{,}9 \pm 0{,}32^{b}$	0,9999

Data represented by mean ± standard deviation; means followed by the same letter are not statistically different by Tukey test at 5% probability; R^2: coefficient of determination.

Viscosity can be strongly influenced by the fatty acid profile of vegetable oils, since the more double bonds are present in the oil, the lower the viscosity. This is because the presence of the double bond hinders the intermolecular interactions between the fatty acid molecules, and consequently reduces the flow resistance of the fluid (17). This can be confirmed by Table 2, in which the fatty acid composition according to scientific literature for the oils in this study is presented. Sunflower and soybean oils have the highest values for polyunsaturated fatty acid composition, 62.6% and 60.0%, respectively, which may explain their lower viscosity values. On the other hand, andiroba and baru oils, with higher viscosity, present in their composition a higher concentration of monounsaturated fatty acids, 49.4% and 49.2%, respectively. The profile of fatty acids may vary among the same plant species since it will depend on the geographical origin, climatic conditions during cultivation and the fruit's state of maturity (18,19).

According to Siqueira et al. (20), baru oil presents in its main composition the oleic and linoleic acids, which favors its use as part of the human diet and in the pharmaceutical industry. Andiroba oil, on the other hand, is rich in essential fatty acids, such as oleic, palmitic, and linoleic, enabling its use for food purposes, and, in addition, it has proven effective in the field of medicine, presenting, for example, insect repellent effect and wound healing (21,22).

Table 2. Fatty acid (FA) profile of andiroba, baru, sunflower and soybean oils in terms of saturation.

Oil	FA saturated (g)	FA monounsaturated (g)	FA polyunsaturated (g)	Reference
Andiroba	36,5	49,4	12,1	(19)
Baru	10,3	49,2	31,5	(20)
Girassol	10,8	25,4	62,6	(23)
Soja	15,2	23,3	60,0	(23)

Composition per 100 grams of edible part.

CONCLUSION

The andiroba, baru, sunflower and soybean oils showed Newtonian behavior and the viscosity values varied among the sources, which can be explained by the difference in chemical composition among the oils. The viscosity of andiroba oil did not differ from conventional oils and baru oil. The results suggest that vegetable oils from alternative sources, such as andiroba, have potential applications in food, pharmacy, cosmetics and medicine.

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