Investigation of some physical properties of some Nigerian farm and local market honey samples

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Honey is the oldest sweetener known by man. Its consumption linked to its medicinal value has also enhanced the well-being of humans. This study was embarked upon to investigate some properties of physical origin of samples of honey sourced from farms and local markets across Nigeria so as to check their quality. The honey properties of physical origin investigated here include viscosity, moisture content, sugar content (contents of glucose and fructose) and glass transition temperature. The contents of glucose and fructose of the samples of honey were analyzed and their viscosity values determined at 25°C were used to calculate their moisture content. These results were then incorporated into an equation so as to calculate the glass temperature of transition. The viscosity and content of moisture of the analyzed honey samples varied from 472.63 to 3345.51 mPa.s and 20.1 to 26.4% respectively at 25°C. The results obtained pointed out the high viscosity and low glass temperature of transition characteristic of the honey samples ranging from -61.89 to -52.14°C. The overall average viscosity result is indicative of the farm honey samples having a better quality than their market counterparts.

Key words: Honey, moisture content, sugar content, glass temperature of transition, granulation

INTRODUCTION

Honey is a sweet smelling fluid with a viscous character. It is made by bees by harnessing the nectar of flowering plants. It stands out as the oldest and only natural sweetening product available to mankind and therefore is used by people of all ages without undergoing any meaningful processing (Sudhanshu et al., 2014). Besides other components like organic acids, amino acids, mineral matter and fats which may serve as sources of dietary antioxidants, the major compositions of honey include carbohydrates and water. In Nigeria, the major variety of honey found is the *Apis mellifera* (Oyerinde and Ande, 2006).

The employment of honey as food and medicine has been in existence. Credit has been given to honey for its many therapeutic and biological purposes such as in the treatment of gastrointestinal diseases and wounds. This honey's beneficial role may be attributed to its properties of antimicrobial and anti-inflammatory origin arising from its low content of acid and high content of sugar. Several enzymes like invertase, glucose oxidase, catalase and phosphatases found in samples of honey are very helpful in the healing process of ailments like ulcers and diabetes (Amril and Ladjama, 2013; Khalil et al., 2010; Ahmed et al., 2007).

In the characterization of honey based on its physical properties, certain parameters like viscosity, moisture content, glucose content, content of fructose, and glass temperature of transition are very useful. The viscosity measurement of samples of honey is an effective way of determining their rheological behavior. It gives important information as far as the design of equipment needed for the processing and transportation and honey's storage are concerned. Viscosity is a key rheological property of honey which is controlled by the content of its moisture and temperature. The power of preservation,

quality and storage capacity of honey is heavily dependent on content of its moisture and this may become unbearable if not checked which may in turn affect its market value (Eman et al., 2018; Juszczak and Fortuna, 2006).

The content of moisture of a honey sample is a physical property which plays a major role in the checking of its overall property. Furthermore, it can be used in the final stage of assessing the quality of honey because it influences both the honey's stability plus resistance to microbial spoilage brought about during the storage period. When the value moisture content increases above a maximum bearable level, it can result in honey spoilage and this will in turn, affect its sensory properties. As this value increases, there will be a greater probability of yeast fermentation and thus changes in the honey's flavor and color will be more pronounced. When honey ferments, it produces alcohol which may break down to form ethanoic acid and water when there is sufficient supply of oxygen. Therefore, it will be left with no choice than to have a sour taste (Nwoko et al., 2017). Honey is a supersaturated solution containing sugar and as such, its major constituents are glucose and fructose. The percentage of these two monosaccharides in honey is very useful in assessing its glass temperature of transition and its classification with respect to the geographical and botanical origins. The value of the key content of sugar in honey is of great importance and as such, the knowledge of the ratio of its glucose content to fructose content could be used by honey processors in the production of granulated honey. The higher this ratio, the higher the readiness for it to granulate (Cui et al., 2008).

The determination of honey's glass temperature of transition is a technique of assessing the thermophysical property of the honey samples like crystallization or granulation. Honey contains a high concentration of sugar with fructose and glucose having a higher proportion than all other constituents. For this reason, honey may often be transformed into a semi-solid state referred to as crystallized or granulated honey. The concept of honey granulation may be employed as a remedy to the numerous problems associated with liquid honey samples such as ease of transportation and handling by virtue of its high viscosity (Cui et al., 2008). Certain factors affect the speed of honey granulation and they include the sugar content, the method in which the honey is being processed and its glass transition temperature. Honey glass transition occurs when it undergoes a cooling process in order to change from its state of rubber to the state of glass (Sopade et al., 2002). When equipped with the knowledge of glass temperature of transition, it can be used to assess the quality as well as stability and safety of the product and of other food products which contain honey. Glass transition in honey is a key predictor which reveals the tendency of the honey to be converted to granulated form especially during cold weather. The temperature at which honey displays a glass transition nature is known as the glass temperature of transition. It refers to the temperature where the honey sample acquires a viscosity of 10^{12} Pa.s (Debenedetti and Stillinger, 2001). Considering the numerous importance of honey having nutritional and medicinal origin despite the fact that its price is very high in local markets and international counterparts, there is limited information on the properties of honey samples with rheological origin in Nigeria, coupled with the fact that there is little or no reported data on the glass temperature of transition of honey samples in Nigeria. The objective of this research was to determine the viscosity, moisture content, glucose content and fructose content of some Nigerian Honey samples from selected farms and markets at room temperature and use these values to calculate their glass transition temperature.

MATERIALS AND METHODS

Sample collection

Eleven honey samples from different farms and local markets in Nigeria were analyzed for viscosities, moisture contents, sugar contents and glass transition temperatures in the study. The farm honey samples were labeled HS_1 (Irikefe farm, Jesse), HS_2 (Sunshine farm, Akure) and HS_8 (Okowalt farm, Benin City). The market honey samples were also labeled as HS_3 (Mubi market), HS_4 (Saki market), HS_5 (Nsukka market), HS_6 (Okirighwre market), HS_7 (Makurdi

market), HS_9 (Boru market), HS_{10} (Amukpe market) and HS_{11} (Tureta market).

Viscosity measurements

Viscosity measurements were made at 25°C by means of a Digital Rotary Viscometer (Model NDJ-5S, manufactured by M and A Instruments Inc., Shanghai China) at 60 rpm employing the four spindles.

Determintion of moisture, glucose and fructose contents

The viscosity (μ), moisture content (w) and temperature (t) are related as shown in Equation 1 (Slawomir, 2007). By making the moisture content (w) the subject of Equation 1, the moisture contents of the honey samples was calculated from the measured viscosity values as shown in Equation 2.

$$\mu = 14200 \exp(-0.31w - 0.085t) \quad (1)$$

$$w = 30.842 - 3.226\ln\mu - 0.274t \quad (2)$$

where μ is viscosity, w is moisture content and t is room temperature in degree Celsius, °C.

Equation 3 was employed to determine the glucose and fructose contents of the honey samples from the absorbance values obtained from the spectrophotometric analysis using the method of Nwoko et al. (2017). The glass transition temperature was then calculated using Equation 4 on the basis of the fact that the main sugars which are contained in honey are glucose and fructose (Sopade et al., 2000).

$$\%\ \text{Fructose or Glucose} = \left[\frac{S \times W}{25 \times H}\right]^{-1} \quad (3)$$

where S and H are the calculated absorbance of the dilute standard and honey sample respectively, while the weight of honey sample used is W.

Calculation of glass transition temperature

The glass transition temperature of each of the honey samples was quantitatively determined using Equation 4 (Sopade et al., 2000), where T_g is glass transition temperature, w is moisture content, F is fructose content and G is glucose content.

$$T_g = -7.9 - 2.3w - 5.4 \times 10^{-3}F + 136.4 \times 10^{-3}G \quad (4)$$

RESULTS AND DISCUSSION

The viscosity and moisture content of the analyzed honey samples varied from 472.63 – 3345.51 mPa.s (Figure 1) and 20.1-26.4% (Table 1) respectively at 25°C.

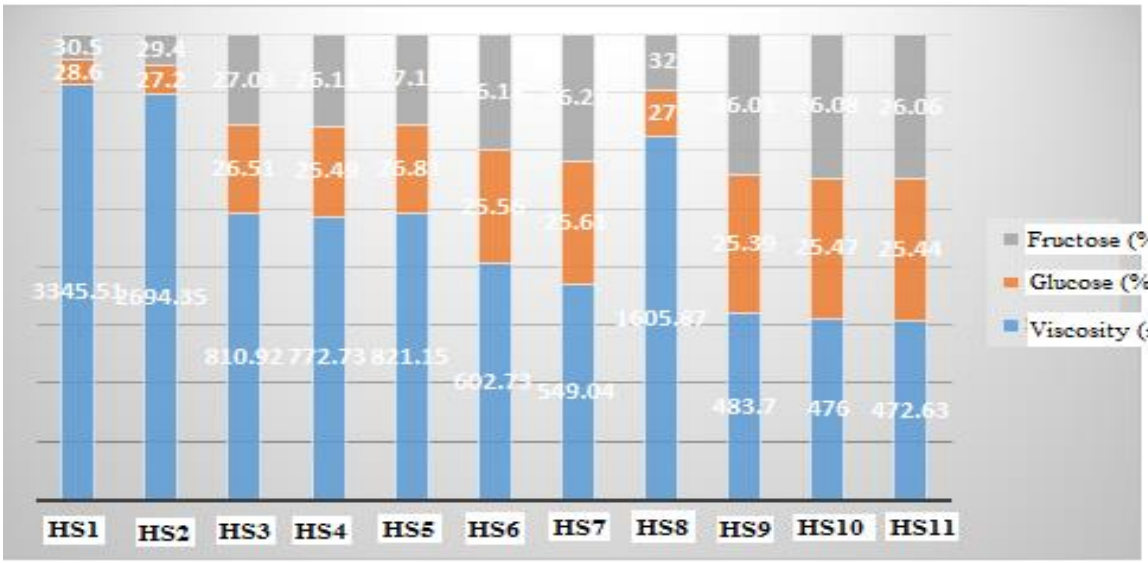

Figure 1. Viscosity, glucose and fructose contents of the honey samples at 25°C.

Table 1. Moisture content (%) and Glass transition temperature (^{o}C) calculated at 25^{o}C.

	Honey sample										
	HS_1	**HS_2**	**HS_3**	**HS_4**	**HS_5**	**HS_6**	**HS_7**	**HS_8**	**HS_9**	**HS_{10}**	**HS_{11}**
w	20.1	20.8	24.7	24.8	24.6	25.6	25.9	22.5	26.3	26.4	26.4
T_g	-56.37	-54.00	-59.86	-52.14	-61.89	-52.52	-52.65	-61.87	-52.95	-52.96	-52.97

The honey sample HS_1 had the highest value of viscosity and lowest value of moisture content, while the honey sample HS_{11} had the lowest viscosity value of 472.63 mPa.s at 25°C. The honey samples, HS_{10} and HS_{11}, and the same value of moisture content at 25°C which is the highest. It can be observed that the farm honey samples are more viscous than their market counterparts at the specified temperature. A high honey viscosity is an attribute of its purity and hence its quality. The viscosity of a honey sample is a measure of its quality. A pure honey sample has a high viscosity, low moisture content and hence good quality. A low viscosity is indicative of a high moisture content and hence of poor quality (Cervantes et al., 2000). However, the values of moisture content of the honey samples in this study are in agreement with the values of 16.4 to 34.0% (Japhet et al., 2018) and 18.0 to 25.6% (Oyeyemi, 2017) earlier reported by other researchers from Nigeria. The discrepancies between the viscosities of the honey samples from the farms and markets in this study therefore suggest that the farm honey samples are of better quality than the honey samples from the markets, as the latter might have been diluted to maximize profits at the expense of quality.

The contents of the major sugars (fructose and glucose) in the honey samples in this study are shown in Figure 1. However, fructose and glucose constitute the main constituents of honey, making up to about 95% of honey dry weight. The glucose content of the farm honey samples ranged from 20.1 to 22.5%, while the fructose content ranged from 30.5 to 32.0%. Also, while the glucose content of the market honey samples fall in the range of 25.49 to 26.81% their fructose contents ranged from 26.01 to 27.15%. It could be observed that the honey samples had key sugar content ranging from 50 to 60%. The overall sum of the moisture and the key sugar content constitute 70 to 90% and the remaining 10 to 30% could be attributed to the presence of other minor components in these samples. This sugar values fall within the range of 63.82 to 80.25 % obtained for some honey samples from the Southern part of Nigeria and are similar to results from other countries (James et al., 2009).

The glass transition temperature, T_g of the honey samples in this study varied from – 61.89 to – 52.14°C (Table 1). The highest T_g value (– 52.14°C) was observed from honey sample HS_4; whereas, the lowest T_g value was noticed from honey sample HS_5 (– 61.89°C). Roos (1995) explained that the closer a food's glass transition temperature is to its storage temperature, the more stable potential that food will attain. The T_g values obtained in the current study are in agreement with literature values which reported the ranges such as – 65.30 to – 47.90°C, (K´antor et al., 1999); – 65.30 to – 41.9°C, (Rubin et al., 1990); and – 51.00 to – 46.00°C (Sopade et al., 2000). The results obtained for the glass transition temperature of the honey samples in this study may be relied upon to claim that most of the honey samples are likely to be pure honey samples to some extent but of floral origin (T_g<– 42.9°C) (Cordella et al., 2003). Glass transition in honey samples is a valuable property that can be used for the prediction of the tendency of honey to be converted to granulated or powdered form and it is very useful in honey processing industries, such as in the snack-food and baking industries, where honey is a valuable ingredient. Also, honey granulation is quite an interesting topic for discussion amongst its processors, especially during the cold season (Sopade et al., 2000).

Conclusion

The study investigated some physical properties of honey samples purchased from farms and local markets across Nigeria with the view of ascertaining their quality so as to compete

favourably in the local and international markets. The results obtained revealed that the studied samples of honey are characterized with high viscosity and low glass transition temperatures. Comparatively, the study showed that the farm honey samples are better in quality than their market counterparts, considering the high viscosity values and low moisture contents of the former.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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