QUALITY EVALUATION OF HONEY FROM DIFFERENT FLORAL SOURCES IN SOKOTO STATE, NIGERIA

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ABSTRACT
Adulteration of honey has becoming a matter of deep concern. Quality evaluation will ensure prompt detection of adulterated honey. This study aimed to assess quality evaluation of honey from different sources in Sokoto State. The parameters estimated included, color, purity , free acidity, lactic acidity, Total acidity, relative density, moisture, ash, protein, fat, carbohydrate, energy, vitamin C, glucose, fructose, sucrose ,glucose + fructose fructose/glucose ration and mineral elements. These parameters were estimated according to Association of official analytical chemist (AOAC) (1990) and Food and Drugs Administration(FDA) . The parameters are color : dark amber, amber and light amber, PH (3.47 ±0.02 – 6.0 ±0.01), free acidity (5.33 ± 1.07 – 24.53 ± 2.85 meg/kg) , lactic acid (1.20 ±0.24 – 5.50 ± 0.63 meg/kg), total acidity (11.760 ± 1.31 – 30.050 ±3.46 meg/kg) relative density (1.440 ±0.00 – 1.730 ±0.03 g/dm^3), moisture (4.130 ± 0.06 – 13.20 ± 0.11g/100g), ash (0.470 ±0.07 – 4.06 ±0.18 g/100g), protein (0.690 ± 0.01 – 1.010 ± 0.01g/100g), fat (0.060 ±0.03 – 0.630 ±0.03g/100g), carbohydrate (85.050 ±0.22 – 93.760 ±0.02 g/100g), energy (13970 ±1.62 – 1609.280 ±0.52 kcal/100g), vitamin C, (13.520 ±0.07 - 66.260 ±2.06g/100g), Glucose(11.86 ±0.10-32.5±0.23), Fructose(23.53±0.44-51.94±0.82),Sucrose(0.76±0.01-2.01±0.003), Na (20.330 ± 0.33 – 61.660 ±0.88 mg/100g), K (16.330 ±0.33 – 59.330 ±0.66 mg/100g), Ca (0.290 ±0.03 – 0.740 0.01 ±), Mg (0.140 ±0.01 – 1.00 ±0.003 mg/100g) and P (1.300 ±0.06 – 1.570 ±0.01 mg/100g) . The parameters are comparable with those from many parts of the world and are also within the limits of international standards which confirm their nutritional quality and support their utilization in various food products.

1. INTRODUCTION

Honey is a naturally sweet substances synthesized by honey bees (*Apis mellifera),* from the nectar of plants (Codex Alimentarius commission, 2001a). Natural honey, is a complex mixture of carbohydrates and other minor substances, such as organic acids, amino acids, protein, minerals and vitamins. In almost all honey types, fructose predominate, glucose being the second main sugar (Abdel *et al*., 2013). These two account for nearly 85 – 95% of honey carbohydrates (Abdel *et al., 2013).* Honey also contains volatile its substances which are responsible for characteristic flavor (Finola and Lasagono, 2007).

The increasing demand for honey in the market leads to high cases of the dishonest act of adulteration and production of synthetic honey (Korth and Ralston, 2002). This has been driven by high profit sought by the sellers, as the price of adulterated honey or synthetic honey is much lower than that of pure honey (Sanford, 2003). Adulterated honey is difficult to be identified which poses problems in its trades (Korth and Ralston, 2002). Over the years many foreign substances such as glucose, dextrose, malasses, corn syrup, sugar syrup, flour and paraffin had been used as adulterants in honey (Korth and Ralston, 2002).

Fortunately, a lot of laboratory techniques and test for honey adulteration have been developed to identify and check the purity of honey. However, not all of the tests may meet the world standards because the standard of honey purity varies between countries. The Codex Alimentarus Standard (2001b) for honey quality include several chemical and physical parameters such as moisture, mineral, acidity, enzymes activities and apparent sugar content. These help to determine quality of honey analyzed (F.D,A. 2014).

Lack of information on the quality of honey hinders its wide spread use. Therefore, the objective of this research was to evaluate the quality of honey samples collected from different apiaries of Sokoto State, Nigeria and compare the quality parameters with international standards.

2 MATERIALS AND METHODS

2.1 Collection of Honey Samples: Samples were obtained from local producers. Ten villages were randomly selected from 24 local producing areas of the Sokoto State. All samples were collected in a separate sterile containers (Labelled with number, place and date of collection) and stored at ambient temperature until analyzed. Unwanted materials such as sticks dead bees and particle combs ware removed before analysis.

Table 1: The Floral and location of honey used in study

S/N	Villages/LGAS	TREE SOURCE OF NECTAR
1.	Turbah (Isa)	*Acasia nilotica*
2.	Tarah (Sabon birni)	*Acasia nilotic*a
3.		*Azadracta indica*
4.	Hausawa (Dange)	*Acasia nilotica*
5.	Garin Magaji (Silami)	*Parkia africana*
6.	Majiya(Dange)	*Balanite aegyptica*
7.	Jurga(Dange)	*Diospyros mespliformis*
8.	Tozai(Isa)	*Acacia nilotica*
9.	Gidan Buwai(Rabah)	*Diospyrus mespliformis*
	Gatawa(Sabon birni)	*Onion twister*
10.	Karadadaye(Kware)	

2.2 Physicochemical Characteristics

Colour: Honey sample was poured into petridish and observed directly. Subjectivity was done by comparing colour choice of three observers and upholding the most common in according to FDA (2014).

Purity: This was done by keeping honey in the refrigerator for 24 hours to check for freezing according to Allen *et al.*, (1991).

pH: The pH was determined using pH meter(Janween,3015,England) by direct insertion of the electrodes into the samples.

Total or free acidity: Twenty five mililitres of each sample (diluted) were titrated against O.1N Na0H using phenolphthalein as indicator. The free acidity and lactic acidity were calculated using the following formula.

$$\%\text{free acidity} = \frac{Titre\ value \times Normality \times 10}{Volume\ of\ samples}$$

$$\%\text{lactic acidity} = \frac{Titre\ value \times Normality \times 9}{Volume\ of\ samples}$$

%Total acidity = was obtained by combining percentage free and lactic acidities.

Relative density:- This was determined as the ratio of the weight of sample to that of an equal volume of water.

2.3 Biochemical Analyses

Proximate Chemical Analysis: This was determined using the method of Association of official Analytical chemists (AOAC) (2000). For moisture content, 2.0 grams of each sample were dried to constant weight in hot air oven (Philip Hans limited England) at 70^0c and the moisture was calculated on dry basis. Ash content was determined by drying 5.0g of honey sample in porcelain crucible at 105^0c for 3hrs. The dried samples were ignited in furnace at 550 600^0c to constant weight, cooled and weighed. Protein content was determined using micro-kjeldhal procedure to estimate the total nitrogen content and the protein content was calculated using the nitrogen (%) x conversion factor (6.25).The crude fat content was determined following extraction by Majonnier fat extraction apparatus.

The carbohydrate contents were determined by difference as follows:-

% Carbohydrate = 100% - (% moisture + % crude fat + % crude protein + % Ash).

The energy content was calculated using the formula;

Energy (KJ/100g) = 4.186 [(% crude protein x 4) + (% crude fat x 9) + (% carbohydrate x 4)]

Determination of Sugar Contents

Determination of Glucose Content: Glucose was determined by enzymatic oxidation with glucose using glucose oxidase reagent (Radox laboratories Ltd, UK) based on AOAC (2000). Twenty microliters (20ul) of the standard and sample were reacted with 2.0ml of the reagent and incubated for 10min at 37^0c. The absorbance was read against a reagent blank within 60 minutes. Glucose concentration was calculated as follows:

Glucose content (mg/dl) = (A sample/ A standard) X Conc. of standard

Determination of fructose content: Fructose was determined using AOAC (2000) method. To solution of the honey sample 1.0ml resorcinol reagent was added and mixed thoroughly and then 1.0ml of dilute Hcl was added. Standard solution containing 0.2, 0.4, 0.6, 0.8 and 1.0mg/ml and made up to 2ml with distilled water was also treated with 1.0ml of resorcinol reagent and 1.0ml of dilute HCl as above. A blank solution was prepared along with the standard, and were heated in water bath at 80^0C for about 10 minutes.
The solutions were then cooled by immersing in tap water for 5minutes and the absorbance read against blank solution at 520nm within 30 min. The fructose contents were then extrapolated from a stand curve prepared using the absorbance of the standard.

Determination of Sucrose Content: The determination of sucrose was done using the Layne – Enyeon Method as described by AOAC (1990).

Determination of Ascorbic Acid (Vitamin C): This was done by the 2, 6 – dichloro phenolindophenol titrimetric method as described by AOAC (1990).

Determination of Minerals: Magnesium and Calcium were determined using atomic absorption spectrophotometry and Sodium and Potassium were determined by flame photometer while phosphorus was determined calorimetrically.

3. STATISTICAL ANALYSIS

The parameters were replicated three times (n=3). Result presented are mean values of each determination and standard error of mean (SEM).Analysis of variance was performed by one way (ANOVA) procedure (SPSS 11.0 window).

1. RESULT AND DISCUSSION

Table1 shows the physiochemical characteristic of honey collected from the various traditional apiaries of some villages of Sokoto State. The color obtained varied within the earlier reported array in honey i.e. Dark amber, Amber and light amber color, although dark amber color were more frequently encountered but few honey posses amber and light amber coloured. This may be linked to the floral variation in agreement with the report of FDA standard for honey (2014). All honey samples tested for purity show negative results as none of the honey completely froze which was in accordance with Allen *et al.,* (1991) who reported honey did not freeze.

The pH values of the honey samples were within the acidic range of pH of 3.85- 6.05, the pH values were within the acceptable range specified by Codex Alimetarius (2001). Similarly, the pH values obtained in this study agreed with previous works of Adebiyi *et al. (*2004) who reported value for some Nigerian honey ranged from 4.37 – 6.02. Similarly Kayode and Oye yimi (2014) reported pH range of 4.10 – 4.65 for fifteen honey samples in Nigeria. In general honey is ac idic in nature irrespective of its geographical origin (Adebiyi *et al*., 2004).

The free acidity, lactone and total acidities of the samples analyzed show all honey fall under the prescribed limit of 50meg/kg specified by the international standards (Codex Alimentarius Commission, 20001b). In this study the averages values obtained for free acidity lactone and total acidity are in line with the observation of White and Doner (1980) who reported free acidity, lactone acidity and total acidity of 22.03meq/kg, 7.11meq/kg and 29.12meq/respectively.

The present study also agree with the finding of Omafuvbe and Akanbi (2009), who reported the free acidity, lactone acidity and total acidity of some commercial Nigeria honeys from south as 27.00meq/kg, 10.55meq/kg and 37.20meq/kg respectively. This present study also reveals that acidity predominate over lactone acidity in all the samples analysed which is similar to observation reported by Ciappini et al., (2008).

From our results the relative density of the honey samples ranges from 1.44-1.7 3, the values are similar to reported by Oyeyemi *et al.,* (2015). Who reported relative density of 1.23- 1.48. Our finding are also in line with work of Ndife *et al*., (2014) who reported a range of 1.42 – 1.44 relative density for Nigerian honey.

The results of proximate composition of honey samples analyzed are presented in Table 2. The moisture of range from 4.13 – 13.21%.These are lower than the 21% maximum recommended as standard for a good quality honey (Codex Alimentarus 20001b). The values fall below the range of moisture content reported by White and Doner (1990). who reported moisture content range of 13.4 to 22.9/100g. The ash values are range between 0.47 – 4.06. Our findings disagree with the previous works of Adenekan *et al*., (2010) and Buba *et al.,* (2013). These researchers reported the ranges of 0.12

to 0.50% and 0.37 to 0.54% respectively for some Nigerian honey samples. The values of our parameter are higher compared with the range of 1.18% to 1.73 reported by Ndlife *et al.,* (2014). Codex Alimentarium Commission standard (2014) proposed not more than 0.6% ash content for honey samples. Our result for the honey samples may be indicative of the fact that honey contain higher quantities of essential inorganic macro and micronutrients. The crude protein content of our honey samples range from 0.69-1.01% and are relatively lower than the value range of 1.43 -2.72% reported by Agunbiade et al., (2012) for honey obtained from three state of Nigeria. The result were similar with the work of Buba *et al.,* (2013) who reported crude protein values of 0.35 – 1.08g/100g on analysis of biochemical composition of honey samples from North – East Nigeria.

The result also revealed the crude fat content of honey samples range from 0.06- 0.63 these signified little or no fat several literature reported that honey has little or no fat (Singh *et al.,* 1997). These results were in line with the work of Buba *et al..,* (2013) who reported fat content of honey samples ranging from 0.1-0.5g/100g. Khalil *et al* (2010) reported total fat contents in range of 0.134 to 0.146g/100g: thus indicating that honey contains very little amount of lipid and therefore not considered as good source of lipid. Our result show that honey samples contain higher amount of carbohydrates (85.05 – 93%). These values were comparatively higher than values of 77.60 to 86.20% reported for honey sample from six states in Northern States in Nigeria by Buba *et al.*,(2013). The result corresponds to the finding Khalil *et al.,* (2010). Carbohydrates are the main constituents of honey comprising about 95% of honey dry weight (Doner, 1997).

The energy values of honey samples from all the floral and villages ranged between 1397.34 to 1601.31kj/100g, these values are in line with Buba *et al*., (2013) who reported that energy value of honey sample of North-east state ranged from 1383.23 to 1410.20kj/100g.

Honey is primarily a high energy carbohydrate food and honey sugars are easily metabolized by the body unlike the refined sugar, hence honey is regarded as good food for both young and adults. The vitamin C contents are observed to be within the range of 13.52 to 66.26mg/100g, the highest vitamin C observed from the study are within the range reported by Matei (2004), who reported Vitamin C contents ranging from 226-229mg/100g for floral sample honey in Romania. Honey contains ascorbic acid because most flowers on which the bees forage contain this vitamin which serves as an antioxidant in addition to many other functions (Kesic *et al.,*2009). Indeed, it has been shown that antioxidant activity of honey depend on its botanical origin i.e. Content vitamin C has significant impact on total antioxidant activity in honey (Kesic *et al.,* 2009).

The results on sugar content of honey samples from different villages of Sokoto State are presented in Table 3; the glucose contents of the honey samples analysed in this study varied between 11.86 to 32.54 g/100g. These values fall within the range of values reported by other scientist Buba *et al*., (2013) who reported that the glucose content of honey samples varied from 7.25 to 39.56g/100g with an average of 31.65g/100g.From our study the fructose contents of honey samples varied from 23.53to 51.9 g /100g . Fructose is of higher content than the glucose contents. This indicates that fructose is the major sugar in all the samples analyzed except sample from Tarah, this is in agreement with earlier observation by White and Doner (1980).

Glucose and fructose are dominant sugar types in honey's but no limits have been fixed by Codex Alimentarus for their individuals values (Buba *et al.,* 2004). But the combined sum (Fructose + glucose) has been fixed at a value > 60g/100g as one of the requirements of the international standard for honey established by Codex Alimentarius Commission(2001b).The sum of glucose and fructose of the honey tested range between 42.01 to 73.29g/100g. These values are withing the range of Buba *et a*l.,(2013) with 66.70 and 79.08g/100g. In addition to sum of fructose and glucose, other important factors to relate to honey quality include the fructose / Glucose ratio; these fall in the range of 0.75-1.5. The fructose glucose ration indicate the ability of honey to crystallize (Buba et al., 2013). White and Donar (1980) stated that even though honey has less glucose than fructose it is glucose that crystallizes when honey granulates because it is less soluble in water than fructose. When fructose glucose ration is high, honey remains liquid (White and Donar, 1980).

The international norms established by Codex Alimentarius Commission (2001b) require that good quality honey should not contain more than 5g/100g sucrose. The sucrose contents of honey samples analysed were in the range of 0.76-20.01/100g. These values are within the limit of the international standard, of Codex Alimentarius commission (2001b). The values for sucrose obtained in this investigation are within the range reported by Buba et al., (2013) who reported that sucrose content ranged from 0.53 to 3.29/100g. Our result of the mineral contents presented in Table 4. The concentration of the mineral found in the honey samples was in order of Potassium > Sodium > Phosphorus > Calcium >Magnesium. The values are in agreement with the findings of Abagwa *et al.,* (2011) and Ndife *et a*l.(2014) who reported potassium dominance in honey investigated.

The mineral element content of honey may vary as result of the difference in plant species visited by the honey bees during nectar collection and the type of soil in which the floral were found .These minerals play several physiological and biochemical functions in the human body (Turan *et al.*, 2003)

2. CONCLUSION

The values of quality parameters for all the honey studied agree with those specified by the international honey regulations, thus it can be concluded that honey samples from villages of Sokoto State are of good quality and have met international standards. The honey also contain high vitamin C levels which confer good antioxidant properties. The honey could be used in preparations of other food products.

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Table I: Physico- Chemical Characteristics of Honey Samples from Some Villages of Sokoto State

S/N	Village of collection	Colour	Purity test	PH	Free acidity (meq/kg)	Lactic acidity (meq/kg)	Total acidity (meg/kg).	Relativeden sity(g/dm^3)
1.	Turbah	D.AM	-	6.5±0.01	14.40±0.92	3.24±0.21	17.64±1.13	1.48±0.06
2.	Tarah	AM.	-	5.16±0.0	16.00+1.85	3.57±0.44	19.6±2.26	1.59±0.003
3.	Hausawa	D.AM	-	4.70±0.08	24.53±2.85	5.5±0.63	30.05±3.46	1.44+0.00
4.	Garin	L.AM.	-	4.87±0.01	10.67±1.82	2.4±0.63	13.07±3.45	1.73±0.03
5.	Magaji	AM.	-	3.85±0.02	10.67±1.07	2.37±0.21	13.07±131	1.470.06
6.	Majiya	D.AM.	-	4.04±0.08	9.6±3.20	2.16±0.72	11.76±1.31	1.49±0.01
7.	Jurga	D.AM.	-	4.57±0.01	18.13±1.06	4.08±0.24	27.21±1.31	1.50±0.03
8.	Tozai	D.AM.	-	4.67±0.19	5.33±1.07	1.2±0.24	6.53±1.13	1.48±0.04
9.	Gidan Buwai	D.AM.	-	3.92±0.01	17.60±1.06	3.96±0.24	21.56±1.03	1.56±0.01
10.	Gatawa Kardaday e	L.AM.	-	3.47±0.02	7.47±0.01	1.68+0.23	9.15±1.31	1.54±0.03

KEY; D.A.M=DARK AMBER. , AM= AMBER, L.A.M.=LIGHT AMBER, MEANS NO FREEZING

Table 2: Proximate Composition of Honey Sample from Some villages of Sokoto State, Nigeria

S/N	Sample	Moisture% (g/100g)	Ash% (g/100g)	Protein% (g/100g)	Fat% (g/100g)	Carbohydrate% (g/100g)	Energy (Kcal/100g)	Vitamin C(g/100g)
1.	Turbah	5.2±0.12	0.90±0.05	0.78±0.01	0.63±0.03	92.49±0.08	1.585.52±0.08	24.47±0.07
2.	Tarah	7.13±0.13	0.76±0.02	0.69±0.01	0.41±0.01	91/01±0.15	1555.68+2.51	17.89±0.04
3.	Hausawa	11.36±0.20	0.57±0.03	0.69±0.08	0.62±0.02	86.7±3.42	1601.31±57.55	47.51±0.04
4.	Garin Magaji	4.13±0.06	0.50±.05	1.01±0.01	0.60±0.03	93.76±0.02	1609.28±0.52	15.15+0.00
5.	Majiya	8.1±0.57	2.93±0.18	0.80±0.014	0.39±0.00	87.78±0.17	1498.78±1.63	13.52±0.07
6.	Jurga	8.4±0.06	0.53±0.66	0.92±0.02	0.4±0.00	89.75±0.09	1529.45±1.36	43.55±0.16
7.	Tozai	4.23±0.15	4.06±018	0.81±0.08	0.63±0.03	90.26±0.04	15.79.93±12.72	18.3±0.46
8.	Gidan Buwai	7.4±0.66	1.43±0.08	0.93±0.01	0.43±0.06	90.70±0.09	1553.84±14.60	19.97±0.9
9.	Gatawa	13.2±0.11	0.47±0.07	0.75±0.01	0.53±0.06	85.05±0.22	1397.34±1.62	40.56±2.63
10.	Kardadaye	4.073±0.07	3.98±0.13	0.79±0.01	0.06±0.03	90.44±0.10	1539.66±4.53	66.26±2.06

Table 3: Sugar Content of Honey Samples From some Villages of Sokoto State, Nigeria

S/N	Sample	Glucose(G) (g/100g)	Fructose (F) (g/100g)	Sucrose (g/100g)	Glucose + Fructose	F/G (ration)
1.	Turba	32.54±0.23	31.53±0.54	2.01±0.003	64.07	0.97
2.	Tarah	31.51±0.05	23.53±0.44	0.94±0.03	55.04	0.75
3.	Hausa	29.54±0.08	31.14±0.78	1.51±0.76	60.68	1.05
4.	Garin Magaji	20.05±0.02	51.94±0.82	1.32±0.50	71.99	2.59
5.	Majiya	24.77±0.02	31.84±0.59	1.05±0.00	56.61	1.29
6.	Jurga	20.066±0.15	25.89±2.13	1.28±0.00	45.96	1.28
7.	Tozai	20.34±0.30	42.88±0.81	1.28±0.00	63.22	2.11
8.	Gidan Buwai	25.75±0.13	38.55±0.72	0.94±0.03	68.22	1.5
9.	Gatawa	11.86±0.10	30.21±0.60	0.89±0.00	42.01	2.55
10.	Kardadaye	31.37±0.51	41.92±1.06	0.76±0.01	73.29	1.34

Table 4: Mineral Composition of Honey Samples from Apiary of Some Villages in Sokoto State, Nigeria

S/N	Sample	Na(mg/100g)	K(mg/100g)	Ca(mg/100g)	Mg(mg/100g)	P(mg/100g)
1.	Turba	31.33±0.88	53.33±1.2	0.74±0.01	0.31±0.01	1.30±0.06
2.	Tarah	57.0±0.58	59.33±0.66	0.52±0.02	0.35±0.03	1.33±0.05
3.	Hausa	29.66±0.88	55.66±0.33	0.34±0.08	0.43±0.17	1.34±0.001
4.	Garin Magaji	44.33±0.80	56.00±1.15	0.65±0.01	0.25±0.03	1.42±0.03
5.	Majiya	20.33±0.33	16.33±0.33	0.29±0.03	0.25±0.00	1.55±0.05
6.	Jurga	36.33±0.33	53.66±0.33	0.64±0.01	0.42±0.08	1.57±0.01
7.	Tozai	61.33±0.88	49.66±0.33	0.34±0.01	0.46±0.05	1.44±0.01
8.	Gidan Buwai	51.00±0.57	56.66±0.66	0.39±0.11	0.41±0.01	1.53±0.01
9.	Gatawa	47.66±0.33	44.00±2.0	0.70±0.12	0.14±0.01	1.32±0.01
10.	Kardadaye	61.66±0.88	42.33±0.38	0.64±0.01	1.0±0.003	1.52±0.034