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Full Length Research Paper

Assessment of quality attributes of natural honey from Adamawa State North Eastern, Nigeria

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Honey production, output, processing, marketing and quality in Adamawa State of Nigeria were studied through survey on four local governments of honey production. There were also physicochemical, microbial and sensory evaluations of samples to evaluate quality. Results showed that about 300 apiarists exist in Adamawa State with volume produced at 12,600 L per annum. Apiarists keep between 1 and 4 hives, harvesting an average of 10 L twice a year. Methods of detecting honey adulteration locally include visual inspection and tongue testing methods. Laboratory evaluations to detect adulteration with caramel or water showed that match-lighting test can detect adulteration with water from 20% water: honey ratio but could not detect adulteration with caramel. Similarly adulteration up to 70% with caramel was not detected by panelists. Soluble solids, water and ash ranges were 58.40 to 80.00, 15.60 to 19.20 and 26 to 0.70, respectively. Other parameters were pH (3.80 to 4.50), viscosity (1.16 to 1.19), specific gravity (1.299 to 1.329), diastase number (4.00 to 10.00), bacterial count (1.0×10^2 to 2.0×10^2) and fungal count (Nil to 1.0×10^2). Sensory scores all rated above 3.0 except for 100% caramel sample. In conclusion, adulteration of honey up to 70% of caramel did not have any appreciable reduction on its organoleptic acceptability.

Key words: Adamawa, adulteration beekeeping, beeswax, caramel, honey and hives.

INTRODUCTION

Honey is the natural sweet substance produced by honey bees when processing the nectar of plants. The bees collect, deposit, and store the honey in the honey combs to mature (Stefan and Martin, 2002; Stefan, 1997). Honey is a solution of sugars (fructose and glucose), vitamins, minerals and pollens together with small amounts of miscellaneous compounds (http://www.beesource.com/, 2009). Codex Alimentarius and European Union esta-blished quality standards for honey which includes such parameters as moisture, sugars, diastase number and hydroxy-methyl furfural (HMF). Others are colour, electrical conductivity, pH and flavour (Stefan, 1997).

Beekeeping, known as Apiculture, is a branch of agriculture that is concerned with the effective and efficient use of untapped agricultural resources produced by bees, and includes products such as honey, pollen, beeswax, propolis, and bees' venom that are useful and beneficial to mankind (Marcucci, 1995). Beekeeping is an ancient widespread profession believed to have originated in the Middle East. Several thousand years ago, the early Egyptians kept bees and traded honey and beeswax along the East African coast (Hui, 1992). Hui further reported that until 1851, beekeepers harvested honey and beeswax by killing the colonies inhabiting the hives. It was reported that the discovery of "bee space" by American apiarist Lorenzo Lorraine Langstroth made it possible to harvest honey and wax without destroying the colony. The first man-made hives were made of clay, straw or tree bark. Keeping or rearing bees in wooden hives became popular in Bangladesh at the time of self reliant movement of Mahatma Ghandi in 1940 (Adjare,

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1990; http://www.beesource, 2004).

Honey has been produced in Adamawa State for a longtime but data relating to the quantity, methods of production and quality of the honey is lacking. There is apparent lack of consumer confidence due to suspected adulteration hence less patronage to this highly valued commodity. Worse still is despite the high cost of honey, consumers are cheated through adulteration. These problems are the basis of this research.

MATERIALS AND METHODS

The study area is Adamawa State, which has 21 Local Government Area (LGA) and in the northeastern part of Nigeria. Adamawa State lies between latitude 7° and 11° N and between longitudes 11° and 14° E. It shares boundary with Taraba State in the south and west, Gombe State in its North West and Borno State to the North (Adebayo and Nwagbaoso, 2005). Ganye, Jada, Mubi North, Mubi South and Jimeta were the LGAs selected for the study.

Honey, which was the major material of study were bought from honey sellers at Jada, Ganye, Mubi and Jimeta. The reagents and chemicals used for honey analyses were from Departments of Food Science and Technology, Chemistry and Soil science of Modibbo Adama University of Technology, Yola.

Oral interviews were conducted on beekeepers while questionnaires were administered on honey sellers and beekeepers in the study area. There were also observations on the apiarists regarding processing techniques. The oral interview was conducted on four beekeepers, two each from Jada and Ganye LGAs. Also, oral interview was conducted on five honey sellers each from Ganye, Mubi and Jimeta markets.

Structured questionnaires were administered to apiarists. Distribution of respondents was based on perceived quantities of honey production. Hence, the distribution was Ganye (15), Jada (10), Mubi South (4) and Mubi North (6). Sampling of LGAs and respondents for this study was based on purposive and random sampling techniques. This was based on the general observation of places of abundance of honey production and marketing in Adamawa State.

Questions asked in the oral interview and questionnaires included: Methods used in beekeeping, honey production and production potential, processing and marketing techniques, and methods of identifying adulterated honey.

Laboratory methods

Titrable acidity used the sodium hydroxide-phenolphthalein method while the pH meter was adopted in pH determination as reported by Kirk and Sawyer (1991) of Pearson chemical analysis of foods. Moisture determination was by hot-air oven drying method while ash content was done in a muffle furnace (Kirk and Sawyer, 1991). Specific gravity was calculated using pyknometer, viscosity in a viscometer, colour using a colour book match, and total soluble solids (sugars) by hand refractometer (Kirk and Sawyer, 1991). Microbial analysis using total plate count (Eugenes et al., 1998) and test for honey adulteration was done using the match-lighting test as found from survey studies.

A five-point Hedonic scale was used to rate the flavour of five honey samples (E, F, G, H and J) for flavour, colour, taste and general resemblance to honey. The five honey samples had different ratios of caramel to honey on a volume to volume basis. The ratios were 0: 100 (E), 30:70 (F), 50:50 (G), 70:30 (H) and 100:0 (J).

Frequencies, means, percentages, analyses of variance and Duncan's Multiple Range tests were the techniques of data analyses employed. SPSS (Statistical Package for Social Sciences) was the computer software used in data analyses. Descriptive technique was used to analyze data from oral interview and results of open ended questions in the questionnaires.

RESULTS AND DISCUSSIONS

Results of survey studies showed that no difference exist in honey production, marketing and handling techniques among the apiarists from the four local government areas, which are the major centres of honey production in Adamawa State. It was found that beekeepers still practice local methods of honey production. Materials popularly used for beehive construction are not sophisticated as they use straws (dried grasses), tree-backs and clay pots. The distribution of usage of these materials for beehive construction varies. For example, in Jada LGA, the three materials are all popular among 83% of the apiarists. But in Ganye LGA, 92% use straw hive, while only 8% of apiarists use both clay pot and tree-backs.

In Mubi south LGA, clay pot is more popular as 75% of apiarists use it for hive construction while 25% use straw to build hives. They use only clay pot (50%) and tree-backs (50%) in Mubi north LGA for hive construction.

The hives are set all year round but beekeepers prefer dry season, which they believe that bees-swarming is high and so can be attracted easily into the hives. Availability of water, rich vegetation, little disturbance by animals and man (serenity environment) are major considerations in establishing bees hive. Also, hives are kept on trees which serve as stands and shades. This is unlike modern stands constructed using woods or concrete blocks to raise it to a height of about 50 to 60cm from the ground and placed under trees or shrubs for shade.

They use perfumes, honey and honey combs to attract bees into the hives. Presence of lizards around the entrance of the hive is an indication that the bees have been attracted into the hives. They normally check hives regularly to see if the honey is ready for harvest.

Indications to show that honey is ready for harvest include aroma (honey flavour), and hive entrance being reduced and turning black.

In harvesting honey, the Adamawa State apiarists used smokers (grasses tied together and lit with a fire) to blow smoke into the hive which renders the bees inactive and enables the removal of the comb. Honey harvested in dry season has low moisture compared to the ones harvested in rainy season which is normally sweeter and has higher yield. This may be due to the availability of water and nectar in the rainy season.

Protection against attack by the bees and deleterious effects of smoke involves covering of nose and mouth, however, in modern methods, beekeepers use protective

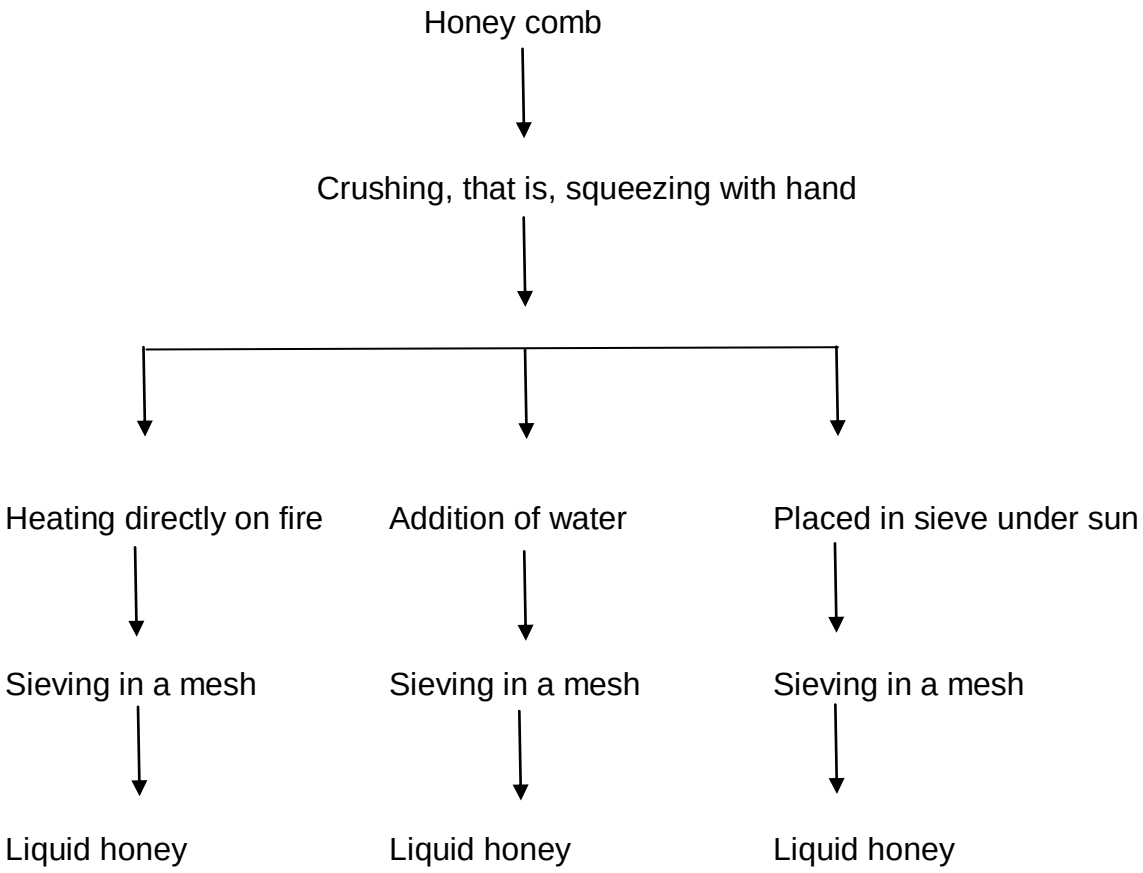

Figure 1. Three traditional methods of processing liquid honey from honey comb by apiarists in Adamawa State, Nigeria.

suits. Commonly, honey is harvested with comb is known as comb honey which may consist of immature comb, bee hairs and bee larvae, all of which have to be removed to avoid honey spoilage.

Apiarists also reported that bees can attack if they start eating the honey before harvesting time. They said that in such circumstance, you leave the honey till another harvesting season.

The apiarists reported preferring to sell their products as honey combs rather than process them into liquid honey. This is because harvests in January are very difficult to extract the comb because it is always very thick and cannot be processed without the addition of water. They were also cautious of the fact that addition of water could cause fermentation.

The apiarists sell honey in bulk as they all have their customers that come and buy directly from them. The liquid honey sellers in the market reported that they get honey normally from the villages using middlemen that buy directly from small beekeepers and honey hunters who bring them to the market.

They sell in containers (basins and jerry cans) of various sizes of 1, 4 and 20 L. A seller could sell as much as 100 L in each market day.

The three techniques of producing liquid honey from honey comb in Adamawa State are shown in Figure 1. There are slight differences in the methods of processing harvested honey combs into liquid honey among the apiarists that do not sell their honey as honeycombs.

It is at the sieving stage that this occurs. After crushing of the honey combs, investigation showed that three options of sieving are available to both the honey sellers and apiarists. Some use hot water, while some place the honey directly on fire for a short while and some put the honey comb inside a sieve and place under the sun. Those that add water reported that they normally boil to concentrate after sieving.

Findings showed that the apiarists keep between three to five hives a year. They can harvest up to a bucket (about 10 L) full of honey (comb honey) from each hive which weighed after extraction was 30 to 35 kg.

It is important to note that skeletal honey farmers are found in some other parts of Adamawa State e.g. Toungo LGA. The concentrations of apiarists in towns and villages in the four LGAs where honey production is popular are given in Table 1.

Results of questionnaire administration showed that in Jada LGA, 16.67% of respondents kept three hives per

Table 1. Estimates of bee-farmers in towns and villages in four LGAs known for honey production in Adamawa State.

S/N	LGAs	Towns	Villages	Bee farmers / LGA
I	Jada	Mbulo	Gangsanji Boro	88 (27.94%)
		Danaba	Nawai Nadeu	
II	Ganye	Tiduri	Tiduri	93 (29.52%)
		Yelwa	Sandasini Dabora	
		Gangdadirum	Gangdadirum	
		Babidi	Babidi	
		Gurum	Sitim	
		Gangwoki	Gangwoki	
		Jaggu	Jaggu	
		Sugu	Batal	
		Gangdona	Gangdona	
		Dadiri	Dadiri	
		Gangjamanu	Gangjamanu	
III	Mubi south	Mubi	Didifi Monova Tsamo Vokuna	43 (13.65)
	Mubi north	Mubi	Mufka Mayobani Besto Muchalla	91 (28.89%)
		Vintim	Degil	
	Total			315 (100.00%)

year, also 16.67% kept four hives while 66.66% kept more than four hives per year. Still in Jada LGA, 50.00% of bee-farmers harvest more than three buckets per hive, while 16.67% each harvest less than one, two and three buckets per hive respectively.

In Ganye LGA, 53.85% kept four hives a year and 46.15% kept more than four hives. Only 76.92% harvest one bucket per litre while 15.8 and 7.69% harvest less than one bucket and three buckets, respectively.

In Mubi north LGA, 33.33% of apiarists kept one hive per year, 16.67% two hives while 33.33% kept four hives and 16.67% kept more than four hives a year. Also, 66.67% claimed they harvest one bucket while 33.33% harvest more than three buckets per hive.

In Mubi south LGA, 25% of bee-farmers kept three hives per year while 75% kept more than four hives per year. The implication is the abundance of large number of bee-farmers in this LGA when compared to other LGAs. Half (50%) of apiarists harvest three buckets per hive while 25% each harvest two and three buckets per hive respectively.

Estimates of production in Adamawa State is therefore dependent on a number of factors which include the number of bee-farmers, number of hives kept by each bee-farmer, number of harvest per year and quantity harvested per hive. Assuming only 315 apiarists (Table 1) exist in Adamawa State who manage an average of two hives and from each harvest one bucket (10 L) is obtained, then Adamawa State honey production in a year is calculated thus:

No of apiarists * No of hives per apiarists * No of harvest per year * Quantity harvested per hive. Therefore Adamawa State annual honey production potential = 315 *2 * 2 * 10 L = 12,600 L (that is, 12.6 metric tonnes).

Survey results showed that honey adulteration is usually with water and caramel to increase quantity. It was also

Table 2. Dilution effect of honey with caramel and dipping time in whole and diluted honey to sustain a lit match inside the dip.

No	Volume: Volume ratio	HS-A			HS-B			HS-C			HS-D		
		1 s	1 min	5 min	1 s	1 min	5 min	1 s	1 min	5 min	1 s	1 min	5 min
1	0: 100	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
2	10: 90	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
3	20: 80	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
4	30: 70	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
5	40: 60	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
6	50: 50	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
7	60: 40	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
8	70: 30	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
9	80: 20	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
10	90: 10	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL
11	100: 0	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL

Key: Min = Minute; EL = Easy to light; DL = Difficult to light; HS = Honey samples; A, B, C and D = Different honey samples.

found out that some honey sellers after chewing honey comb drop it back into the honey so that they now use the chewed comb and the honey to flavour caramelized sugar. For such type of honey only small comb particles (not whole comb) are seen floating on the surface of the liquid honey. The honey comb when kept for a long time forms webs on top which does not normally affect the liquid honey, but when crushed to extract can increase the moisture content which can cause fermentation. Fermented honey tastes sour and affects honey flavour.

On water addition to honey during processing, all (100%) the respondents from Jada, Mubi north and Mubi south claimed they do not add water to honey during processing.

But 74.62% from Ganye claimed they do not add water to honey during processing while 24.38% agreed that they add water during processing.

None of the respondents (apiarists) in the four LGAs admitted to adding sugar or caramel during honey processing. Also, all (100%) of the apiarists from Jada and Ganye stated they do not know if other apiarists add sugar or caramel while 83.33 and 50% of apiarists from Mubi north and Mubi south, respectively, stated that apiarists other than themselves add sugar or caramel during processing.

Also, both honey sellers and apiarists apply the same techniques in their assessment of honey quality, that is, detecting good and adulterated honey. Methods used include tasting with tongues, visual inspection, use of match-lighting, dropping the honey on the ground and dipping a stick into the honey.

Visual inspection is used to inspect/check for maturity of the honey. Immature honey is normally greenish in colour and tasteless. When observed, the remedial measure is to blend with matured honey. Dropping on the ground test is used because when water is added to the honey it flows freely and when it drops on the ground it is absorbed. But when honey is pure, it can be picked by a finger when it drops on the soil as it is not absorbed by the soil. Use of match-lighting technique is used to check adulteration either with water or caramelized sugar. If a lit match is dipped into a pure honey it lights, but if adulterated the lit match is extinguished.

Results of laboratory experiments to test the levels of adulteration of honey (0 to 100%) with caramel and water are given in Tables 2 and 3, respectively. Results showed that up to 80% dilution with caramel and dipping times of 5 min could not be detected by the match-lighting technique.

However, above 80% ‘adulteration’ with caramel persistence of the lit-match was very difficult even at 5 min dipping time. The implication is that this method claimed by the people in honey business is not efficient in detecting honey adulteration with caramel.

The reverse is the case with dilution of honey with water. This test almost proved good as the lit-match could only be sustained easily (EL) inside the honey at 10% dilution irrespective of the dipping time. However, at 20 and 30% dilutions, the lit-up match was difficult to be sustained (DL) inside the honey. But from 40% dilution and above, it could not light-up completely (NLC) inside the honey (Table 3). Tables 2 and 3 reveal that dipping time inside honey seem not to be important in this match-lit test of honey adulteration with caramel and water.

Table 4 gives the results of physicochemical and microbial tests. Variations exist among the different honey samples (A, B, C and D) that are of different sources.

Soluble solids range of 58.4 to 80.0% falls within the prescription of Codex Alimentarius and European Union standards reports (http://www.beesource.com/, 2009). This is in compliance with the report that that honey sugar content is about 80% soluble sugars consisting principally of fructose (38.2%), glucose (31.3%), sucrose

Table 3. Dilution effect effect of honey with water and dipping time in whole and diluted honey to sustain a lit match inside the dip.

No	Volume: volume ratio	HS-A			HS-B			HS-C			HS-D		
		1 s	1 min	5 min	1 s	1 min	5 min	1 s	1 min	5 min	1 s	1 min	5 min
1	0: 100	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL	EL
2	10: 90	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL
3	20: 80	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL
4	30: 70	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL	SDL
5	40: 60	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
6	50: 50	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
7	60: 40	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
8	70: 30	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
9	80: 20	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
10	90: 10	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC
11	100: 0	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC	NLC

Key: Min = Minute; EL = Easy to light; SDL = Slightly difficult to light; NLC =Not lighting completely; HS-A, B, C and D = Different Honey samples.

Table 4. Physicochemical and microbiological characteristics of Adamawa State honey.

NO	Honey sample A	Honey sample B	Honey sample C	Honey sample D
Physicochemical				
% Soluble solids	80.00	76.00	76.00	58.40
% Moisture content	19.00	19.20	16.30	15.60
% Ash content	0.260	0.300	0.640	0.700
pH at 32°C	4.20	4.50	3.80	3.80
Specific gravity 20°C	1.315	1.299	1.319	1.329
Diastase number (DN)	10.00	8.00	7.00	4.00
Viscosity (mm^2/s) at 8% concentration	1.16	1.19	1.49	1.54
Colour	Yellowish brown	Yellow	Dark yellowish brown	Brownish yellow
Microbial loads				
Bacteria count (cfu/ml)	1.4×10^2	1.0×10^2	1.0×10^2	2.0×10^2
Fungal count (cfu/ml)	1.0×10^2	1.0×10^2	Nil	Nil

(1.3%), and higher sugars (1.5%).

The moisture content values of the honey ranged bet-ween 15.60 and 19.20%, while the pH ranged from 3.8 to 4.2 and the ash contents ranged from 0.20 to 0.70%. These values were all acceptable based upon United States of America standards that reported moisture content of good quality honey to be between 18.0 and 20.0% percentage moisture content (USDA, 1970;

Table 5. Mean sensory scores of a five-point Hedonic rating of honey samples.

S/No	Honey samples	Caramel: honey	Flavour	Taste	Colour	Resemblance to honey
1	Honey sample E	0:100	4.50 ± 0.35	4.50 ± 0.32	4.30 ± 0.15	4.30 ± 0.67
2	Honey sample F	30:70	3.70 ± 0.35	4.40 ± 0.32	4.90 ± 0.15	4.40 ± 0.67
3	Honey sample G	50:50	4.00 ± 0.35	3.70 ± 0.32	4.30 ± 0.15	3.60 ± 0.67
4	Honey sample H	70:30	3.60 ± 0.35	3.20 ± 0.32	3.40 ± 0.15	3.00 ± 0.67
5	Honey sample J	100:0	2.50 ± 0.35	2.40 ± 0.32	1.40 ± 0.15	1.30 ± 0.67

http://en.wikipedia.org/wiki/Honey, 2010) and pH of 3.2 to 4.5 (Waikato Honey Research Unit, 2006). However, only the ash content of honey samples A (0.26%) and B (0.30%) were within the reported range of 0.20% (USDA, 1970; http://en.wikipedia.org/wiki/Honey, 2010).

The diastase numbers of honey from Ganye and Jada were within the Codex Alimentarius value of not less 8.0 (USDA, 1970; http://en.wikipedia.org/wiki/Honey, 2010).

But honey from Mubi and Jimeta that have respectively low diastase numbers of 4.0 and 7.0 may be due to conditions of processing and / or storage. Similarly, total plate bacterial count (1.4×10^2) and fungal counts (1×10^2) were within recommended reported levels by Bidemi of Centre for Research and Development (Bidemi, 1999). The viscosity of all the honey samples did not vary significantly (1.16 to 1.54) from each other.

Table 5 shows the sensory scores of the organoleptic ratings of five honey samples (E, F, G, H and J) of various dilutions with caramel. Apart from honey sample J, the sensory scores of all the honey samples were above 3.0 on a five – point Hedonic scale for all the sensory parameters. This implies that dilution of honey sample with up to 70% caramel (volume to volume ratio) was still acceptable by the taste panelists. The exceptional low sensory rating of sample J (100% caramel) implies that from organoleptic point of view that caramel cannot substitute as 100% honey.

Conclusion

Several conclusions were drawn from the findings in this research. First, Adamawa State produces a substantial quantity of honey and has the potential to produce even more honey if there is government or organized intervention by some expert bodies or agencies. Also considering the finding that methods of honey production are crude, it is hoped that if there are some modernizations in methods of honey production, then Adamawa State will become one of the leading States of honey production in Nigeria.

Second, honey produced in Adamawa State is of good quality and grade, and was in substantial compliance to international standards based on organoleptic, physico-chemical and microbial requirements.

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