Honey Quality as Affected by Handling, Processing and Marketing Channels in Uganda

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Summary

The factors that affect honey quality in Uganda were surveyed in 120 beekeeping households. Honey was sampled from supermarkets, hawkers and stall markets along four transects across Kampala, the capital. Honey quality parameters assessed were diastase number (DN), free acidity (FA), moisture content (MC), hydroxymethylfurfural (HMF), and water insoluble solids (WIS). Honey was mostly harvested from basket and grass hives. Pressing, boiling and straining were popular honey processing methods. Honey quality was mainly compromised by harvesting immature honey, bad extraction methods and contamination by extraneous materials. Constraints to beekeeping were lack of appropriate equipment (52%), inadequate farmer skills, bad weather and vermin. Honey brands differed (P< 0.05) in DN, most failed the Uganda and Codex Alimentarius standards, and 20% met European Union HMF and DN standards. Correlation was observed between HMF vs. DN (r= 0.94); MC vs. FA (r= 0.56). Supermarket honey (4.65) was more superior (P< 0.05) in DN than stall markets (1.93), and hawkers (2.3). Similarly, WIS levels differed (P< 0.05) between honeys from supermarkets (0.08), stall markets (3.0) and hawkers (3.15). All honeys met MC standards, while DN and WIS were major shortcomings. Farmer training and extension in proper honey harvesting, handling and processing should be strengthened. Quality monitoring at all levels should be emphasized.

Résumé

Influence de la manipulation, de la transformation et des circuits de commercialisation sur la qualité du miel en Ouganda

Les facteurs qui affectent la qualité du miel en Ouganda ont été étudiés auprès de 120 producteurs fermiers. Des échantillons de miel ont été collectés dans les supermarchés, auprès de revendeurs et dans des marchés à l'étal le long de quatre transects traversant la capitale Kampala. Les paramètres étudiés ont été la concentration en diastase (diastase number, DN), l'acidité libre (free acidity, FA), l'humidité (moisture content, MC), l'hydroxymethylfurfural (HMF) et les solides insolubles dans l'eau (water insoluble solids, WIS). Le miel était essentiellement récolté dans des paniers et des ruches en herbe. Le pressage, l'ébullition et l'égouttage sont des procédés de transformation courants. La qualité du miel a été particulièrement diminuée par la récolte de miels immatures, des méthodes d'extraction inadaptées et la contamination d'éléments extérieurs. Les contraintes liées à l'apiculture ont été le manque d'équipement approprié (52%), le peu d'habileté du producteur, les mauvaises conditions climatiques et les parasites. Les différents miels se sont différenciés par la concentration en diastase (P< 0,05), la majorité d'entre eux ne répondant pas aux standards ougandais et au Codex Alimentarius; 20% correspondaient à ceux de l'Union Européenne, aussi bien pour HMF que pour DN. Les corrélations observées entre HMF et DN, et entre MC et FA, ont été respectivement de 0,94 et 0,56. La concentration en diastase a été supérieure dans les miels de supermarché (4,65) que sur les étals de marché (1,93) et que chez les revendeurs (2,3). De même, les niveaux en solides insolubles dans l'eau étaient différents (P< 0,05) entre les miels de supermarché (0,08), les marchés à l'étal (3,0) et les revendeurs (3,15). Tous les miels étaient conformes aux normes en humidité, alors que pour la majorité d'entre eux ils ne l'étaient pas pour DN et WIS. La formation et l'encadrement des producteurs en récolte, manipulation et transformation du miel doivent être renforcés. L'accent doit être mis sur les aspects liés à la qualité à tous les niveaux de la filière.

Introduction

The exploitation of bees provides a sustainable environmentally beneficial food and income source for rural households in developing countries. Beekeeping has been widely promoted in many countries as a major contributor to rural development (2). Products such as honey, beeswax, bee pollen, propolis, royal jelly, venom, queen bees and larvae are all of socio-economic value (11). Honey production is of growing socio-economic significance worldwide, particularly in developing countries. The quality of honey is a key factor for both local and international markets (11) to enable attainment of competitive premium prices and ensure human health. Honey quality consideration is an aspect disregarded by producers and processors especially in developing economies. Proper understanding and standardisation of honey components and attributes that are most vulnerable during processing cannot therefore be over emphasized. The major constituents of honey are sugars, water, proteins, enzymes, acids and minerals (6), while the major causes of quality deterioration include heating at high temperatures, high moisture content, adulteration, poor packaging and poor storage conditions (11). These honey quality hazards appear to be common along the pathway from producers, retailers to consumers in Uganda, though no research has verified this. The maintenance of honey quality is vital in protecting consumers from potential health hazards such as food poisoning (13). Recent initiatives in

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Uganda have aimed at establishing a national beekeepers association and development of a national monitoring plan for residues in honey.
In Uganda, honeybees give three major nutritionally and financially important outputs namely: honey, beeswax and propolis. Bees also play a key role in crop pollination, especially important for coffee, pulses, oil seeds, fruits and vegetables. It is estimated that there are over 120,000 small scale beekeepers in Uganda with a national annual honey production of about 5,000 metric tones (23). In 2001, Uganda's honey yield was estimated at 3,000 tons, worth US$ 2.7 m and 362 tones of beeswax worth US$ 1.1 m (4). Assessment of the factors that affect quality is very critical since fresh honey normally meets the quality requirements for export markets, but it deteriorates eventually during handling and marketing. This formed the basis of this study.

Materials and methods

Study site

A descriptive survey with both qualitative and quantitative parameters was conducted in the districts of Bushenyi (00° 35'S, 30° 10'E), Luweero (01° 27'N, 32° 15'E), Katakwi (01° 43'N, 33°35'E) and Kitgum (03° 17'N, 32° 52'E) located in western, central, eastern and northern Uganda respectively. These districts were purposively selected for the study since they are rated as the highest producers of honey in their respective geographical regions. The four districts are located in the sub-humid agro-ecological zone of Uganda (7). The experimental study was conducted in Kampala (00° 20'N, 32° 30'E), Uganda's capital city, also the biggest consumer of honey, and possessed the highest number of honey brands in the country.

Survey design

Thirty beekeeping households were randomly sampled across each of the four districts (Figure 1). A standard questionnaire was administered in an interview to all respondents to characterize the beekeeping households of Uganda and determine the major factors affecting productivity and honey quality. The instrument was tested for validity to make sure that questions asked were exhaustive for the study objective. Suitability and clarity of questions were determined by pre-testing the instruments with farmers from the selected study areas but who did not participate in the actual study. Reliability of the instruments was tested using the internal check, by having some selected questions asked in different ways. The instrument was revised during the data collection process to probe on some pertinent issues arising during the study.

Experiment design

We tested whether the quality of honey is affected by the marketing method, and whether the various honeys meet the national and international standards. The major honey retailers are supermarkets that sell branded honey, while hawkers and stall markets sell unbranded honey. The study was conducted in a completely randomized design with five brands of honey from each of three supermarkets randomly selected along four transects across the city. Along the same transects, 15 hawkers and five stall markets were selected randomly. From each hawker, one honey sample was taken and from each stall market, three samples were taken. Branded honey samples weighed 500 g each while unbranded honey samples were 250 g. The number of honey samples to be collected was determined using established procedure (15). All samples were stored at room temperature. Parameters assessed and methods used were: diastase activity (DN) using acetate buffer procedure (6); free acidity (FA) using titration with 0.05 N NaOH (1); hydroxymethylfurfural (HMF) concentration using absorbance procedures (6); moisture content (MC) using refractometric method (1); and water insoluble solids (WIS) using the gravimetric method (24).

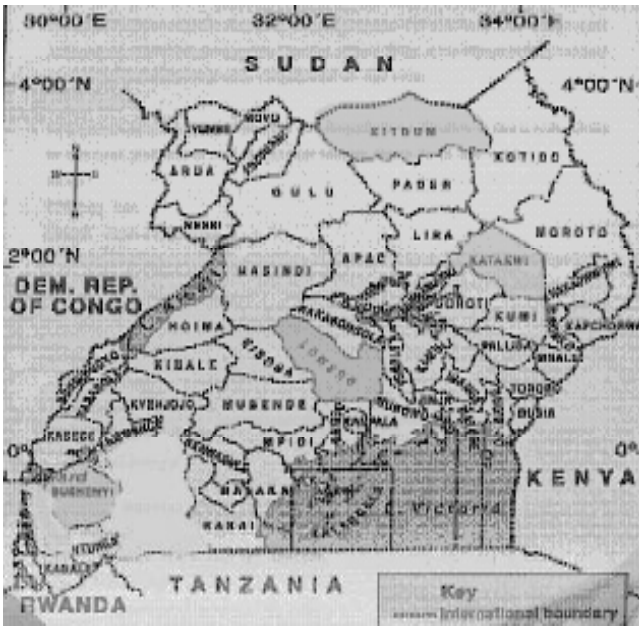

Figure 1: Map of Uganda showing study areas.

Statistical analysis

Survey data was collated, coded and analysed using descriptive statistics of Statistical Package for Social Scientists (21). Experimental data, namely: DN, FA, HMF, MC and WIS was analysed using analysis of variance procedures and significant means were separated using Fisher's protected least significant difference of Statistical Analysis Systems Institute (19).

Results

Characteristics of the beekeeping households

Across all districts, most beekeepers (77%) were men. Over 82% of the beekeepers were 30 years or older (Table 1). Luweero district of central Uganda had the highest number of elderly beekeepers. With exception of Luweero where 80% of keepers kept top-bar hives (Table 1), majority of beekeepers in Bushenyi, Kitgum and all respondents of Katakwi district kept traditional fixed comb hives made from grass, fired clay and stick mats marred with earth.
Pressing of combs, boiling and straining were popular methods of honey extraction and processing. Over one third of the respondents across all districts sell their honey unprocessed. The study revealed that honey was the major hive product (93%) and was predominantly for sale. Beekeepers reported that honey quality was mainly compromised by harvesting immature honey (93%), poor extraction and storage methods (90.2%) and contamination by extraneous materials (60%). The main constraints to beekeeping (Table 1) were inadequate skills, mainly due to weak extension service; lack of appropriate equipment especially hives, harvesting gear, and storage containers; bad weather especially prolonged drought which affects flowering patterns; lack of transport and general poor infrastructure; vermin, especially wild animals and wax moth; lack of credit facilities for beekeeping development and lack of market for honey and other hive products.

Variability of quality among branded honeys

Significant differences ($P < 0.05$) were observed only in diastase number among the five honey brands (Table 2). All brands met the moisture content and water insoluble solids standards of Uganda (24), the European Union (3) and the

Table 1
Proportion of beekeepers by gender, age structure, types of hives kept, honey processing methods and constraints faced in four districts of Uganda

	District				
	Bushenyi	Luweero	Katakwi	Kitgum	Mean
	Proportion of households (%)				
	n= 30	n= 30	n= 30	n= 30	
Gender of beekeeper					
Male	75	80	90	64	77.3
Female	25	20	10	36	22.7
Age group (yrs)					
≤ 20	10	-	-	11	10.5
21-30	25	-	-	25	25.0
31-40	30	40	20	23	28.3
41-50	20	20	60	32	33.0
≥ 51	15	40	20	10	21.3
Types of hives kept					
Traditional	60	9	100	70	59.8
Top-bar	40	80	-	30	37.5
Langstroth	-	11	-	-	2.8
Honey processing method					
Boiling	30	10	30	30	24.7
Sun heating	-	-	20	-	13.4
Pressing	-	40	20	50	32.5
Straining	10	40	-	-	22.2
Unprocessed	60	10	30	20	30.7
Constraints faced by beekeepers					
Lack of equipment	60	50	20	76	52.0
Inadequate skills	70	-	-	61	32.8
Lack of transport	50	-	40	48	34.5
Bad weather	80	20	-	57	39.3
Thieves	30	10	20	-	15.0
Vermin	2	-	-	80	20.5
Lack of honey market	-	20	40	-	15.0
Lack of credit facility	-	50	30	-	20.0

Codex Alimentarius (8). Most brands failed the DN, FA and HMF tests. Though brands did not differ significantly in free and total acidity levels; 80% of them did not meet the free acidity standards. One fifth of the brands qualified in DN and HMF for the European Union market. There was a positive though weak (r= 0.56) correlation between MC and FA across the honey brands (Figure 2).

Variation in honey quality among honey retail markets

Moisture content of honey from different retail groups showed non-significant differences but met the three standards (Table 2). Although free acidity levels did not significantly differ, all retail markets failed to attain the standards, with stall markets having the highest acidity (54.2 ± 2.4 meq. kg^{-1}). The mean total acidity for honey from the different markets was 56.4 ± 2.5

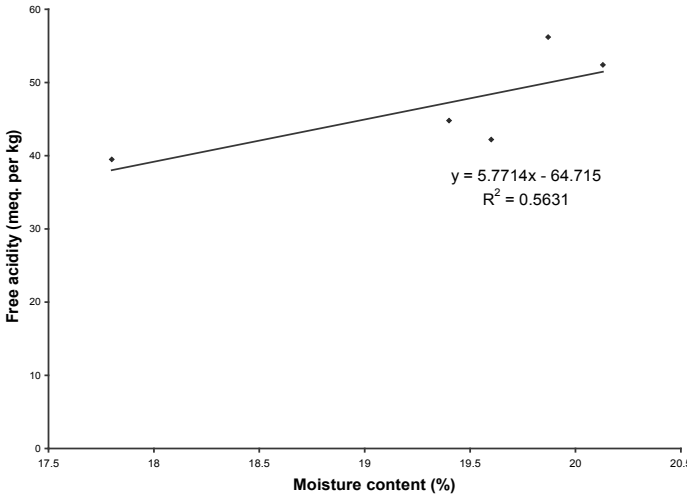

Figure 2: Correlation between moisture content and free acidity in different honey brands.

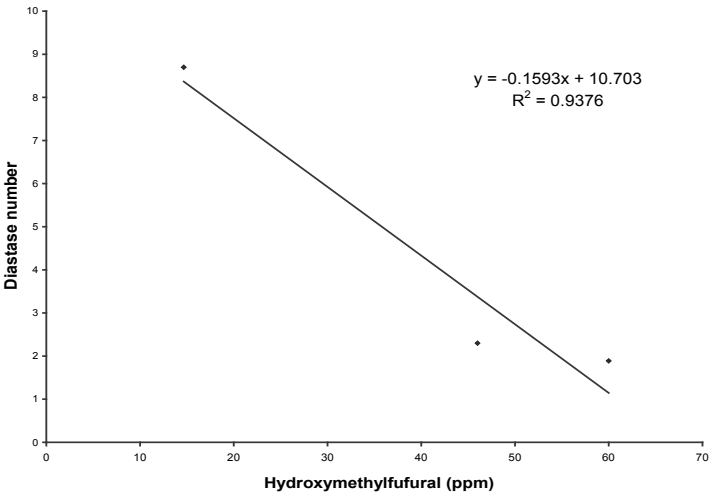

Figure 3: Correlation between diastase number and hydroxymethylfurfural across honey retail groups.

Table 2
Mean moisture, acidity, hydroxymethylfurfural, diastase and water insoluble solid content of honey by honey brand and retail group

	Moisture Content (%)	Free acidity (meq. kg^{-1})	HMF (meq. kg^{-1})	Diastase number	Water insoluble solids (%)
Brand Identity					
1 (n= 3)	19.4 ± 1.3	44.8 ± 5.1	123.3 ± 55.8	5.12 ± 2.79	0.030 ± 0.01
2 (n= 3)	19.9 ± 0.3	56.2 ± 0.3	75.5 ± 2.8	0.87 ± 0.26	0.100 ± 0.05
3 (n= 3)	17.8 ± 0.2	39.5 ± 2.2	267.5 ± 183.2	2.74 ± 1.08	0.117 ± 0.09
4 (n= 3)	19.6 ± 0.1	42.2 ± 8.0	7.1 ± 2.1	10.21 ± 1.53	0.067 ± 0.01
5 (n= 3)	20.1 ± 1.8	52.4 ± 7.9	42.8 ± 14.8	4.29 ± 2.28	0.083 ± 0.04
$LSD_{0.05}$	NS	NS	NS	5.74	NS
CV (%)	9.3	20.8	144.1	68.0	74.6
Retail group					
Supermarkets (n= 15)	19.36 ± 0.44	47.0 ± 2.7	103.2 ± 40.5	4.65 ± 1.08	0.08 ± 0.02
Stall markets (n= 15)	18.27 ± 0.30	54.2 ± 2.4	60.1 ± 12.5	1.93 ± 0.49	3.00 ± 0.49
Hawkers (n= 15)	19.33 ± 0.31	46.3 ± 3.3	45.5 ± 5.7	2.30 ± 0.58	3.15 ± 0.27
$LSD_{0.05}$	NS	NS	NS	2.12	0.89
CV (%)	7.3	22.4	137.8	99.6	56.5
Quality standard					
Uganda[a]	≤ 22	≤ 40	≤ 80	≥ 3	≤ 0.5
European Union[b]	≤ 21	≤ 40	≤ 40	≥ 8	≤ 0.5
FAO[c]	≤ 21	≤ 40	≤ 80	≥ 3	≤ 0.5

HMF= hydroxymethylfurfural; [a]UNBS, 1993; [b]CPIDC (1996); [c]FAO and WHO (1994).

(stall markets), 52.3 ± 2.8 (supermarkets) and 50.7 ± 3.5 meq. kg^{-1} (hawkers). The variation in HMF and WIS content among retailers was very high (Table 2). Diastase number and implicitly, activity varied significantly ($P< 0.05$) among retail groups. Supermarket honey was more superior ($P< 0.05$) in WIS than stall markets, which also had significantly better honey ($P< 0.05$) than hawkers. Only supermarket honey qualified in both Uganda and Codex Alimentarius DN standards, but none of the retailers met the EU Standards (Table 2). Diastase number and WIS were major bottlenecks to quality for Ugandan honey. Strong correlations were observed between DN vs. HMF across honey retail markets (Figure 3); and between free acidity and total acidity (Figure 4).

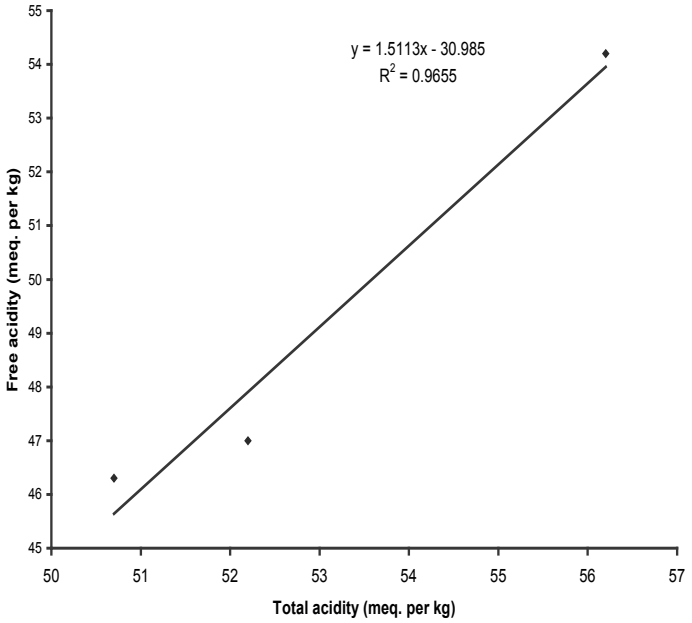

Figure 4: Relationship between total and free acidity in honey across retail groups.

Discussion

Results of this study showed that men predominate in beekeeping in all districts, but this is likely to change with adoption of modern beehives. Traditional hives are usually hanged high up in trees. Cultures in most parts of Uganda dictate that women cannot climb trees, and this keeps them away from engaging in beekeeping. Traditional hives were more common than improved hives in all districts except Luweero, which is closest to Kampala city, and therefore more accessible to modern equipment.

Pressing of combs was prevalent in Luweero and Kitgum districts but was absent in Bushenyi where two thirds of the beekeepers sold unprocessed honey. Of the four honey extraction methods, boiling is the worst at destroying quality. Boiling breaks down enzyme diastase and increases hydroxymethyl furfural content (20). It may also destroy the flavour of the honey. Unfortunately, boiling was widespread and was being used by one third of all respondents in Bushenyi, Katakwi and Kitgum. On the other hand, straining, which gives best results of he four methods was absent in Katakwi and Kitgum. Results show that farmers knew that they use bad honey extraction methods, as > 90% across all districts mentioned it as a major compromise of quality. It therefore implies that lack of knowledge on better methods, and poor extension service should be blamed. Contamination of honey by extraneous materials was widespread in the districts. This mainly arises from bad harvesting methods such as use of fire leads to honey laden with dead bees, soot and other plant debris. Use of unclean containers at harvesting and during honey transporting could also be concomitant factors.

The lack of difference in moisture level among the honey brands is consistent with previous studies, which also concluded that water content in honey rarely changes significantly. Generally, water content beyond the recommended limit promotes yeast proliferation, fermentation and subsequent accumulation of acidity. This process leads to honey thinning due to a drop in honey viscosity and, therefore, loses its typical marketable texture.

Moisture content ranging from 17.8 to 20.1% have been reported for Ugandan honey (9, 16, 25), and agree with results of this study though higher values have also been documented (10), possibly due to the use of raw honey, which is often known to contain higher amounts of moisture than processed honey.

Over half of the honey brands met the Uganda and Codex Alimentarius Hydroxymethylfurfural standards, which is very encouraging as the country strives to connect her trade with sophisticated world markets. However, only one brand passed the EU standard. HMF is a product of simple sugar decay caused by temperatures >75 °C and / or prolonged storage of honey and is the main indicator of honey deterioration (11). Honey affected by these factors is identified by HMF levels exceeding 100 $mg.kg^{-1}$ (17), while >150 mg. kg^{-1} is an indicator of honey adulteration with commercial invert sugar and could explain the high HMF level in Brand 3. The EU recommends HMF levels of 25 $mg.kg^{-1}$ for raw or fresh honeys (20). Hydroxymethylfurfural values above 40 $mg.kg^{-1}$ have been found in some Saudi Arabian honeys (22), similar to over half of brands in this study.

Only 20% of the study brands passed the free acidity test. Acidity is responsible for the taste of honey; however, excessive acidity is undesirable because it leads to a sour-off-taste and running texture (17). High levels of acidity in honey are associated with fermentation resulting in alcohol and subsequently into acetic acid. Acidity is promoted by high yeast cells counts and increase in MC (25). This promotes yeast proliferation, accelerating fermentation and acid production (5). Free acidity values were consistent with 40.93 – 52.78 meq. kg^{-1}(14), but much greater than 6.38 – 7.83 meq. kg^{-1} (9) because the latter used fresh honey, which could not have began to ferment. The relatively high FA values in the present study could be due to excessive yeast count in Uganda honey (16). The linear relationship between TA and FA suggests that one parameter can be predicted from the other. This also implies that the two acid pools are largely in equilibrium in all the brands. Though there are no TA standards this study brings into perspective the potential value of this parameter as an alternative to FA.

The poor performance of the brands in diastase number is sufficient cause for concern for Uganda's supermarket sector and should constitute one of the focal points for checking the quality of honey. Diastase number (DN) is an indicator of diastase activity (DA) in honey. Generally, all honeys contain small quantities of diastase enzyme, sensitive to high temperatures (> 75 °C), which destroys it and long-term storage that lowers its concentration. It is hard to distinguish the contribution of each of the factors without a historical account of honey. Diastase is responsible for the hydrolysis of starch (25), and is produced during honey making. Results of this study compare closely with 2.28 – 10.64 (14) also from processed Ugandan honey. However, there was disparity with studies in which raw and heated honey was used (9, 10, 12). Diastase numbers for raw honey were generally much greater than for processed honey. This is expected because processing, particularly heating, destroys the diastase enzyme (11).

Natural honey is known to contain moulds, inorganic and organic matter foreign to its composition such as insects, insect debris and brood or grains of sand (8), which are water insoluble hence "water insoluble solids (WIS)". The low amount could be due to supermarkets, being retailers for the affluent clientele requiring the honey suppliers to properly filter the honey. WIS levels was 0.0 - 0.82% for processed (supermarket) honey, and 0 - 0.08% for natural honey were found in Spanish honey (12), showing that Ugandan honey is superior in this attribute. The high negative correlation between DN and HMF (Figure 2) is logical because high HMF and low diastase are symptomatic of excessively heated honey or honey kept for lengthy periods (20). These findings underscore HMF as a useful indirect confirmatory tool for establishing the status of honey quality with respect to heating and storage.

The significant linear correlation between MC and FA across the honey brands suggests that dilution of honey enhances its acidification. This is explained by previous viewpoints that water content beyond 18% promotes yeast multiplication and its associated fermentation, and subsequent acid accumulation (5). Although the MC data obtained in the present study is within the local and international standard limits, it poses a potential threat to honey quality among the brands studied (Table 1). Uganda's honey was reported with high yeast counts of >1400 cfu. g^{-1} right from its fresh state (16). The impact of this initial yeast content on honey quality could be the high values of FA obtained.

Variability of honey quality among retail groups

Honey from all groups passed the moisture content test implying that there was no adulteration with water. Furthermore, it probably reflects on the limited loading of atmospheric moisture into Ugandan honey, despite honey's hygroscopicity. The high free acidity values could be a major handicap to the acceptance of Uganda's honey. The most affected category is the stall markets, whose honey acidity level was 36% over the minimum for the three standards, attributable to the high counts of yeast in Ugandan honeys (16). Hence, in order for Uganda to target lucrative markets, serious consideration must be directed at rectifying this problem through exercising hygiene, to prevents entrance of yeast cells during processing. The other option is by honey pasteurisation at temperatures that do not affect diastase activity. Acidity results of this study concurred with some previous ones (12, 14) but departed from others (9).

Retail market effect on HMF content (Table 2) was not significant despite the clearly large mean value for supermarkets. This variability was due to lack of enforced quality control. The high HMF value lends to possibilities of heat treatment and / or adulteration. Other markets had HMF values that met Ugandan and Codex Alimentarius standards.

The significantly low DN for the Hawker and Stall market groups (Table 2) and their inferiority to the quality standards implies that these groups might be tampering with honey. This constraint needs better attention most especially if these categories are going to become suppliers to retailers engaged in sophisticated markets. Water insoluble solids content in supermarket honey was significantly ($P< 0.05$) lower than other groups probably because the suppliers strain out these materials in response to clientele interests. Negative correlation between DN and HMF (Figure 3) was due to HMF being a circumstantial product of processes that are destructive to diastase enzyme.

Generally, the poor quality of the honey can be attributed to the constraints identified in the survey section of this study. If honey is harvested using crude methods and or from traditional hives, then diastase enzyme is destroyed, acidity, HMF and WIS increase and ultimately quality is compromised.

Conclusion

This study shows the challenges in quality for Ugandan honey, and proposes a road map that the industry stakeholders may take to bring products from the hive to the consumers with as little change as possible. The honey marketed in Kampala did not meet the three quality standards. We therefore recommend that quality regulatory bodies such as the national bureau of standards should ensure compliance of Uganda's honey with local and international

quality standards. An integrated sensitisation programme on quality assurance and its accruing benefits at all stages of honey production, processing and general handling should be conducted. Honey quality testing laboratories should be set up to enable honey dealers quickly establish their honey quality. They could be incorporated into honey collection centres, or district veterinary laboratories.

This study established the different factors that directly and indirectly influence honey quality. Inadequacy in skills can be overcome through strengthening extension especially through use of the field school technique with active apiary demonstrations. The lack of appropriate equipment calls for a proactive government policy that supports private sector led beekeeping initiatives. Beekeepers need to establish perennial forage sources such as fruit tree and multi-purpose tree woodlots, especially in western and northern Uganda where drought was a big problem. There is also a need for development of alternative dry season feeding for bees. Transport and general poor infrastructure affect marketing of hive products and may have a strong bearing on the product prices. Creation of collecting centres and marketing of products under beekeeper groups would ameliorate this problem and also improve access to markets. These groups could also be used to access credit from micro-finance institutions, which prefer dealing with individuals in formal groups. Vermin was a felt constraint in Kitgum district only, and could be controlled by ensuring good bee colony and apiary management practices, and proper hive siting which would curtail the wild animals.

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