

# Determination of physical-chemical parameters in bee products: a preliminary investigation from Africa's most renewed bee village in Tanzania

## ABSTRACT

**Aim;** *the main objective of this study was to evaluate the determination of physical-chemical parameters in bee products: a preliminary investigation from Africa's most renewed bee village in Tanzania; specifically, the study present preliminary findings of an enquiry that examined pesticide contamination in bee products from Kijiji cha Nyuki located in Tanzania. The study measured the levels of physical-chemical parameters in honey products harvested from the selected bee apiaries.*

**Material and methods;** *A mixed methods approach was adopted for this study and collected data both primary and secondary data was collected using physical observation and survey, interviews and questionnaires, the purposive and random sampling techniques was used in this study to select total of 104 participants who was taken as a sample from universal populations. Qualitative and quantitative data were analysed using IBM Statistical Package for Social Sciences (SPSS) Computer Programme version 25, where statistics aspect was determined from the results obtained from both questionnaires and laboratory experiment. A preliminary investigation from Africa's most renewed bee village in Tanzania; Collected sample were analysed at TBS & SGS laboratories.*

**Results;** *The results show all studied areas met honey quality assurance guideline stipulated by the ministry of natural resources and tourism suggesting moisture content in honey should not exceed 21%. pH test showed honey sample from Egypt apiaries had higher pH 4.3 and honey from Kijiji cha Nyuki had a low pH 3.54 implying honey from the studied areas fall within the pH applicable range. Test of HMF mg/kg discovered an average of 13.65 mg/kg in honey samples from 4 studied areas out of the 5, with 107.13 mg/kg of HMF in honey samples from Egypt. Suggesting that honey samples from the 4 studies areas with exception of samples from Egypt met the TZS 851:2006 standards and national's guidelines of 40mg/kg HMF. Finally, Test of total reducing sugar as invert sugar % m/m, from five samples as per TBS laboratory results found maximum of 68.91 % m/m and 64.4 % m/m minimum. The amount of physical mechanical contaminations that were identified in honey from 4 areas with exemption of sample from Egypt apiaries poses no risk to consumers.*

**Contribution to policy implication;** *This study recommends interventions among farmers and beekeepers on safe use of pesticides, good hygienic handling and the storage practices. It has contributed to the understanding of how the regulations outlining the use of insecticides is being implemented, and the current economic condition of studied farms. This calls on policymakers to rethink ways of engaging the beekeepers, and to have an ongoing discussion with beekeepers and concerned stakeholders about a model that could be used to enhance pesticides regulation in Tanzania.*

**Key Words:** *Pesticides, honey, physical-chemical, TBS & Kijiji Cha Nyuki*

## 1. INTRODUCTIONS

Globally the consumption of bee products is on the rise, as consumers perceive honey as one of health products that contain several benefits, this is despite several publications that have reported the presence of pesticides in honey and other bee products (Luvanda, & Lyimo, 2018; Hungerford 2020; Alavaisha, 2020). Several researchers continue to argue that honey products such as beeswax, honey,

and bee pollen are not immune to pesticides contamination due increased uses of pesticides by emerging and existing farmers (Brina et al. 2021), which may cause the introduction of those toxic chemicals into the food thus put consumers health at risk since hives may be contaminated by direct or indirect exposure (Wong et al., 2019). For example, Wong et al. (2019) show the pesticide residues may originate from the treatment of bee hives with acaricides in the

control of *Varroa destructor*. Similarly, the bees can get in touch with those pesticides during the foraging activities in an average radius of 3-6 km around the farms (Fawzy et al. 2014; Nabati et al. 2021; Recha et al., 2022). Notwithstanding the negative aspect associated with chemical, Ismail et al. (2021) argued that honey is a valuable food not only for its nutritious value, but also for its physical, chemical, and biological capabilities.

Luvanda, & Lyimo, (2018) show that beekeeping activity in Tanzania can yield up to 138,000 metric tons of honey every year. The primary beekeeping and honey production areas are the Western area which include Singida, Tabora and Dodoma. The growing honey production is a result of excellent climate. To date, the consumption of honey is rising due to its advantageous biological and physical-chemical attributes, involving antioxidant and antibacterial activities. According to Luvanda, & Lyimo, (2018) more than half of the honey yielded in the nation is consumed locally for diet and medicine. Alavaisha, (2020) noted that more than 70% of Tanzanian's population living in rural areas depend on agriculture for their livelihood. Which call for studies that can assist in revealing challenges associated with continued ecosystem functions when landscape changes, particularly as these changes relate to water-soil resources within a developing agricultural sector

Alavaisha, (2020) study recommended further empirical studies that can examine the level of physical chemical in honey products and its effect on consumers. The amount of chemical contamination in honey should be assessed in order to minimize chances of honey products being contaminated (Nabati et al. 2021; Recha et al., 2022). Consumer have the rights to safeguards their health, rights to information on the types and kinds of pesticides that have been used by farmers surrounding bees should be made available (Hungerford, 2020). Bee products are produced in an environment that is contaminated by various pollutants. Therefore, monitoring of bee products and their effects on human being and the environment is vital. For instance, Fawzy et al., (2014) show three main purposes of monitoring bee product exist: international competition, consumer health protection and better-quality products.

According to Murashova et al. (2020) the maximum purity of honey is determined by its biochemical formation and by careful draining

of pollen grains from nectar by an intermediate valve in a honey sac. Furthermore, Murashova et al. (2020) investigation found the amount of heavy metals accumulated in the body of bees due to intensive consumption of pollen and bee bread. Honey product is perceived as ecologically clean when the correspond to established organoleptic, hygienic, technological and toxicological standards (Lebedev and Murashova, 2016). To determine the degree of pollution by toxicants, researchers rely on analysing the content in the soil, water, and air which involved extensive labour, time and financially demanding (Kharitonova, 2015). As results there is a dearth of empirical information on the level of contamination of specific agricultural land in most poor countries (Hungerford, 2020), yet environment pollution with heavy metals has mutagenic and carcinogenic effect causing poisoning and disruption of various physiological functions of the body (Eskov, 2012; Kharitonova, 2015; Ismail, et al., 2021). For example, increased in pollution resulting from industrialisation of nations has also increased waste yet most national hardly have competent waste management system (Murashova, 2016). Hence, many plants have been exposed to high content of pollutants in the soil, and in the process exposing consumers to contaminated food and honey products, in the end causing chronic diseases (Dubovik, 2011). In addition, environmental pollution resulting from road transport has further caused notable threat to purity of products of bee colonies (Yadav, 2010; Adalin et al. 2020). According to Kumar et al. (2015) honey collected near large industrial enterprises and highways contains much more lead than that collected far. For instance, sample size of honey collected from a long distance from the highway showed a very low content of iron, zinc, magnesium, copper, nickel, lead, cadmium and cobalt (Adalin et al. 2020). In the same way Murashova (2016) postulated that low concentrations of substances in the soil is dangerous for humans when moving along food chains, from plants to bees and then through honey products to consumers. Plants accumulate heavy metal through air, and sometimes contamination is very low or sometimes higher. For example, vegetable absorbs much lead from air, up to 95% (Murashova, 2016, Kakengi, and Idani, 2018). Notwithstanding the notable negative effect, the quality of bee product can be attained through the adoption of technological requirements during their production, storage, and transportation (Osintseva, 2008; Kakengi,

and Idani, 2018). Researchers have agreed that the application of pesticides without complying with regulation have been instrumental in causing negative effects to individual and colony level (Sgolastra et al., 2017; Tosi et al., 2018).

Tosi et al. (2018) states that the risks posed by chlorpyrifos on human health, especially on child neural development, caused the United States Environmental Protection Agency (US EPA) to ban its use as a household pesticide. Tosi et al. (2018) results showed that pesticide risk assessment procedures should investigate field-realistic exposure to pesticide combinations. Despite other sources of pollutions, it is becoming increasingly clear that the widespread use of pesticides on agricultural crops is a major factor (Gill et al. 2012; Irungu et al., 2016). As such, tight regulation is required in order to preserve honey bee health and rigorous analytical methods to confirm product quality (Kakengi, and Idani, 2018). Honey is composed of over 300 compounds, mostly carbohydrates (>75 %) and water (~18 %), with minor components comprising of proteins, amino acids, vitamins, antioxidants, minerals, essential oils, sterols, pigments, phospholipids, and organic acids (Bogdanov et al. 2008; Wong et al. 2019). The chemical composition and quality of honey depend on type of the melliferous plants the nectar was collected from, the beekeeping practices, and storage condition. Hence examining the presences of pesticides in honey is critical regards with the reproduction of safe and quality honey product (Kasianchuk, 2020). Therefore, the purpose of this study was to present preliminary findings of an enquiry that examined pesticide contamination in bee products from Kijiji cha Nyuki located in Tanzania. Specifically, to measure the levels of physical-chemical parameters in honey products harvested from the selected bee apiaries.

## 2. LITERATURE REVIEW

Nabati et al. (2021) study measured moisture using the refractometry method. The refractive indices of honey samples were measured at ambient temperature using refractometer and all measurements were done at 20°C by adding a correction factor to obtain the corresponding percentage of moisture from the refractive index by referring to a standard table of AOAC. Bafo et al. (2019) postulates that physicochemical properties of honey should not exist average moisture content of honey samples 20% and 21% mellifera honey.

In spite of the fact that mineral content of honey is a positive nutritional feature, Hungerford (2020) is of the view that it may contribute to environmental pollution, hence regular monitoring of toxic heavy metals is vital to ensure nutritional quality and safeguard consumers against contaminants (Hungerford, 2020). On a slight note, Ismail, et al., (2021) show that honey possess different colours varying between dark amber, light amber, and white. The difference in colour is due to the difference in the percentages of dissolved substances in the origin of the plant, such as the pigment compounds that are transported through nectar and are rich in chlorophyll and carotene. Internationally the pH values of honey samples specifications ranged between 3.44 to 4.83 (Laaroussi et al., 2020). To conclude a study by Ismail, et al. (2021) revealed diverse activity in terms of mineral contents, pH, density, sugar contents, and antioxidant and antibacterial activity. This could be related to the difference in properties of the nectar source, the climate, the environmental conditions, and geographical distribution.

### 2.1 Honey activities landscape in Tanzania

Tanzania is among the Sub-Saharan countries with the largest forest ecosystem which are covered with Miombo woodlands in more than two thirds of the total forested land (Luvanda, & Lyimo, 2018; Alavaisha, 2020). According to the Tanzania National Forestry Resources Monitoring and Assessment (NAFORMA) report (MNRT, 2015), the woodlands covers about 44,726,246 hectares out of 48.1 million hectares. Beekeeping sector in Tanzania generates about US\$ 19 million per annum, employing about 2 million people, helps in biodiversity, and increases agricultural production through pollination (BTC, 2012). At the household level, the sector contributes up to about 33% of the household income source in the Miombo woodlands of Tanzania. Naturally besides honey, there are beeswax, propolis, royal jelly, and honeycomb as the by-products of beekeeping (BTC, 2012).

Luvanda, & Lyimo (2018) show that beekeeping activity in Tanzania can yield up to 138,000 metric tons of honey every year. Honey product are predominantly cultivated in Singida and Tabora. Luvanda & Lyimo (2018), further indicated that more than half of the honey harvested nationwide is consumed locally for diet and medicine. Additionally, the

consumption is motivated by its biological and physical-chemical attributes consisting of antioxidant and antibacterial. According to Alavaisha, (2020) about 70% of Tanzanian's population living in rural areas depend on agriculture for their livelihood. This view is further cemented by Recha et al. (2022) stating that the main source of livelihood remains agriculture, including growing of cereals, sorghum, beans and cow peas. In terms of quality, Luvanda, & Lyimo, (2018) postulates that honey harvested from Singida and Tabora had more capability of impeding microbial growth than that from the central area. Accordingly, Luvanda, & Lyimo, (2018) concludes that honey from central and western region had a relatively higher capability to inhibit microbial growth. For example, honey from Inyonga, Manyoni, Dodoma town, Issuna, Singida town, Shinyanga town, and Nzega showed relatively higher total phenol, antioxidant, and vitamin C substance (Luvanda, & Lyimo, 2018). In regards with acidic pH, Kakengi, and Idani (2018) study found honey was acidic with pH ranging from 4.05 to 4.8, which falls within the regulation pronounced by United Republic of Tanzania - Ministry of Natural Resources and Tourism (2007) who reported a pH range of 3.42 to 6.10 for Tanzanian honey. According to Kakengi and Idani, (2018) low pH and high sugar content of honey creates acidic environment and osmolarity that results into antimicrobial properties of Tanzanian honey. According to Brina et al. (2021) the content of honey can vary from 15 – 23%, and water content can affect the quality and some characteristics of honey such as viscosity, specific gravity, maturity, taste and crystallization, specific gravity. Therefore, the quality of honey and composition depends on vegetation types available in an area (Kakeng & Idani, 2018).

## **2.2 Types of pesticides and its usage in Africa**

Irungu et al. (2016) indicates that Kenya farmers rely heavily on mechanisation and use of pesticides in order to meet the market demands. Inguru et al. (2016) study showed pollen contained 90% of the pesticides, and 50% was detected in honey. Similar trend has been noted in previous studies with some researchers concluding that pollen is the most contaminated hive product (Adalin et al. 2020; Ismail, et al., 2021). In general insecticides are the most prevalent, presenting (>50%), followed by fungicides (27%) and herbicides (20%), the study further identified

organophosphates (31%) and carbamates (33%) appeared to be the most commonly used throughout Kenya (Inguru et al., 2016). Furthermore, Kumar et al. (2020) indicated that 60% of the dairy farm owners from Northern Ethiopia sell products to the public from animals treated with a variety of pesticides without considering its effect to human health. Likewise, Negutu et al. (2021) revealed that increased pesticide use, handling and management of pesticides associated with environmental and health risks in Ethiopia. In terms of their categories, Mulati (2018) show pesticides can be classified in 7 classes: carbamates, organophosphates, herbicides, acaricides, neonicotinoids, pyrethroids and fungicides.

## **3. RESEARCH METHODOLOGY**

The areas of the study were selected bases on the growing bees farming activities as major Agro-ecological zones in Tanzania in terms of honey production. Kijiji cha Nyuki is one of the major leading bee farming in Africa and leader in the use of advanced technology and bee farming practices. The selected apiaries spread apart (<10m from each other).

Samples were collected from the apiaries between August and September 2021 and represented locally produced honey from the Kijiji cha Nyuki. Samples were stored in scientifically approved cooler boxes and transported to TBS and SGS laboratory for real time examination, and it was stored at 20°C. Sample collection process were guided by experts and experienced agronomists from the selected area. After collection, the pollen pellets were homogenized using a glass jar, and 100 g were subsampled and frozen at -20 °C. As shown by Fawzy et al. (2014) researchers have opted to make use of small samples and reduce solvent volumes in analytical procedure due to the environmental and economic concerns. Hence this investigation opted for the QuEChERS. The QuEChERS method is being used by several researchers as it assists in reducing several steps in analytical procedure thereby minimizing potential sources of error. Building on noted concerns, this study main objective was to examine the level of chemical contamination in honey samples collected from various apiaries located in Kijiji cha Nyuki. Sample were cleaned and extracted based on the methods given by TBS.

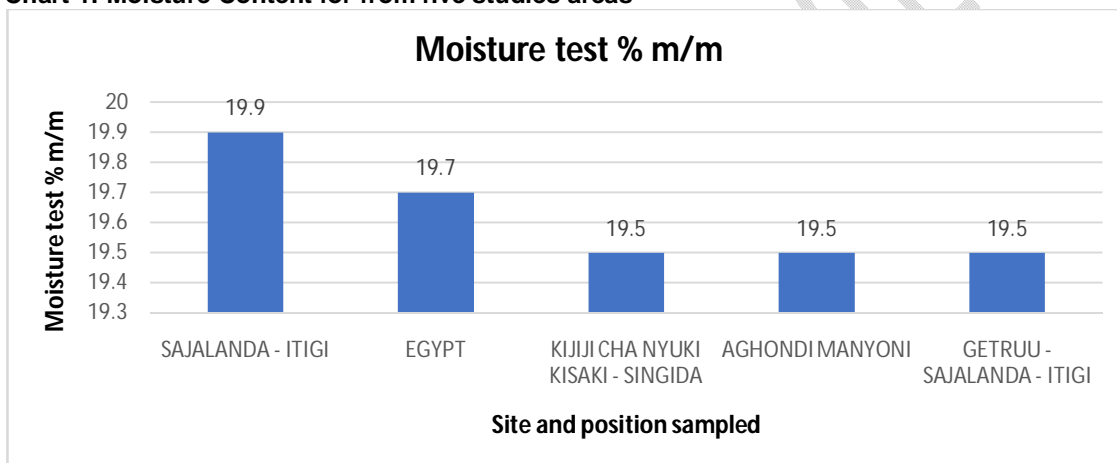
## 4. DISCUSSION AND RESULTS

### 4.1 Moisture Content in Honey

This study was conducted to investigate the presence of pesticide residues in honey produced in the Kijiji cha Nyuki Singida. The analysed sample consisted of organophosphorus, organonitrogen, organochlorine, and certain pyrethroids compounds. The TBS laboratory examination identified 19.5 % m/m of moisture in honey samples collected from three different places (Kijiji cha nyuki, Aghondi Manyoni and Getruu Itigi). The examination further identified 19.7 % m/m in honey samples from Egypt and 19.9% m/m in honey samples from Sajalanda

– Itigi. All the five tested areas reported an average samples size of 19.62% m/m as per TBS laboratory test. In general, raw honey will normally have a moisture content of approximately 18%, which still within internationally recommendation of 21% of moisture content. Therefore, the results of this study show all studied areas met honey quality assurance guideline (TZS 851:2006) for Tanzanian honey products promulgated by ministry of natural resources and tourism that suggest the moisture content in honey should not exceed 21%, also standard guides that honey produced by stinging honey bee for table honey the moisture contents should not be more than 20% whereby to industrial honey the moisture content should not be more that 22 %.

Chart 1: Moisture Content for from five studies areas



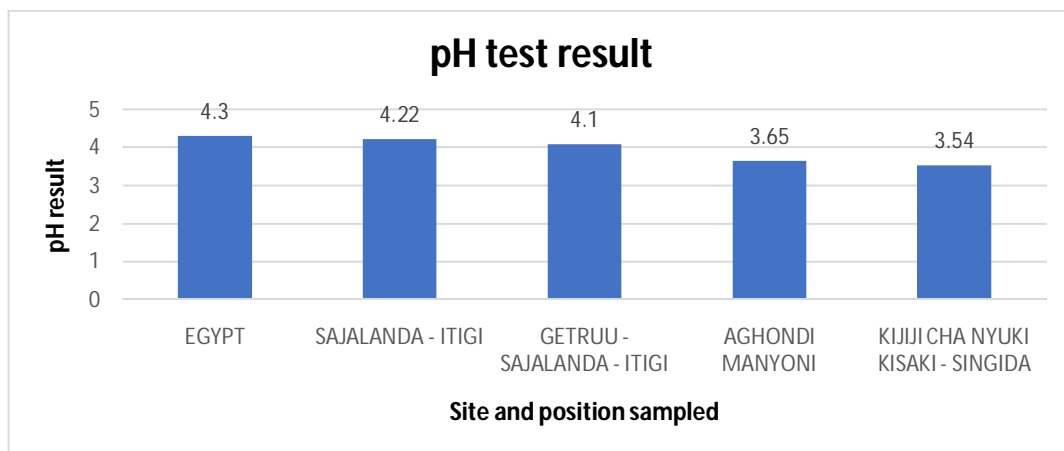
Data source: TBS Laboratory Report

### 4.2 pH test of honey from five samples

Chart (2) discuss pH test of five honey samples collected from five different sources (Kijiji cha nyuki, Aghondi Manyoni, Getruu Itigi and Sajalanda – Itigi and Egypt) reveal an average of 3.96 pH. On contrary, honey sample from Egypt apiaries had higher pH 4.3 and honey from Kijiji cha Nyuki had a low pH

3.54. The normal acidity of honey ranges from a pH of 3.5 and 5.5 depending on its botanical source, the pH of nectar, soil or plant association, and the concentration of different acids and minerals such as calcium, sodium, potassium and other ash constituents. Therefore, current results fall within the pH applicable range.

Chart 2: pH test of five honey samples collected from five different sources

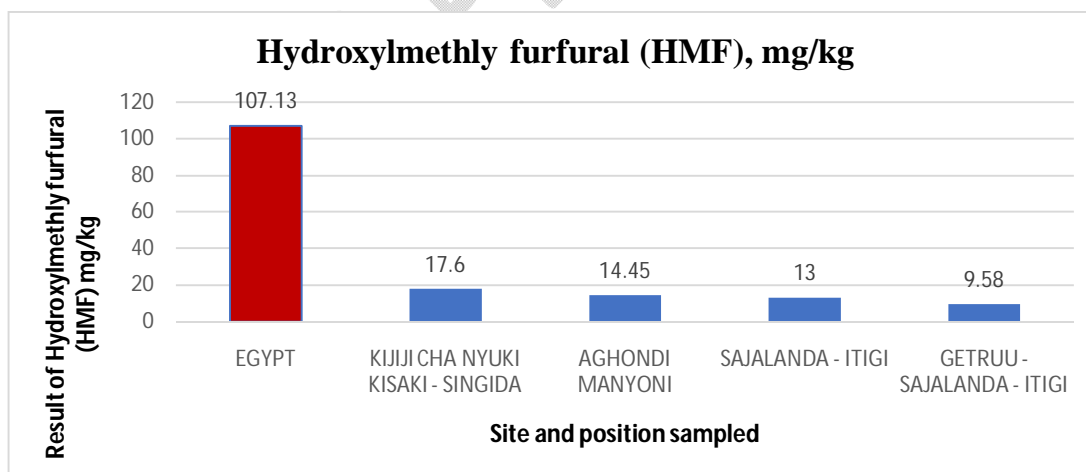


Data source: TBS Laboratory Report

#### 4.3 Test of hydroxymethylfurfural (HMF) mg/kg

The examination in chart (3) reveals an average of 13.65 mg/kg of HMF in honey samples from Kijiji cha Nyuki, Aghondi Manyoni, Getruu Itigi and Sajalanda – Itigi. However, the study also found 107.13 mg/kg of HMF in honey samples from Egypt as seen in the chart 3 below. The Codex Alimentarius Standard commission established by Food and Agriculture Organization (FAO) has set the maximum limit for HMF in honey at 40 mg/kg (with a higher limit of 80 mg/kg for

honey samples from tropical regions) to ensure that the product has not undergone extensive heating during processing and is safe for consumption (FAO, 2018). This means honey samples from Kijiji cha nyuki, Aghondi Manyoni and Getruu – Sajalanda – Itigi and Sajalanda – Itigi met the TZS 851:2006 (Honey- Specification) standards and guidelines for quality assurance of bee products produced in Tanzania which states that the HMF should not exceed 40mg/kg. On contrary honey samples from Egypt failed to pass this standard.



Data source: TBS Laboratory Report

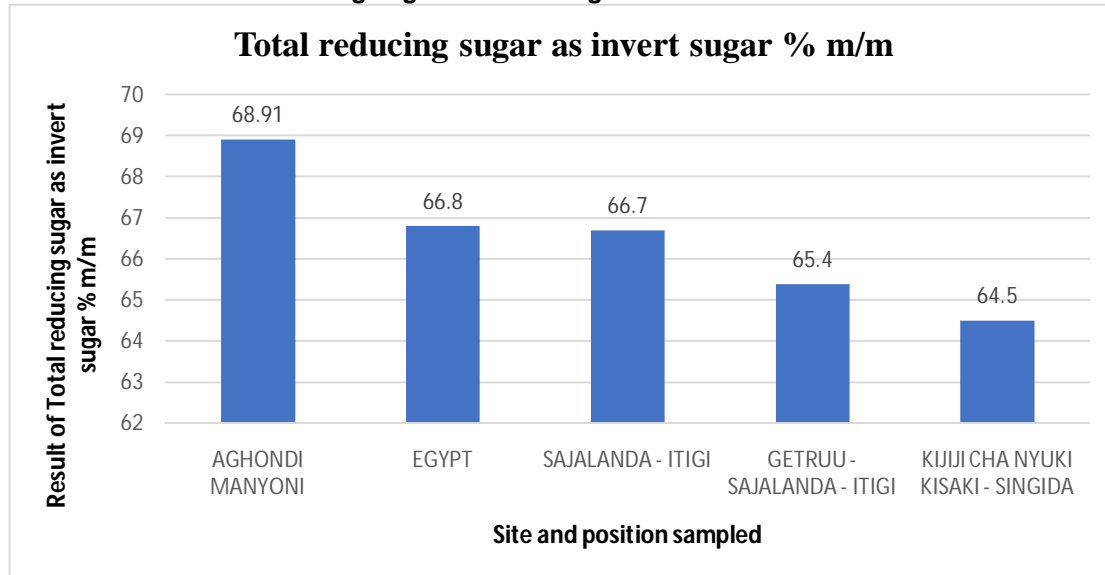
#### 4.4 Test of total reducing sugar as invert sugar % m/m

The examination of five samples as per TBS test found 68.91 % m/m as the maximum amount of total reducing sugar as per sample collected from Aghondi Manyoni and 64.4 %

m/m as the minimum amount of total reducing sugar based on the sample collected from Kijiji cha Nyuki. The average amount of total reducing sugar as invert sugar identified from all five samples of honey is 66.46 % m/m. All the five samples correspond to TZS 851:2006 Honey- Specification standards since the total

presence is above the minimum requirement of 60%.

**Chart 4: Test of total reducing sugar as invert sugar % m/m**



Data source: TBS Laboratory Report

## 5. CONCLUSION

In terms of the amounts of moisture content in honey, the results of this study show all studied areas met honey quality assurance guideline TZS 851:2006 stipulated by the ministry of natural resources and tourism suggesting moisture content in honey should not exceed 21%. In regards to pH test, 3 samples out of 5 revealed an average of 3.96 pH. On contrary, honey sample from Egypt apiaries had higher pH 4.3 and honey from Kijiji cha Nyuki had a low pH 3.54 inferring that honey from the studied area fall within the pH applicable range.

Further, Test of HMF mg/kg discovered an average of 13.65 mg/kg of HMF in honey samples from 4 studied areas out of the 5, with 107.13 mg/kg of HMF in honey samples from Egypt. This implies honey samples from the 4

studied areas with exception of honey samples from Egypt met the TZS 851:2006 standards and national's honey production guidelines of 40mg/kg HMF.

Finally, Test of total reducing sugar as invert sugar % m/m, from five samples as per TBS laboratory results found maximum of 68.91 % m/m and 64.4 % m/m minimum. To conclude, the study found existing physical mechanical contaminations in honey samples resulting from increased use of pesticides by farmers owners. Nevertheless, the amount of physical mechanical contaminations that were identified in honey from 4 areas with exemption of sample from Egypt apiaries poses no risk to consumers this suggests that honey products from the Kijiji cha Nyuki and surrounding areas can be used for various needs, medical needs included.

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