ZIMBABWE HONEY PHYSCO-CHEMICAL PROPERTIES: A CASE STUDY OF HONEY PRODUCED IN MANICALAND PROVINCE, ZIMBABWE

John Mwandifura, Chinhoyi University of Technology
Lovemore Chikazhe, Chinhoyi University of Technology
Josphat Manyeruke, Chinhoyi University of Technology
Nilton Mashavakure, Chinhoyi University of Technology

ABSTRACT

This study was carried out to assess the entrepreneurial potentials and opportunities of beekeeping in Manicaland Province of Zimbabwe to meet customer honey quality preferences. Honey in Zimbabwe is considered as a delicious food; for old people, sick and pregnant women. The price of honey is determined by its quality. Consumers worldwide value quality of food when buying food for consumption. The research focused on honey physco-chemical properties in Manicaland province of Zimbabwe: moisture contents, hydroxymethylfurfural (HMF), diastase (amylase) activity, reducing sugars (glucose and fructose), pH, ash and electrical conductivity. To study the physco-chemical properties of the honeys collected from the seven districts of Manicaland province, eighty five honey samples were collected and stored under refrigerator conditions until the chemical analyses were conducted in the laboratory. All the honey samples were collected, kept in tied glass bottles (250 gm/sample), and put directly in the refrigerator until the experimental analysis was done in the laboratory. For each parameter, the tests were replicated three times and the mean values were recorded. All the samples were found to be within the recommended levels.

The eighty five honey samples were taken from the seven districts in the province. The districts are Chipinge, Chimanimani, Buhera, Makoni, Mutasa, Mutare and Nyanga. Ten honey samples were taken from each of the seven districts to make them seventy honey samples and fifteen honey samples were taken from the traditional beehives (5), Kenyan Top Bar hives (5) and Langstroth (5). The honey was analyzed in the laboratory. All the samples were found to be within the international standards. The results were showing that honey produced in Manicaland province of Zimbabwe can be exported and earn foreign currency for the country. The quality of honey produced in Manicaland has a potential to improve the status quo of the honey entrepreneurs in the province if taken seriously due to the high price of similar quality of honey at which honey is sold in other countries.

Keywords: Entrepreneurship, Customer Preferences, Reducing Sugars, Consumers, Physco-Chemical Properties and Entrepreneurial Mindset.

INTRODUCTION

The domestic demand for high value honey products substances could provide opportunities for rural employment as the production of these commodities is relatively less

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

labor intensive. Research trends shows that beekeeping entrepreneurship is mostly focused on assessing the entrepreneurial skills and entrepreneurial behavior of beekeepers. Very few studies are available on entrepreneurial potential on honey quality. There are no studies on honey quality, for honey produced in different district of Manicaland Province which beekeepers can exploit to turn into entrepreneurs, by selling honey which meet the requirements of certain segments of the society (Alves et al., 2021). In Manicaland province of Zimbabwe, beekeeping is also carried out by all ages of people including women and youths. The districts in Manicaland are Buhera, Chimanimani, Chipinge, Makoni, Mutasa, Mutare and Nyanga. More honey is from Chimanimani, Chipinge, Nyanga, and Mutasa districts. Women in Manicaland are motivated into beekeeping entrepreneurship by low capital requirements of the enterprise and the all year round availability of bee forage which makes the availability of honey all year round (Dossa et al., 2018). The use of forest areas offered by the local authorities in Chimanimani and Mutasa districts to put up apiaries has helped to break the barriers for youth and women to have access to forests for beekeeping entrepreneurship and make business from honey sales. It was found that women in rural areas surrounded by forests mainly earn income from firewood selling. Beekeeping in such areas reduce the destruction of trees by these villagers because they have a better use for them than destroying the forests which cause climate change (Assia & Ali, 2015); (De-Melo & Almeida-Muradian., 2019);(Ananias et al., 2020). Beekeeping provide a good incentive to communities to manage the forests. The resettled farmers in Chipinge and Chimanimani, in areas where macadamia nuts are grown understand the importance of setting up an apiary around a field of macadamia field that it can increase the yield by 30% through pollination by bees and at the same time the farmer will get income from bee products such as honey, beeswax, pollen grains and propolis (Marini et al., 2022). This has been supported by The Livestock Production Department of Zimbabwe (2012) demonstrated to farmers in Nyanga where stoney fruits are produced that bee pollination services have a great potential to generate income for bee entrepreneurs in horticulture sector through crop pollination and can improve crop yield (De-Melo et al., 2018; Ananias et al., 2020).

Honey is an excellent food containing around 80 g/100 g carbohydrates, 40 g/100 g fructose, 35 g/100 g glucose, 5 g/100 g sucrose and 20 g/100 g water which is the second most important component of natural honey and potassium, being the most abundant nutrient in honey. Entrepreneurship in food industry is the ability to sell quality products which meet customer preferences (Moore et al., 2020; Truzzi et al., 2022; Silvano et al., 2022).

Water content in honey is important since it affects the shelf life of honey. An unadulterated honey contains more than 180 properties, which includes organic acids, like gluconic acids and acetic acids (Alexandre et al., 2018; Khalafi et al., 2021). Most entrepreneurs grow their businesses and sustain by coming up with new and innovative products that revolve around their main products which meet customer preferences. The entrepreneur can meet customer preferences if he is able to create an innovative product from an existing product preferred by customers and sell it to the new set of customers in the new market (Alexandre et al., 2018).

There are minor constituents that are important for acidifying honey and contribute mainly to honey taste, honey entrepreneurs should label them on the package to make the customers aware of what they are consuming (Bogdanov & Martin, 1997; Augusto et al., 2016; Alves et al., 2021).

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Honey is being accepted as an effective therapeutic agent by health practitioners and by the general public due to good clinical results that are obtained and the rational explanations for honey therapeutic actions (Sousa et al., 2016; Suntiparapop et al., 2021). Honey has some biological activities such as wound healing, antimicrobial activities, anti-inflammatory, treatment of gastrointestinal disorder such as constipation, cancer, skin rash, cancer, neurological degeneration, heart diseases and hair dropping (Siok et al., 2018; Moore et al., 2020).

Honey is a natural product with high price and has several medicinal health functions, has become a target for adulteration in order to make easy money. The authenticity and quality of honey is of great importance for business and medicinal aspects (Dossa et al., 2018). Detection of artificial honey is not easy due to variability of honey due to different plant species used by the bees to collect nectar, honey maturity, environment, processing methods used and storage techniques (Manuela et al., 2021). Adulterated honey has poor nutritional and medicinal benefits as compared to pure honey. The study of the physical and chemical properties of honey has increased in most developed countries for the certification process that determines honey quality for consumption and help entrepreneurs to market their products with known values (Assia & Ali, 2015);(Alexandre et al., 2018).

MATERIAL AND METHODS

Moisture Content

The moisture content of honey samples was determined by measuring the refractive index of the sample using an Abbe Refractometer using the relationship between refractive index and water content reading at 20°C, as described in the harmonized methods of the International Honey Commission (IHC, 2009).

Hydroxymethylfurfural

Determination of hydroxymethylfurfural (HMF) content of honey samples was based on the measurement of absorbance of HMF at 284 nm using UV. Spectrophotometer (Evolution–201 UV Visible Spectrophotometer, Thermo Scientific) was used. Five grams of honey sample was weighed into a small beaker. The honey sample was dissolved in 25 ml of water and transferred into a 50 ml flask. Half ml of Carrez solution I was added and mixed. Half ml of Carrez solution II was added into the 50 ml flask and mixed, then diluted with distilled water up to the volumetric mark of the flask. A drop of ethanol was added to the mixture to suppress foam. The mixture was filtered through general purpose filter paper and the first 10 ml of the filtrate was discarded. Five ml of the remaining filtrate was pipetted into each of two test tubes. Then five ml of water was added to one of the test tubes and thoroughly mixed and five ml of sodium bisulphite solution (0.2%) was added to the second test tube and mixed (the reference solution) using a Vortex mixer. The absorbance readings of the sample solution against the reference solution at 284 and 336 nm, respectively were taken using the UVVisible Evolution 201 spectrophotometer within one hour of preparation. The result was calculated as follows: HMF in mg/kg=(A284 – A336) x 149.7 x 5 x D/W Where A284 = absorbance at 284 nm, A336 = absorbance at 336 nm, 149.7 = constant, 5 = theoretical nominal sample weight, W = weight of the honey sample in gram, D = dilution factor.

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

pH

Twenty grams of honey sample was dissolved in 75 ml of distilled water in a 500 ml beaker and stirred using a magnetic stirrer. Then the pH was measured with a digital pH-meter (Orion Star J257), which was calibrated using pH 4.0 and 7.0 buffer solutions.

Total ash

A quartz dish was heated in an electric furnace at 600°C and subsequently cooled in a desiccator to room temperature and the dish was weighed (M2). Five grams of honey sample was weighed to the nearest 0.001g (M0) and added to the dish. Two drops of olive oil was added to the dish to prevent frothing and then the dish was placed in preheated furnace and heated for 1.5 hour at a temperature of 600°C The dish with the ash was then cooled in a desiccator and weighed. The ashing procedure was continued until constant weight was reached (M1). Ash (% by mass) was calculated using the following formula:

Ash (% by mass) = (M1 – M2)/Mo x100.

Determination of Sugars in Honey

The reducing sugars and non-reducing sugar were determined by HPLC Knauer Instrument. The flow rate was adjusted at 1.5 mL/min, the column used was Luna NH2 column for carbohydrate analysis. Sample preparation: 5 g of sample dissolved in 12 mL methanol HPLC grade, Quantitatively transferred to measuring flask 50mL completed to the mark with HPLC grade water, sonicated for 20 min, Filtering through PTFE filter (0.2mm), kept at 0°C until analysis. Pipette 25mL methanol into a 100mL calibrated flask. Dissolve 40mL water and transfer quantitatively to the flask and fill to the mark with water. Fructose: 2.000g; glucose: 1.500g; sucrose: 0.250g; maltose: 0.150g.

Free acidity

Honey sample (20 g) was dissolved in 150 ml distilled water in a 500 ml beaker and stirred with a magnetic stirrer. The solution was titrated with standardized 0.1 M NaOH solution to a final pH of 8.30. The results were expressed in milliequivalent (meq) of acid per kg of honey using the following equation.

Acidity =10V

Where V = the volume of 0.1M NaOH used and 10 is the amount of honey sample used.

Determination of Diastase Activity

Determination of diastase activity was evaluated spectrophotometrically based on the method of Schade, et al.(1958) using the Shade method (UVA/IS Spectometer Lambda ll, Perkin Elmer, USA). The diastase activity is calculated as diastase number (DN). DN expresses units of diastase activity (Gothe unit).

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Electrical Conductivity

The electrical conductivity at 1/5 was determined according to the method described by Bogdanov, et al (2004) using a conduct meter (Cond 3210 WTW).

RESULTS AND DISCUSSION

Moisture Content

The moisture content of honey in the study areas of Manicaland province varied from 18.2% to 25.6%, with the mean of 19.63% (shows in Table 1). Among the honey samples 97.3 % had moisture content within the accepted range (less than 20% moisture content). Moisture content can reduce the storage of honey if it is more than 21% and is one of the important parameter to be considered in the honey quality. Honey samples collected in areas of relatively high humid like Nyanga, Chipinge Highveld, Chimanimani Highveld and Vumba part of Mutare district found to consist high moisture content than honey produced from low humid areas of the province such as Buhera District.

Table 1
MOISTURE PHYSICOCHEMICAL PROPERTIES OF HONEY

Variable	**Sample size**	**Moisture %**	
		Range	**Mean (± SD)**
Chipinge	10	18.8 – 24.7	19.9(± 0.3)
Chimanimani	10	18.7 – 24.6	19.5(± 0.8)
Buhera	10	18.2 – 22.3	18.9(± 0.9)
Makoni	10	18.2 – 25.4	19.8(± 0.9)
Nyanga	10	18.9 – 24.7	19.9(± 0.9)
Mutasa	10	18.1 -24.9	19.7(± 0.5)
Mutare	10	18.9 -25.6	19 .6(± 0.3)
Mean		**18.9 – 19.3**	**19.63(± 0.4)**
Hive type Traditional hive	5	18.6 – 22.8	18.7(± 1.0)
Kenya Top Bar Hive	5	18.5 – 21.3	18.3(± 0.5)
Langstroth Frame Hive	5	18.1 – 20.4	18.2(± 0.4)
Mean		**18.7 – 21.4**	**19.2(± 0.3)**

Results showed that honey from traditional hives such as log hives have higher moisture content than honey samples collected from improved hives such as Kenya Top Bar hive and the Langstroth hive. In this result the moisture content of honey from traditional and top bar hive are higher than the Langstroth bee hive.

Hydroxymethylfurfural (HMF)

The hydroxymethylfurfural (HMF) test results of the sample ranged from 15.4-54.8mg/kg with mean value of 29.2 mg/kg 54.8mg/kg with mean value of 29.2 mg/kg. The quantity of HMF in the honey is the important indicator of honey whether it is over heated, aged or adulterated

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

with invert sugar (hydrolyzed sucrose). In Zimbabwe the acceptable HMF is below 40 mg/kg of honey. In this study 91% of the samples fall within the accepted standard quality below (Table 2).

Table 2
HYDROXYMETHYLFURFURAL (mg kg^{-1}) PHYSICOCHEMICAL PROPERTIES OF HONEY

Variable	Sample size	Hydroxymethylfurfural (mg kg^{-1})	
		Range	**Mean (± SD)**
Chipinge	10	18.3-48.6	22.4(± 0.4)
Chimanimani	10	17.6-52.1	29.5(± 0.1)
Buhera	10	35.6-44.1	21.6(± 0.3)
Makoni	10	17.3-43.4	37.3(± 0.5)
Nyanga	10	15.4-47.6	28.2(± 0.2)
Mutasa	10	14.8-51.3	36.1(± 0.3)
Mutare	10	16.8-54.8	35.7(± 0.4)
Mean		16.4-48.6	29.2(± 0.4)
Hive type Traditional hive	5	17.4-31.1	31.8(± 0.2)
Kenya Top Bar Hive	5	16.9-38.2	27.2(± 0.4)
Langstroth Frame Hive	5	16.7-25.3	24.8(± 0.1)
Mean		16.8-36.3	26.1(± 0.4)

There was a significant ($p<0.05$) different in HMF between honeys sampled from different places. The HMF from various places ranged from 15.4-54.8 mg^1/kg, with Mutare having the highest value of 54.8 mg^1/kg and Buhera district has the lowest (15.4 mg^1/kg) as shown in Table 2. These results were consistent to what was obtained by Chitesa in 2014. The results for all the districts were below the acceptable minimum limit of 65%. These results were consistent with the results obtained by Chitesa *et al.*, 2014. Mutare district honey had the highest amount of reducing sugars while Nyanga honey had the lowest at 54.8 mg^1/kg. There was a significant difference at $p < 0.05$ in reducing sugars among the honeys from various locations within each district and for each district.

The HMF content is considered as a parameter of honey sample freshness and increases during processing and/or aging of the honey product. HMF in honey is mainly formed from carbohydrates, generally from fructose, which is thermally more labile than Saccharose and glucose (Bogdanov, 2017). The formation of fructose is a natural process because honeys are acidic, but atmospheric temperature accelerates the process and the HMF concentration in honey increases according to storage duration and also according to beekeeping practice systems (Noor et al., 2019). HMF value is generally absent or very low in fresh honey and is high in honey that has been heated and the level depends on time taken to heat the honey, stored in poor conditions or adulterated with sugar syrup (Duarte et al., 2018). Chemical properties of honey such as pH, mineral content and total acidity also affect HMF content in the honey. The presence of organic acids also favors the production of HMF because it's an acid catalyzed dehydration of hexose sugars (Moore & Spink, 2012). Another factor that can affect the HMF level of honey in bee hive is the tropical climate, which can increase the level of HMF level. Hot weather can increase the level of HMF in honey in the bee hive. Consequently the Codex Alimentarius (2011) and International Honey Commission (2002) set maximum concentration of HMF to 40 mg^1/kg for

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

honey from non-tropical regions and 80 mg[1]/kg for honey from tropical regions (Oddo et al., 2008).

Diastase (amylase) Activity

Diastase activity values of the 85 honey samples analyzed ranged between 2.1 and 11.9 (Gothe scale). There was no significant difference in diastase activity value among honeys from the seven districts of Manicaland province, honeys obtained from Buhera district had a lower range diastase activity (2.1-8.8) as compared to the other six districts.

Table3
DIASTASE ACTIVITY

Variable	Sample size	Diastase Activity (Goethe scale)	
		Range	Mean (± SD)
Chipinge	10	2.5-11.2	(± 0.2)
Chimanimani	10	2.8-11.9	(± 0.5)
Buhera	10	2.1-8.8	(± 0.4)
Makoni	10	2.5-11.9	(± 0.3)
Nyanga	10	2.1-9.6	(± 0.2)
Mutasa	10	2.7-10.5	(± 0.3)
Mutare	10	3.1-11.2	(± 0.4)
Mean	**10**	**2.5 – 10.7**	**(± 0.3)**
Hive type			
Traditional hive	5	3.2-11.7	(± 0.5)
Kenya Top Bar Hive	5	3.4-10.6	(± 0.2)
Langstroth Frame Hive	5	3.2-10.5	(± 0.4)
Mean	**5**	3.3 -10.9	**(± 0.4)**

These results indicate that Buhera district is very hot and the honey samples had low enzyme content resulting from overheating of the honeys due to high temperature of the area. The levels of diastase activities for all the seven districts, however are within the recommended levels. Diastase activities of honey for Manicaland province is not affecting the consumption and marketing of honey to high paying markets. The type of beehives has no effect to the honey quality due to the levels of diastase activity.

Reducing Sugars

The results shows that all the honey samples are within the accepted range (60-70%). This shows that Manicaland has a potential to export honey since the reducing sugar levels are within the accepted levels. Honey from Manicaland, indicates that it can be accepted internationally if it is to be exported. The results shows that best honey in terms of reducing sugars is from Buhera, Chimanimani, Mutasa and Mutare districts. However, all the districts were found to be within the recommended level shows in Table 4.

Table 4
REDUCING SUGARS

Variable	Sample size	Reducing sugar %

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

		Range	Mean (± SD)
Chipinge	10	63.3 – 67.5	66.1 (± 0.2)
Chimanimani	10	65.3 – 70.2	68.2 (± 0.5)
Buhera	10	65.2 - 70.1	65.7 (± 0.4)
Makoni	10	60.7 – 66.9	65.8 (± 0.3)
Nyanga	10	64.7 – 66.9	65.8 (± 0.2)
Mutasa	10	65.3 – 70.2	65.9 (± 0.3)
Mutare	10	65.2 - 69.9	65.8 (± 0.4)
Mean		**63.7 – 70.2**	**66.2 (± 0.3)**
Hive type Traditional hive	5	64.3 – 67.6	65.8 (± 0.5)
Kenya Top Bar Hive	5	63.3 – 69.9	65.9 (± 0.2)
Langstroth Frame Hive	5	63.6 – 70.6	65.8 (± 0.4)
Mean		**64.7 – 66.9**	**65.8 (± 0.3)**

The main reducing sugars of honey are glucose and fructose. Fructose is used to determine the hygroscopic features of honey while glucose is used to determine the speed of honey crystallization (Majewska et al., 2019). The sugar content of honey depends on the sugars present in the nectar and enzyme present in the bee and nectar (Dzugan et al., 2018). Therefore, the difference in the reducing sugars from different areas is due to environmental conditions and source of nectar for the bees and is different in most regions. The minimum accepted level of reducing sugar is 60% and the maximum level of reducing sugar accepted is 70%. Therefore, most of the district honey samples from all the districts in Manicaland province of Zimbabwe are within the recommended level. In terms of reducing sugar level, type of beehive was not very important. All the beehives produced honey which is within the accepted reduced sugar level

pH

The pH value of honey for Manicaland province of Zimbabwe obtained in this study ranges from 2.1 to 4.4 with mean value of 3.46. Published research reports indicate that acceptable pH of honey should be between 3.2 and 4.5 (Codex almentarius commission, 2001). In this research 98.2% of the sample results fall within the accepted standard quality. The table 5 below shows the results. Honey samples from Buhera district were found to have high pH ranging from 2.1- 3.9. The lowest honey pH was found in Chimanimani district, which was 4.4. Therefore honey for Manicaland province of Zimbabwe is very suitable for consumption and of high grade for export.

Table 5
pH VALUES

Variable	Sample size	pH%	
		Range	**Mean (± SD)**
Chipinge	10	2.3-4.2	(± 0.3)
Chimanimani	10	2.2-4.4	(± 0.8)
Buhera	10	2.1-3.9	(± 0.9)
Makoni	10	2.3-4.1	(± 0.9)
Nyanga	10	2.3-3.9	(± 0.9)

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Mutasa	10	2.3-4.3	(± 0.5)
Mutare	10	2.2-4.3	(± 0.3)
Mean	**10**	3.46	**(± 0.4)**
Hive type			
Traditional hive	5	2.3-4.4	(± 1.0)
Kenya Top Bar Hive	5	2.2-4.3	(± 0.5)
Langstroth Frame Hive	5	2.1-3.9	(± 0.4)
Mean		3.38	**(± 0.3)**

The significance of pH at acidic range in honey cannot be overemphasized. The high pH of honey inhibits the presence and growth of microorganisms in foods. Therefore these parameters have great importance during the extraction and storage of honey, since they influence the texture, taste, stability and shelf life of honey (Belay et al., 2013). The pH of honey prevent the honey samples from infection by various species of micro-organisms and thus help to ensure long shelf life for the honey samples (Lavelli et al., 2013). The pH of honey does not directly reflect the total acid content of honey, it is rather reflects the buffering action of the inorganic cation constituents on the organic acids present in the product (González-Miret et al., 2005). The acidic pH of all honey samples from the seven districts indicates that they have a good and stable shelf life. The difference in the means of pH from various locations was due to the difference in environmental conditions including the source of nectar and humid of the district. Buhera is very dry and its humidity is very low. The pH of the honey produced in that district has low moisture content and high pH.

Honey samples from the Langstroth beehive were found to be containing honey with high pH. This shows that modern beehives produce high quality honey and high volumes of honey. Therefore beekeepers should be encouraged to take up modern technologies in beekeeping in order to get more honey and good qualities. In addition, the variation in the levels of pH in honey reflects the time required for nectar to be completely converted into honey under different conditions of the environment, colony strength and sugar concentration of the nectar (Chirife et al., 2006). From the result, the honey from different location shows that the honey from all the districts of Manicaland province is in good condition and there was no fermentation of the honey samples.

Table 6
TOTAL ASH %

Variable	**Sample size**	**Ash%**	
		Range	**Mean (± SD)**
Chipinge	10	0.16 – 0.32	0.21 (± 0.3)
Chimanimani	10	0.18 – 0.34	0.19 (± 0.7)
Buhera	10	0.22-0.46	0.23 (± 0.5)
Makoni	10	0.18 – 0.31	0.22 (± 0.6)
Nyanga	10	0.21 – 0.46	0.23 (± 0.7)
Mutasa	10	0.14 – 0.36	0.19 (± 0.4)
Mutare	10	0.15 – 0.37	0.21 (± 0.2)
Mean		**0.14 – 0.46**	**0.21 (± 0.3)**
Hive type Traditional hive	5	0.13 – 0.36	0.19 (± 1.0)
Kenya Top Bar Hive	5	0.21 – 0.36	0.19 (± 0.5)
Langstroth Frame Hive	5	0.21 – 0.46	0.23 (± 0.4)

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Mean		**0.13 – 0.46**	**0.20 (± 0.3)**

The ash% content of the samples from the current study ranged from 0.14 – 0.46% with a mean of 0.28%. Ash% content of honey of different countries ranges from 0.02 – 1.03%. The accepted mineral content should be less than 0.6%. In this result the ash% content of honey samples (100%) falls within the honey accepted standard quality.

The nitrogen compounds, minerals, vitamins, pigments and aromatic substance of honey contribute to ash content of honey (Aazza et al., 2013). Codex Alimentarius Commission Standards for honey, proposed ash content not more than 0.6% for good honey (Ohe et al., 2003). The ash content from different districts of Manicaland province of Zimbabwe showed that samples obtained from Buhera and Nyanga districts have the highest value of 0.46% while Mutasa district had the lowest values of 0.14%. The difference in the ash% content between honeys from different districts could be attributed to the bee forage origin and the materials collected by the bees during foraging. The difference was also due to many factors such as difference in soil and atmospheric conditions as well as in the type and physiology of each plant. However, in all the samples from various districts, the ash content was within the acceptable range and this shows that honey from Manicaland province is very good for human consumption.

Electrical Conductivity

Levels of electrical conductivity in the tested honey samples in Manicaland province of Zimbabwe were between 0.05 and 0.6 $\mu S\ cm^{-1}$. Out of a total of 85 tested honey samples, all of the honey samples were within the recommended levels not exceeding 0.8 $\mu S\ cm^{-1}$. The results indicated lowest conductivity in honey samples from Buhera district which is 0.05 $\mu S\ cm^{-1}$, while the highest conductivity is found in honey samples from Chipinge district which is 0.6 $\mu S\ cm^{-1}$. Similar values for electrical conductivity of honey are reported by other authors for the honey samples tested from other provinces of Zimbabwe (Chirinda et al., 2017; Kamanga & Hobvu, 2019). Beehive technology plays very little in honey electrical conductivity improvement. All the types of beehives were found to be producing honey which is within the required levels of electrical conductivity.

Table 7
ELECTRICAL CONDUCTIVITY

Variable	**Sample size**	**Electrical Conductivity ($\mu S\ cm^{-1}$)**	
		Range	**Mean (± SD)**
Chipinge	10	0.08-0.6	0.5 (± 0.2)
Chimanimani	10	0.07-0.4	0.3 (± 0.5)
Buhera	10	0.05-0.3	0.2 (± 0.4)
Makoni	10	0.06-0.5	0.4 (± 0.3)
Nyanga	10	0.08-0.5	0.4 (± 0.2)
Mutasa	10	0.07-0.5	0.4 (± 0.3)
Mutare	10	0.06-0.4	0.2(± 0.2)
Mean		**0.05-0.6**	**0.3 (± 0.3)**
Hive type			

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Traditional hive	5	0.08-0.4	0.3 (± 0.2)
Kenya Top Bar Hive	5	0.07-0.5	0.4 (± 0.2)
Langstroth Frame Hive	5	0.07-0.3	0.2 (± 0.2)
Mean		0.07-0.5	**0.3 (± 0.2)**

Electrical conductivity, is related to the concentration of mineral and organic acids (Sousa et al., 2016). However, farmers in beekeeping are encouraged to take up new technology in beekeeping, such as beehive making to reduce the destruction of trees, which promotes climate change. The National Development Strategy 1 of Zimbabwe has a pillar which promotes industrialization without affecting the environment which will further induce climate change. Therefore, traditional beehives should be avoided since they involve the destruction of the environment.

Honey from Langstroth was found to have a range (0.07-0.3μS $cm^{-1)}$ which is totally within the recommended level of electrical conductivity and higher yield. Traditional beehives have a wider range (0.07-.05 μS $cm\text{-}^{1}$) and have lower yield of honey. The production of these traditional hives involves the destruction of trees. To serve the destruction of trees which in turn promote climate change, modern beehives should be promoted which also slowdown climate change.

RECOMMENDATIONS

Manicaland province of Zimbabwe was found to have a good quality of honey. For the beekeepers in Manicaland province to benefit from honey marketing, beekeepers should:

- Receive technical training on bee breeding, bee disease prevention, honey harvesting, storage and packaging of honey.
- Beekeepers should be trained on combating beehive pests such as varroa, which is an endemic bee parasite which can lead to the destruction of several bee colonies and reduce the quantity of honey produced by few bees.
- Applied research on beekeeping needs to be improved and the research results be passed on to the beekeepers to improve beekeeping management.
- The beekeepers should be trained on honey value addition for them to realize higher price from their honey.
- Beekeepers should be trained to offer pollination services and how to market their bee services to their clients, such as bee removal.

CONCLUSION

Honey produced in Manicaland of Zimbabwe is found to be suitable for exporting, which is an advantage to the country in terms of growing the economy on an average GDP growth rates of above 5%; of the country before 2030 as per Zimbabwe NDS1. This will help the country to meet its National Development Strategy 1, if the government avail loans to the rural youths and women to start beekeeping and export the honey. The exportation of honey from Zimbabwe will help to improve the inflow of foreign currency in to the country and help to stabilize the economy. The government of Zimbabwe should support honey production by providing well trained extension officers to help to promote beekeeping in international acceptable production and processing methods, so that the honey will be exported. Once honey production and

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

exporting policies are favorable to the farmers, more beekeepers are going to join and more youths and women are going to be employed, the government employment rate target of 80% may be reached before 2030. Banks should support beekeeping in terms of loans so that the beekeepers can access them at a low rate.

Economic transformation sustained by high productivity levels, have a capacity to lower inflation of a country. If beekeeping in Zimbabwe is taken seriously, more honey will be exported due to its quality. Most of the honey produced in Manicaland province of Zimbabwe was found to meet international standards. If produced in large quantities and exported, reduction in the Poverty Rate, to under 25 percent of the population from 62.5 percent can be achieved in rural areas. Employment rate of more than 80% can be achieved in rural areas if more women and youths are roped in honey production and well paid due to the honey quality produced in the country. The current status quo of the beekeepers will be transformed. Once beekeeping is well marketed to rural beekeepers, food self-sufficiency from the current level of 45% to a higher level will be achieved. Specialized extension officers should be trained to help rural beekeepers to produce and process honey and honey by-products in an international accepted methods.

REFERENCES

Aazza, S., Lyoussi, B., Antunes, D., & Miguel, M. (2013). Physicochemical characterization and antioxidant activity of commercial portuguese honeys. *Journal of Food Science*, 1159-1166.

Alexandre, A., Machado De- Melo, M., & Bobin, R. (2018). Composition and properties of Apis mellifera hone. *Journal of Apicultural* , 38-49.

Alves, A., Ramos, A., Gonçalves, M.M., Bernardo, M., & Mendes, B. (2021). Antioxidant activity, quality parameters and mineral content of portuguese monofloral honeys. *Journal of Food Composition and Analysis*, 132-149.

Ananias, K., Melo, A., & Moura, C. (2020). Analysis of moisture content, acidity and contamination by yeast and molds in Apis mellifera L. honey from central Brazil. *Brazilian Journal of Microbiology*, 673-689.

Assia, A., & Ali, L. (2015). Enzymes activities,hydroxymethylfurfural content and pollen spectrum of some Algerian honey. *African Journal of Agricultural Research*, 612-635.

Augusto, J., Alexandre, A., & MachadoDe-Melo. (2016). Essential minerals and inorganic contaminants (barium, cadmium, lithium, lead and vanadium) in dried bee pollen produced in Rio Grande do Sul State, Brazil. *Food Science and Technology, 36*, 11-35.

Belay, A., Solomon, W.B., Adgaba, N., & & Melaku, S. (2013). Physicochemical properties of the harenna forest honey, bale, Ethiopia. *Food Chemistry*, 3386-3392.

Bogdanov, S. (2017). Honey quality, methods of analysis and international regulatory. *Food Science*, 28-32.

Bogdanov, S., & Martin, P.(1997). Harmonised method of the European honey commission. *Apidologie, 28*(2), 1-59.

Chirife, J., Zamora, M., & Motto, A. (2006). The correlation between water activity and % moisture in honey: fundamental aspects and application to argentine honeys. *Journal of Food Engineering*, 287–292.

Chirinda, N., Gwiza, l., & Mungana, M. (2017). Rheology and botanical origin of zimbabwean monofloral honey. *Food Science*, 4549.

De-Melo, A., & Almeida-Muradian., D. (2019). Health benefits and uses in Medicine of Bee Pollen. *Journal of Food Biochemistr*, 23-39.

De-Melo, A., Estevinho, L., Moreira, M., & Delerue-Matos, C. (2018). A multivariate approach based on physicochemical parameters and biological potential for the botanical and geographical discrimination of Brazilian bee pollen. *Food Bioscience*, 27-35.

Dossa, L., Victorien, F., Dougnon, T., Christine, N., & Wassiyath, M. (2018). Physicochemical Characteristics and Microbiological Quality of Honey Produced in Benin. *Journal of Food Composition and Analysis*, 21-32.

Duarte, A.W., Vasconcelos, M.R., Menezes, A.P., Silva, S.C., Oda-Souza, M., & López, A.M. (2018). Composition and Antioxidant Activity of Honey from Africanized and Stingless Bees in Alagoas (Brazil). *Journal of Apicultural Research*, 75-82.

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.

Dzugan, M., Tomczyk, M., Sowa, P., & Grabek-Lejko, D. (2018). Antioxidant activity as biomarker of honey variety. *Molecules*, 19-24.

González-Miret, M., Terrab, A., Hernanz, D., Fernández-Recamales, M., & Heredia, F. (2005). Multivariate Correlation between Color and Mineral Composition of Honeys and by Their Botanical Origin. *Journal of Agricultural and Food Chemistry*, 2574-2583.

Kamanga, T., & Hobvu, R. (2019). Physicochemical Characterization of honey in Southern Africa. *Bee World*, 11-15.

Khalafi, R., Goli, S.A., & Behjatian, M. (2016). Characterization and classification of several monofloral iranian honeys based on physicochemical properties and antioxidant activity. *International Journal of Food Properties*, 1065-1075.

Lavelli, V., Kerr, W., & Sri Harsha, P. (2013). Phytochemical stability in dried tomato pulp and peel as affected by moisture properties. *Journal of Agricultural and Food Chemistry*, 700-707.

Majewska, E., Druzynska, B., & Wołosiak, R. (2019). Determination of the botanical origin of honeybee honeys based on the analysis of their selected physicochemical parameters coupled with chemometric assays. *Food Science and Biotechnology*, 49-58.

Manuela, M., Moreira, H., Cristina Delerue-Matos, R., & Alex da Silva de Freitas, O.M.M. (2021). Phenolic profile by HPLC-MS, biological potential, and nutritional value of a promising food: Monofloral bee pollen. *Journal of Food Biochemistry*, 75-82.

Marini, F., Magrì, A., Balestrieri, F., Fabretti, F., & Marini, D. (2022). Supervised pattern recognition applied to the discrimination of the floral origin of six types of Italian Honey Samples. *Taylor & Francis*, 117-129.

Moore, J.C., Spink, J., & Lipp, M. (2020). Development and application of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010. *Journal of Food Science*, 118-123.

Noor, N., Sarfraz, R. A., Ali, S., & Shahid, M. (2019). Antitumour and Antioxidant Potential of Some Selected Pakistani Honeys. *Food Chemistry*, 17-22.

Oddo, L.P., Heard, T.A., Rodríguez-Malaver, A., Pérez, R.A., Fernández-Muiño, M., & Sancho, M. (2008). Composition and antioxidant activity of trigona carbonaria honey from Australia. *Journal of Medicinal Food*, 789-794.

Ohe, W., Oddo, L., Piana, M., Morlot, M., & Martin, P. (2003). Harmonized methods of melissopalynology. Apidologie. *Agriculture Science*, 235-246.

Silvano, M.F., Varela, M.S., Palacio, M.A., Ruffinengo, S., & Yamul, D.K. (2014). Physicochemical parameters and sensory properties of honeys from buenos aires region. *Food Chemistry*, 500-507.

Siok, P.K., Nyuk Ling, C., Yusof, A.Y., Sheau Wei, T., & Chua, L.S. (2018). Classification of entomological origin of honey based on its physicochemical and antioxidant properties. *Taylor & Francis*, 16-29.

Sousa, J.M., De Souza, E.L., Marques, G., Meireles, B., De Magalhães Cordeiro, Â.T., Gullón, B., & Magnani, M. (2016). Polyphenolic profile and antioxidant and antibacterial activities of monofloral honeys produced by meliponini in the Brazilian Semiarid Region. *Food Research International*, 60-71.

Suntiparapop, K., Prapaipong, P., & Chantawannakul, P. (2021). Chemical and biological properties of honey from Thai Stingless Bee (Tetragonula Leaviceps). *Journal of Apicultural Research*, 43-58.

Truzzi, C., Illuminati, S., Annibaldia, A., Finale, C., Rossetti, M., & Scarponi, G. (2022). Physicochemical Properties of Honey from Marche, Central Italy: Classification of Unifloral and Multifloral Honeys by Multivariate Analysis. *Beeworld*, 138-147.

Received: 05-Jan-2023, Manuscript No. AEJ-23-13047; **Editor assigned:** 09-Jan-2023, PreQC No. AEJ-23-13047(PQ); **Reviewed:** 19-Jan-2023, QC No. AEJ-23-13047; **Revised:** 22-Jan-2023, Manuscript No. AEJ-23-13047(R); **Published:** 25-Jan-2023

Citation Information: Mwandifura, J., Chikazhe, L., Manyeruke, J., & Mashavakure, N. (2023). Zimbabwe honey physco-chemical properties: A case study of honey produced in manicaland province, Zimbabwe. *Academy of Entrepreneurship Journal, 29*(2), 1-13.