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PHYSICO-CHEMICAL QUALITIES OF HONEY HARVESTED FROM DIFFERENT BEEHIVE TYPES IN ZAMBIA

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ABSTRACT

Beekeeping is one of the income generating activities in many parts of the rural areas of Zambia and is being promoted by both the government and nongovernmental organizations. The main benefit of beekeeping is the production of honey and beeswax which are valuable sources of income for the small-holder farmers. Honey is a sweet liquid gathered by honey bees from nectar or other secretions of plants which they transform by addition of enzymes and evaporation of water. Beekeeping also plays an important role in protecting the natural environment and gives the communities other economic benefits from the forests as they have a vested interest in protecting trees that are a source for their honey. In the recent past, Zambian farmers involved in this beekeeping have adopted modern bee keeping approaches that involve the use of modern beehives such as the log, mud, standard wood and adjusted wood as opposed to the traditional bark type. In order to ascertain the effect of the beehive type on the quality, honey harvested from these beehives in Kapiri Mposhi area of Zambia was investigated for selected quality characteristics. The investigated parameters included ash, moisture, pH, total soluble solids and soluble sugars. Ash content of the honey is important because it represents its mineral content and forms part of proximate analysis for nutritional evaluation. The ash content ranged from 0.198 and 0.271%, pH 4.26 and 4.44, moisture 14.9 and 16.4%, total soluble solids 83.6 and 85.7% and soluble sugar 81.6 and 83.4%. The findings from the study demonstrated that the beehive type did not have a significant ($P > 0.05$) effect on all the selected quality characteristics investigated. Furthermore, comparisons of the findings on honey quality characteristics to the guidelines stipulated by the Codex Alimentarius and European Union (EU) standards showed conformity to these standards.

Key words: Beekeeping, Beehive, Honey, Quality characteristics

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INTRODUCTION

Beekeeping has been practised since ancient times and honey has been considered by many cultures as a valuable and precious commodity that is used in traditional rituals, healing or as food [1]. It is rich in micronutrients and is also a good source of energy. Traditionally, it has been used for centuries as a medicine for treating various ailments. For example: honey can be used for sore throats, wounds and burns [2], pollen can be used to delay the effect of aging [3] and, combined with honey, is a beneficial food for sick people [1].

In Zambia, beekeeping is becoming increasingly important and is supported by both the government and a number of nongovernmental organisations. Beekeeping is practised in all the nine regions of the country, although Kapiri Mposhi, Mwinilunga, Kabompo and Solwezi are the major production districts. In 2003, the total estimated production was 1500 metric tons, of which 200 metric tons was traded. By September 2004, organic honey export hit the 350 metric tons mark, making Zambia one of the largest organic honey exporters in Africa [4]. Apart from exporting, other markets are in beer brewing, local retail and processing companies.

Beekeepers in Zambia use both traditional and modern beehives to produce honey. Support organizations promote the use of modern beehives, arguing that new technologies will yield better quality honey. However, there has been no systematic research done to determine whether beehive type influences physico-chemical properties of honey such as moisture content, ash, pH, total soluble solids and soluble sugars. Studies of the physico-chemical properties of honey are important for the certification process that determines honey quality [5]. In this study, different beehive types were investigated for honey quality and these included the log, bark, mud, standard wood and adjusted wood beehives. Investigated parameters included ash, moisture, pH, total soluble solids and soluble sugars.

MATERIALS AND METHODS

Collection of honey samples

Honey was harvested from the log, mud, bark, adjusted wood and standard wood beehive types in Kapiri Mposhi area of Zambia in June, 2009. Five samples from a beehive (three of each beehive type) were collected and stored in clean glass bottles and sealed. The tightly sealed bottles containing the samples were delivered to the Food Chemistry and Nutrition Laboratory at the University of Zambia for analysis. Prior to analysis, bottles containing crystalized honey were placed in a water bath that was set at 53°C. This was done to liquefy the honey for easy handling and analysis.

Determination of Ash content

Determination of ash content was done according to the AOAC official method 942.05 [6]. Two grams of each sample was put in a previously weighed porcelain crucible and dried in an oven at 110^{o}C for four hours. This was done to remove moisture that would cause foaming of the honey during the early stages of ashing.

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After removing the crucibles from the oven, they were cooled in a desiccator for about four hours and weighed with the evaporated sample. The materials were then ashed in an electrical furnace at 600^{o}C for six hours, followed by cooling in a desiccator and then weighed

The ash content on dry basis was calculated according to the following equation:

$$\text{Percentage ash content on dry basis} = \frac{(C-A)}{(B-A)} \times 100$$

Where:
A= weight of the crucible
B= weight of crucible and sample after evaporation
C= weight of crucible and sample after ashing

Determination of pH

The pH of honey was determined according to the method described by the International Honey Commission [7]. Five grams of each honey sample was diluted with 50ml distilled water to make a 10% solution. The pH was measured using a digital pH meter which was calibrated at room temperature using buffer solutions at pH 4 and 7. To ensure accurate pH measurement, the instrument was calibrated every time before use and recalibrated every two or three hours to compensate for any possible loss of sensibility.

Determination of Moisture Content, Total Soluble Solids and Soluble sugars (% Brix)

Refractometric method was used to determine the moisture, or conversely the soluble solids in honey as previously described by the International Honey Commission [7]. This was done by measuring the refractive index of honey using an Abbe refractometer thermostated at 20^{o}C, and regularly calibrated with distilled water. This method is based on the principle that refractive index increases with solid content. The homogenized sample was put in a flask and placed in a water bath at 50°C (±0.2) until all the sugar crystals were dissolved. The resulting solution was cooled to room temperature, stirred and immediately covered evenly on the surface of the refractometer prism. After two minutes, the refractive index was recorded by the refractometer. Each sample was measured three times and the average value taken. After each reading the refractometer prism was cleaned using distilled water. Moisture content and soluble solids were obtained from the refractive index of the honey by making reference to a standard table (Annex 1). Soluble sugars (% Brix) were similarly obtained from the refractive index of the honey by making reference to the standard table (Annex 2).

Statistical Analysis

Statistical analyses were performed using S-PLUS 6.1 Windows Professional. To study the effect of the beehive type on the selected quality characteristics, one-way analysis of variance (ANOVA) model was used. The levels of significance were evaluated with *P* values. Effects with $P < 0.05$ were considered significant.

RESULTS

In this study ash, moisture, total soluble solids, soluble sugar contents and pH of the honey harvested from adjusted wood, bark, log, mud and standard wood beehive types were examined. The results are reported in Figures 1, 2, 3, 4 and 5, respectively.

Ash Content

The results of the ash contents of the honey from the adjusted wood, bark, log, mud and the standard wood beehive types are presented in Figure 1. Ash content varied from 0.271 to 0.198%, the highest being honey harvested from standard wood and the lowest being from the log beehive type. The percentage ash contents for the honey from the bark and the mud beehive types were almost the same (0.214 and 0.213%). Honey from the log beehive type recorded a significantly ($P < 0.05$) lower ash content than honey from the other beehive types.

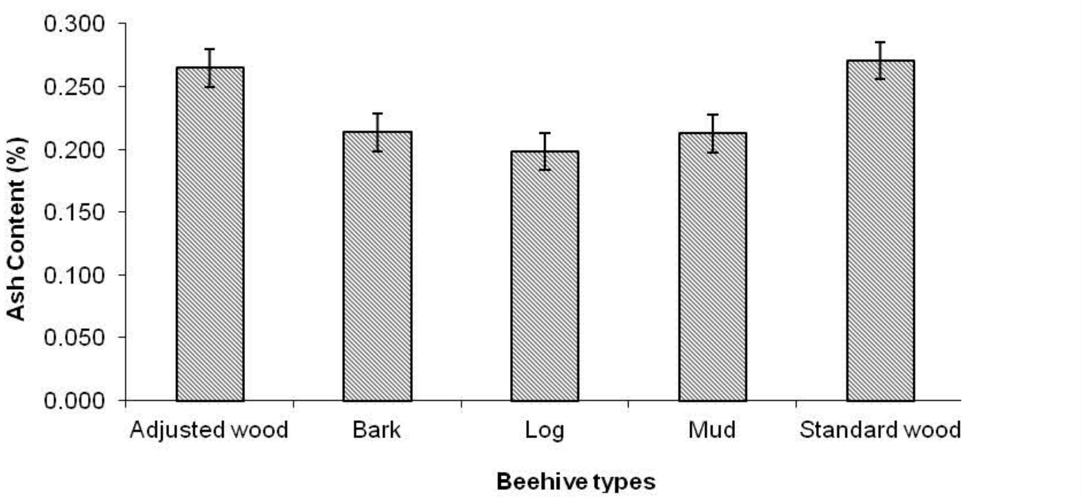

Figure 1: Ash content of the honey harvested from different beehive types

pH of Honey

The results of the pH of the honey from the adjusted wood, bark, log, mud and the standard wood beehive types are illustrated in Figure 2. The honey that had the highest pH was that from the bark beehive type (4.44), while that from log beehive showed the lowest (4.26). Honey from the mud and the standard wood recorded the same value of 4.30 while that from the adjusted wood had the pH of 4.40. The results of the pH of honey revealed that the beehive type did not have a significant ($P > 0.05$) effect on this quality characteristic.

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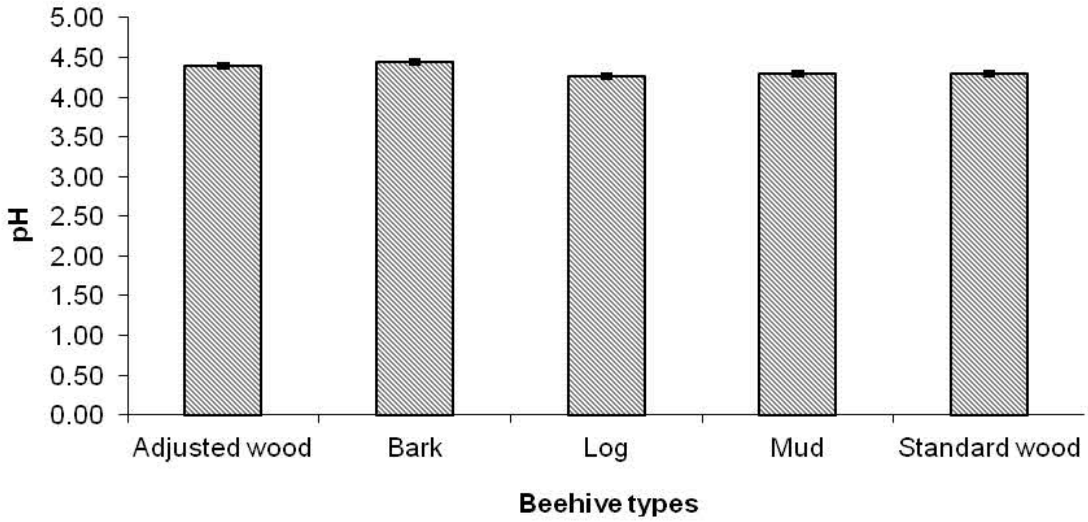

Figure 2: pH of the honey harvested from different beehive types

Moisture Content

The moisture content of the honey samples from five different beehive types ranged from 14.9 to 16.4% (Figure 3). Honey from the standard wood had the highest moisture content (16.4%) and that from the bark recorded the lowest (14.9%). Honey from the adjusted wood and that from the mud beehive types had the same percentage of moisture content (15.1%), while that from the log beehive type recorded 15.7% moisture content. Although differences in moisture content of the honey samples were observed, they were not due to the beehive types as their effect on the moisture content of the honey was found to be insignificant ($P > 0.05$).

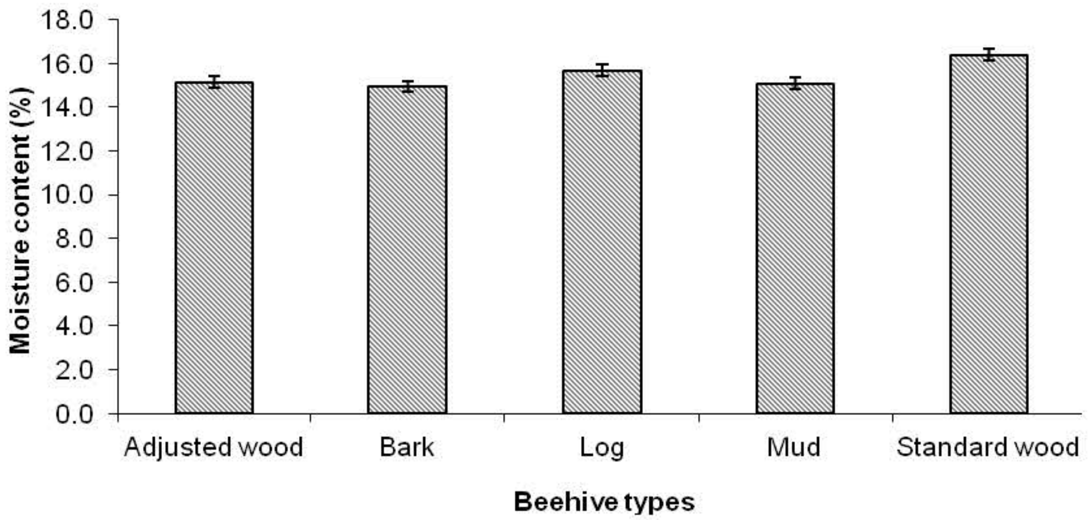

Figure 3: Moisture content of the honey harvested from different beehive types

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Total Soluble Solids

The results of the total soluble solids are presented in Figure 4. The total soluble solids of the honey ranged from 85.7 to 83.6%. Honey from the mud beehive type had the maximum, whereas that from the adjusted wood had the lowest percentage of total soluble solids. Beehive type did not have a significant ($P > 0.05$) effect on total soluble solids of all the honey samples.

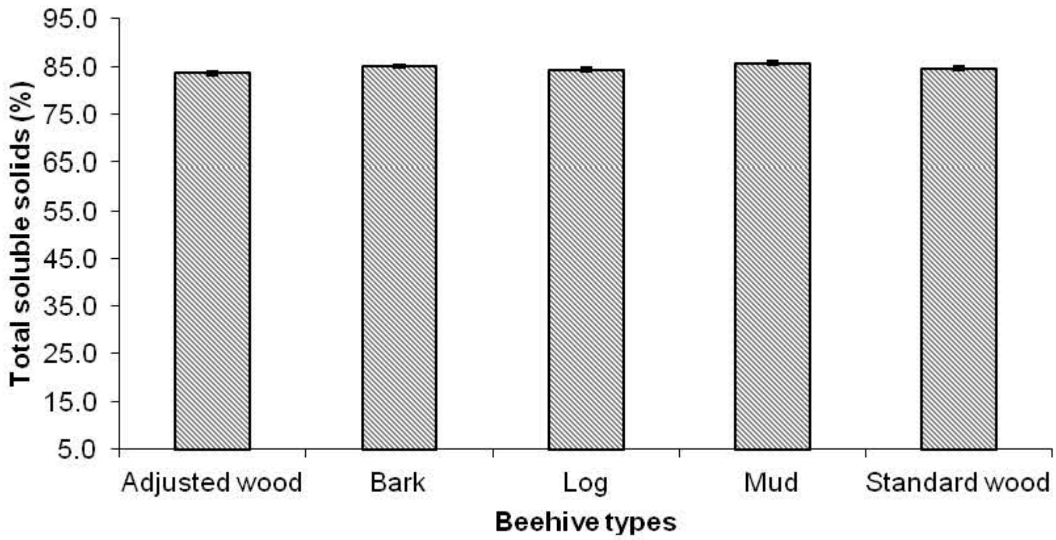

Figure 4: Total Soluble Solids content of the honey harvested from different beehive types

Soluble Sugars

The results of the soluble sugars of the honey harvested from different beehive types are illustrated in Figure 5. The soluble sugar content ranged from 81.6 to 83.4% and the beehive type had no significant ($P > 0.05$) effect on the amount of soluble sugars of the honey.

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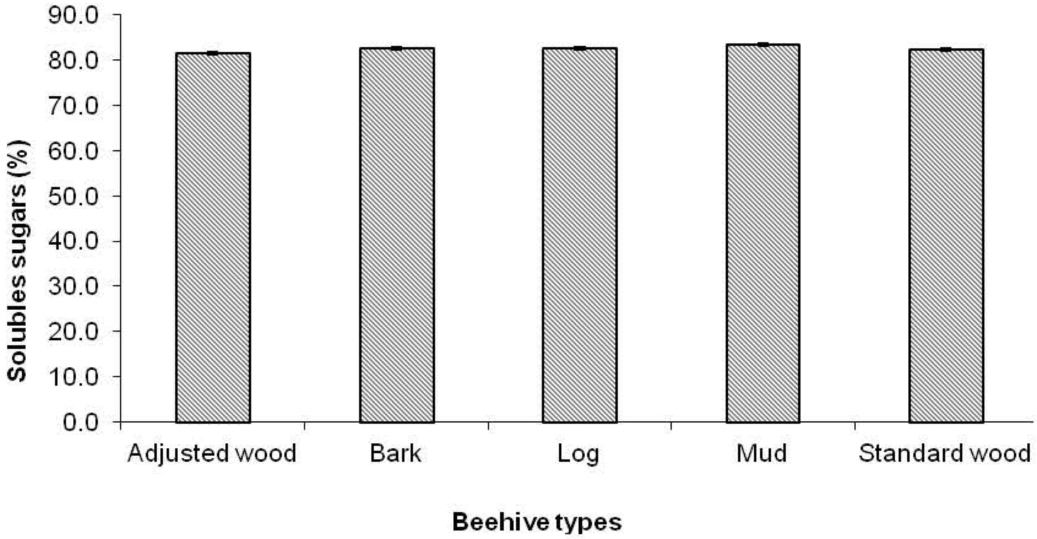

Figure 5: Soluble Sugar content of the honey harvested from different beehive types

DISCUSSION

Ash content is an important quality characteristic of food because it represents the mineral content in the food and is part of proximate analysis for nutritional evaluation. The percentage ash contents for the honey from all the beehive types were within the guidelines stipulated by the Codex Alimentarius Commission [8] of less or equal to 0.6% and are in agreement with the findings of Salim [5], who reported the ash content of between 0.075 and 0.330% for honey harvested from central Algeria. Honey normally has low ash content and may be different from one sample to another because it depends on the material collected by the bees during foraging.

The pH values of the honey samples from different beehives investigated revealed that all the samples were within the acidic range of pH. The pH values were within the acceptable range of between 3.6 and 5.6 [9, 10], and were more or less similar to the Algerian honey (3.58 – 4.72) [5]. The importance acidic pH range in foods cannot be overemphasized. It prevents the honey samples from constant contamination by various species of micro-organisms and thus helps to ensure longer shelf life. Low pH in the acidic range may be an indication of good shelf life [11].

The moisture content of the honey samples ranged from 14.9 to 16.4% and the results are comparable to the findings by Bogdanov [12] whose moisture content ranged from 14 to 18%. Furthermore, the moisture content of all the samples was below 21% as specified by the Codex Alimentarius Commission and the European Union standards [8]. The low moisture content observed may have been due to the increase in sugar content of the samples as the harvest season was dry with low humidity. An increase in the moisture content of honey is an indicator of adulteration and, therefore, the values obtained from this study showed that the honey was of good quality with regard to the moisture content.

Total solid is a measure of dissolved solids in the honey samples. For all the honey samples, total soluble solids were generally more than 80% and can be considered of high grade and highly stable upon storage. On the other hand, honey with less than 80% soluble solids is likely to ferment during storage. According of the grading system of the United States Department of Agriculture (USDA), honey with total soluble solids greater or equal to 81.4% is considered of higher grade (A and B), while that falling between 80% and 81.3% is considered to be of lower grade C. Thus, the honey investigated in this study can be considered stable with regard to fermentation upon storage and thus of high grade.

Most of the total soluble solids for honey are sugars. These account for about 80% or more of solids by weight. All the honey samples had soluble sugars greater than 80%. The findings in this study on soluble sugars are in agreement with Salim [5], who reported soluble sugar levels of between 80.7 and 84.7% for honey harvested from the central region of Algeria. From the results of the total soluble solids and soluble sugars,it was verified verified that soluble sugars in the honey had a larger contribution towards the total soluble solids as stated earlier.

CONCLUSION

The study demonstrated that the beehive type used does not affect the ash, moisture, total soluble solids, soluble sugars and the pH of the honey.

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Table 1: Refractive Indices, Corresponding Percent Soluble Solids, and Percent Moisture in Extracted Honey

Refractive index @20°C	%Soluble solids	%Moisture	Refractive index @20°C	%Soluble solids	%Moisture
1.4817-1.4818	78.1	21.9	1.4930-1.4932	82.6	17.4
1.4819-1.4820	78.2	21.8	1.4933-1.4934	82.7	17.3
1.4821-1.4823	78.3	21.7	1.4935-1.4936	82.8	17.2
1.4824-1.4825	78.4	21.6	1.4937-1.4939	82.9	17.1
1.4826-1.4828	78.5	21.5	1.4940-1.4941	83.0	17.0
1.4829-1.4830	78.6	21.4	1.4942-1.4944	83.1	16.9
1.4831-1.4833	78.7	21.3	1.4945-1.4946	83.2	16.8
1.4834-1.4845	78.8	21.2	1.4947-1.4949	83.3	16.7
1.4836-1.4838	78.9	21.1	1.4950-1.4951	83.4	16.6
1.4839-1.4840	79.0	21.0	1.4952-1.4954	83.5	16.5
1.4841-1.4843	79.1	20.9	1.4955-1.4957	83.6	16.4
1.4844-1.4845	79.2	20.8	1.4958-1.4959	83.7	16.3
1.4846-1.4848	79.3	20.7	1.4960-1.4962	83.8	16.2
1.4849-1.4850	79.4	20.6	1.4963-1.4964	83.9	16.1
1.4851-1.4853	79.5	20.5	1.4965-1.4967	84.0	16.0
1.4854-1.4855	79.6	20.4	1.4968-1.4969	84.1	15.9
1.4856-1.4858	79.7	20.3	1.4970-1.4972	84.2	15.8
1.4859-1.4860	79.8	20.2	1.4973-1.4975	84.3	15.7
1.4861-1.4863	79.9	20.1	1.4976-1.4977	84.4	15.6
1.4864-1.4865	80.0	20.0	1.4978-1.4980	84.5	15.5
1.4866-1.4868	80.1	19.9	1.4981-1.4982	84.6	15.4
1.4869-1.4870	80.2	19.8	1.4983-1.4984	84.7	15.3
1.4871-1.4873	80.3	19.7	1.4985-1.4987	84.8	15.2
1.4874-1.4875	80.4	19.6	1.4988-1.4990	84.9	15.1
1.4876-1.4878	80.5	19.5	1.4991-1.4993	85.0	15.0
1.4879-1.4880	80.6	19.4	1.4994-1.4995	85.1	14.9

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1.4881-1.4883	80.7	19.3	1.4996-1.4998	85.2	14.8
1.4884-1.4885	80.8	19.2	1.4999-1.5000	85.3	14.7
1.4886-1.4888	80.9	19.1	1.5001-1.5003	85.4	14.6
1.4889-1.4890	81.0	19.0	1.5004-1.5005	85.5	14.5
1.4891-1.4893	81.1	18.9	1.5006-1.5008	85.6	14.4
1.4894-1.4896	81.2	18.8	1.5009-1.5011	85.7	14.3
1.4897-1.4898	81.3	18.7	1.5012-1.5013	85.8	14.2
1.4899-1.4901	81.4	18.6	1.5014-1.5016	85.9	14.1
1.4902-1.4903	81.5	18.5	1.5017-1.5018	86.0	14.0
1.4904-1.4906	81.6	18.4	1.5019-1.5021	86.1	13.9
1.4907-1.4908	81.7	18.3	1.5022-1.5024	86.2	13.8
1.4909-1.4911	81.8	18.2	1.5025-1.5026	86.3	13.7
1.4912-1.4913	81.9	18.1	1.5027-1.5029	86.4	13.6
1.4914-1.4916	82.0	18.0	1.5030-1.5031	86.5	13.5
1.4917-1.4918	82.1	17.9	1.5032-1.5034	86.6	13.4
1.4919-1.4921	82.2	17.8	1.5035-1.5037	86.7	13.3
1.4922-1.4923	82.3	17.7	1.5038-1.5039	86.8	13.2
1.4924-1.4926	82.4	17.6	1.5040-1.5042	86.9	13.1
1.4927-1.4929	82.5	17.5	1.5043-1.5044	87.0	13.0

Source: [13]

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Table 2: Refractive indices @ 20 °C and corresponding Brix (% soluble sugars)

Refractive index	%Brix	Refractive index	%Brix	Refractive index	%Brix	Refractive index	%Brix
1.33299	0	1.37058	24	1.41587	48	1.47031	72
1.33442	1	1.37230	25	1.41795	49	1.47279	73
1.33587	2	1.37404	26	1.42004	50	1.47529	74
1.33732	3	1.37579	27	1.42215	51	1.47781	75
1.33879	4	1.37755	28	1.42428	52	1.48055	76
1.34027	5	1.37933	29	1.42642	53	1.48291	77
1.34175	6	1.38112	30	1.42858	54	1.48548	78
1.34325	7	1.38292	31	1.43075	55	1.48808	79
1.34477	8	1.38474	32	1.43294	56	1.49069	80
1.34629	9	1.38658	33	1.43515	57	1.49333	81
1.34782	10	1.38842	34	1.43738	58	1.49598	82
1.34937	11	1.39029	35	1.43962	59	1.49866	83
1.35093	12	1.39216	36	1.44187	60	1.50135	84
1.35249	13	1.39406	37	1.44415	61	1.50407	85
1.35407	14	1.39596	38	1.44644	62	1.50681	86
1.35567	15	1.39789	39	1.44875	63	1.50955	87
1.35727	16	1.39982	40	1.45107	64	1.51233	88
1.35889	17	1.40177	41	1.45342	65	1.51514	89
1.36052	18	1.40374	42	1.45578	66	1.51797	90
1.36217	19	1.40573	43	1.45815	67	1.52080	91
1.36382	20	1.40772	44	1.46055	68	1.52368	92
1.36549	21	1.40974	45	1.46266	69	1.52658	93
1.36718	22	1.41177	46	1.46539	70	1.52950	94
1.36887	23	1.41381	47	1.46784	71	1.53246	95

Source: [13]

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