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Original Article

ASSESSMENT OF CONSUMERS' KNOWLEDGE OF THE COMPOSITION, PROPERTIES AND ADULTERATION OF HONEY

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ABSTRACT

Background/Objectives: Honey is one of the most valuable natural products known to man. The promotion of honey consumption should be based, first of all, on consumer education concerning not only its taste and medicinal values, but also its quality and possible contamination. The aim of this study was to assess the level of consumer knowledge on the composition, properties and adulteration of honey. **Methods**: The research was conducted using an online survey questionnaire. The 203 respondents surveyed included 117 women and 86 men. **Results**: The main factors motivating respondents to purchase honey were flavour values, and health-promoting properties. Among the respondents – 48% did not know what the composition of typical honey was, while 44% knew it correctly. The majority of respondents (56.5%) did not know the origin of Manuka honey. 46% of respondents were unaware that honey and honey-containing products should not be consumed by children under 1 year of age. The information that 5-hydroxymethylfurfural (5-HMF) analysis is used to detect honey adulteration was known to 18% of respondents. **Conclusions**: Almost all the people interviewed declared that they consumed honey. However, knowledge of honey composition, properties and adulteration was insufficient. It is necessary to conduct educational initiatives in this field and this article can help set the direction.

KEYWORDS: properties of honey; composition; consumer knowledge

1. Introduction

Honey is a natural foodstuff produced by honey bees (*Apis mellifera*) from the nectar of plants and honeydew. Due to its rich properties (taste, nutritional and therapeutic), it is used in the food, cosmetic and pharmaceutical industries [1,2]. Currently, approximately 300 types of honey are known [3]. Honey is a mixture of at least 181 different substances [4]. Currently, 61% of the honey used in the European Union comes from outside the Union (mainly Ukraine and China) [5]. Adulteration of honey is very common, involving, for example, the addition of sugar or syrup, artificial feeding of bees, overheating of honey, storage under inappropriate conditions, improper dating, labelling and heating for re-crystallisation. Consumers themselves often seek liquid honey even in winter, which increases the risk of abuse. Promotion of honey consumption should be based primarily on consumer education about the properties and quality of honey so that they can make informed choices. Surveys allow better planning of promotional campaigns aimed at consumers, which may translate into higher consumption and conscious choice of this valuable product.

2. Materials and Methods

The method used in the study was an anonymous survey conducted in an online format (ethical approval code: AKBE/29/2022). The survey questionnaire consisted of some initial questions on the characteristics of the respondents, followed by 8 questions on consumer preferences and 19 questions on knowledge of honey composition, properties and adulteration. The questions were both single-choice and multiple-choice. The survey was made available in the form of a link sent out to those surveyed. A total of 203 people participated in the survey, representing 5 age ranges.

3. Results and Discussion

3.1. Characteristics of the respondents in terms of age, gender, education and place of residence

Based on the data collected, it can be concluded that: 58% of the respondents were female; 49% of the people were under 30 years old; 20% of the people: 31 - 45 years old; 18% of people - 46-55 years old; 13% of people >56 years old. 67% were university educated; 22% were students; 10% had secondary education; 1% had vocational education. 93% of respondents lived in an urban area and 7% in a rural area. 84% of the respondents had completed a master's degree in a field other than medicine. 60% of the students participating in the survey were in their fifth year of study and 51% of them were educated in medical subjects.

3.2. Characteristics of consumer preferences

The first part of the questionnaire included questions on the frequency of honey consumption and consumer preferences regarding the type of honey consumed, choice of other bee products, reason and place of purchase, preferred form, uses and important organoleptic characteristics of honey.

Analysis of the results obtained showed that the majority of respondents, as many as 96%, declared consuming honey. The largest number of respondents consumed honey several times a week (28%), or daily (12%), and once a week - 10%. Only 4% of the respondents did not eat it or consumed it occasionally, i.e. several times a month (19%), and 27% consumed it several times a year. Referring to the origin of the honey, it was shown that consumers most often chose multiflower honey (56.2%) and lime honey (53.7%). Buckwheat honey (31.5%) and honeydew honey (27.1%), rapeseed and acacia honey (22% each) were also frequently chosen. Other types of honey such as phacelia, dandelion, Manuka, coriander, chestnut and meadow honey made up 0.5 - 1% of the respondents' choices. For 17.2% of the respondents, the type of honey did not matter.

Most of the respondents – as many as 70% – did not buy other bee products. The most frequently selected product besides honey was propolis – 16.7%, followed by pollen – 10.8%. On the other hand, bee products such as bee bread (perga), beeswax, royal jelly and mead were characterised by low interest, 4.9%; 4.4%; 1%; 1%respectively.

The main factors motivating respondents to purchase honey were flavour values (60.1%), and health-promoting properties (53.7%), while the fewest respondents, 35.5%, considered honey as a substitute for sugar. Consumers preferring the liquid form of honey accounted for 74% of respondents. Only 26% of respondents preferred honey in crystallised form. This may indicate a lack of knowledge of the physical and chemical characteristics of honey, which change during honey storage.

When analysing the use of honey, it was shown that honey was mainly used as a food additive (68%) and a beverage additive (67.5%). Consumers were least likely to consume honey on its own as a snack - 14.8%. The most preferred way for respondents to purchase honey was from the apiary owner/producer (72.9%). The local market came next with 32%, followed by the supermarket with 27.1%, while health food shops accounted for 14.8% of respondents' choices. The most important factors for respondents, when purchasing honey, were its taste (58.1%) and type (54.7%). Consistency (48.3%), properties (40.4%) and price (37.4%) also played a major role.

Studies on the consumption and knowledge of honey composition were reported in the work of other authors. Żak et al. [6] conducted a survey among Polish and American consumers. It was shown that Poles consume more honey per month than Americans. The majority of those surveyed consumed honey once a week (41%). It was shown that among Poles, 20% consume honey daily and 47% consume honey once a week. In contrast, among Americans, 16% of respondents consume honey daily and 34% once a week. Interestingly, 27% of Poles eat more than 500 g of honey in a month. Americans spend more money on honey than Poles. The cited survey shows that the most common place to buy honey was a bazaar (Poles), a market and the Internet (Americans) and only 10% of consumers bought honey directly from beekeepers (opposite to our survey). Consumers regardless of nationality preferred liquid honey (68% of those surveyed). Americans are far more likely to go for light honeys than dark ones. In the case of Poles, the choice was spread almost 50/50. Multi-flower, rapeseed and lime honeys are the most common types of honey chosen by consumers. However, Poles are more likely to choose species-specific honeys (produced with a huge predominance of one plant). When buying honey, consumers are guided by its price, colour and consistency. For American consumers the appearance of the packaging and the brand of the honey are also important, while for Poles this is of little importance.

On the other hand, Gontarz et al. [7] conducted a survey analysing consumer preferences among a group of students. They found that over 49% of the respondents consumed honey occasionally, with only less than 6% consuming honey daily. In our study, the majority of respondents were under 30 years of age, consuming honey several times a week (28%). In a study by Gontarz et al. [7] it was found that the majority of respondents consume honey in amounts of less than 100 g per month and that, women are more likely to reach for honey and consume it in larger quantities. The most frequently chosen type of honey was, as in our study, multiflower honey (more than 31% of respondents) and lime honey (almost 27%). The most important factors when buying honey were taste and consistency. On the other hand, the least important parameters turned out to be – colour and aroma. More than 53% of consumers preferred light honeys, and less than 9% preferred dark honeys. Respondents were also more likely to choose liquid honey (about 45%) than crystallised honey (about 31%). Consumers were most likely to buy honey from the producer himself. Respondents rarely purchased other bee products, almost 69% never purchased such a product [7]. In our study – other beekeeping products were not very popular either. This is a pity, as bee pollen, propolis or bee bread, due to their valuable properties, are worth using and making proper use of for the benefit of health.

3.3. Knowledge of the composition, properties and adulteration of honey

The results from the part of the questionnaire concerning knowledge on the composition, properties and adulterations of honey are presented in graphical form

in Figs. 1-18. The answers to individual questions (included in the graphs) are presented in the text in terms of the percentage of answers.

Among the respondents – 48% did not know what the composition of typical honey was, while 44% knew the correct answer (Fig. 1). The remaining 8% of respondents gave the wrong proportions of honey ingredients.

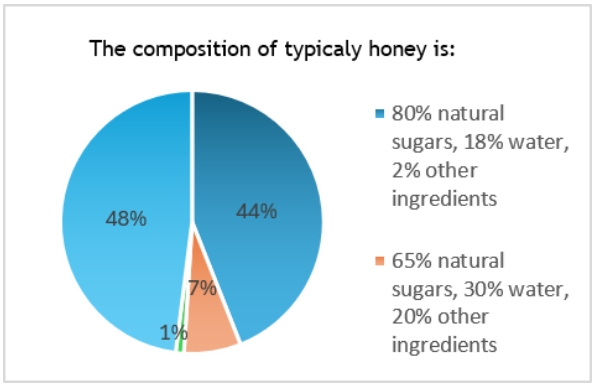

Fig. 1. Respondent's knowledge of the composition of typical honey.

55% of the respondents had knowledge of the simple sugars included in honey, while 45% did not know the answer to this question (Fig. 2). 56% of respondents did not know what the acceptable standard for water content in honey was. Only 30% answered the question correctly (Fig. 3).

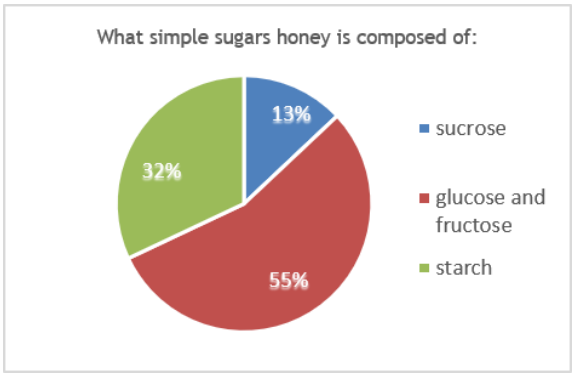

Fig. 2. Respondent's knowledge of the presence of simple sugars in honey.

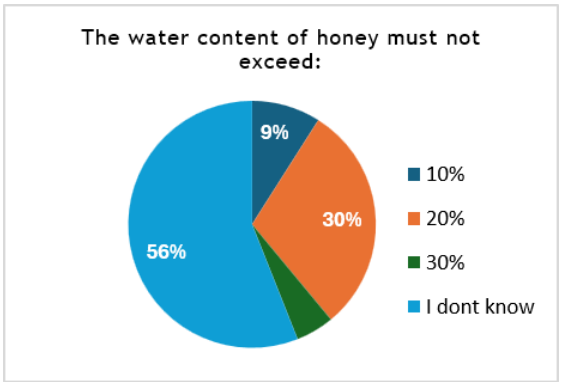

Fig. 3. Respondent's knowledge of the water content of honey.

Honey is composed of simple sugars: glucose and fructose, which make up about 80%, and water, which makes up about 17% of the chemical composition. Initially, water makes up a much larger proportion of honey's constituents, but once the bees have delivered nectar to the comb cells, during dehydration and maturation, honey loses 25-70% of its initial water content [8]. A further 3% are other components that are responsible for the biological activity of honey. These include proteins, enzymes, amino acids, organic acids, vitamins, macronutrients, trace elements, carotenoids and aromatic substances [1,4,8,9]. Honey also contains large amounts of phenolic acids and flavonoids, which also have biological effects, including antioxidant activity [1,2].

As many as 90% of the respondents knew that mead is a traditional alcoholic beverage (Fig. 4).

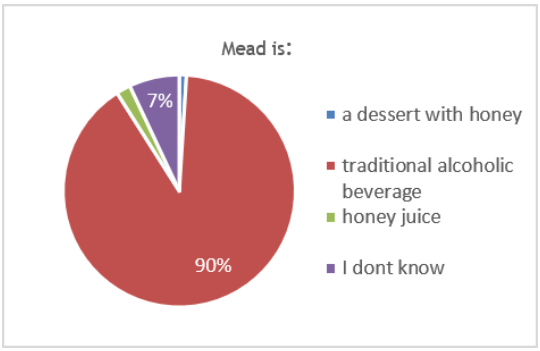

Fig. 4. Respondent's knowledge of meads.

Respondents do not know which honey stays liquid the longest (75%). Only 25% of respondents gave the correct answer, i.e. that it is acacia honey (Fig. 5). Rapeseed honey crystallises quickly and changes colour to a milky white - 34% of respondents were aware of this phenomenon (Fig. 6). In response to the question – "What does the crystallization of honey indicate?" – over 70% of Romanian adults surveyed who were over the age of 25 answered that it is a sign of good quality, and only 17% of those surveyed said they did not know [10].

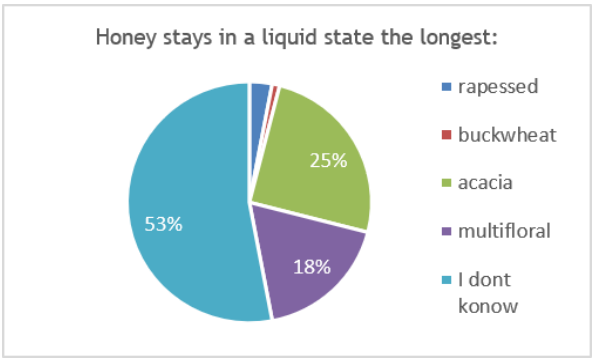

Fig. 5. Respondent's knowledge of consistency and type of honey.

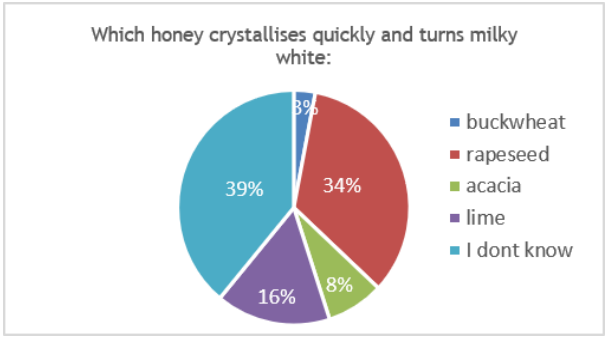

Fig. 6. Respondent's knowledge of crystallization and color of honey.

Rapeseed honey is produced from rapeseed (*Brassica napus*) during its flowering period, i.e. during April and May. It contains more glucose than fructose, which causes it to crystallise quickly and change colour from straw to white. It has a delicate aroma, originating from rapeseed flowers, and a slightly bitterish taste. Acacia honey is obtained in May and June from the nectar of *Robinia pseudoacacia* flowers. Unlike rapeseed honey, it contains amuch higher proportion of fructose, which prolongs its period in liquid form, during which it is colourless. As it crystallises, it turns a creamy yellow colour. This honey has a very sweet taste [7].

The majority of respondents (56.5%) did not know the origin of Manuka honey, only 39% of respondents marked the correct answer and 4.5% gave the wrong origin (Fig. 7). It appears that the compound responsible for the health-promoting effects of Manuka honey is unknown to 84% of respondents. Only 16% of respondents are familiar with this compound (i.e. - methylglyoxal) (Fig. 8).

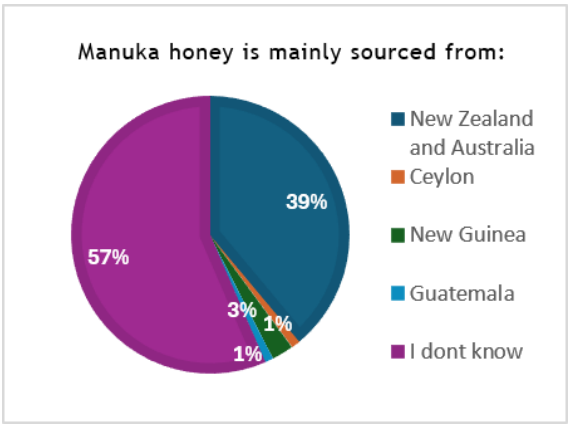

Fig. 7. Respondent's knowledge of the origin of Manuka honey.

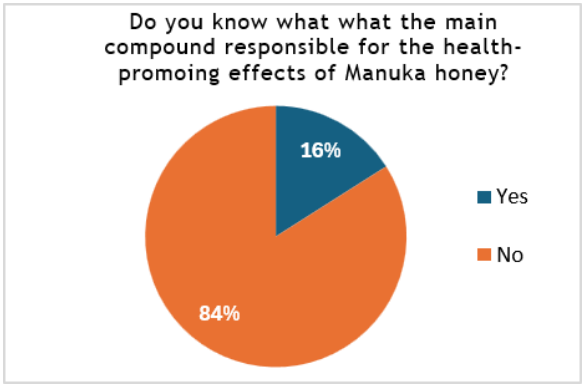

Fig. 8. Respondents' knowledge of how Manuka honey works.

Manuka honey is extracted by honeybees from the nectar of the flowers of the manuka tree (*Leptospermum scoparium*) in the *Myrtaceae* family [11,12]. Manuka belongs to a shrub or small tree species and grows throughout New Zealand and eastern Australia [12]. Manuka honey is dark in colour and has many health-promoting properties, primarily antimicrobial and antioxidant. The antimicrobial activity of Manuka honey is related to the presence of specific plant-derived constituents, the most important of which is methylglyoxal (MGO) [12-14]. MGO is derived from dihydroxyacetone present in the nectar of Manuka flower [15]. It is referred to as the so-called unique manuka factor (UMF) and is specific to this type of honey [14]. A small amount of MGO and a large amount of dihydroxyacetone are present in freshly produced honey. It has been found that storing honey at 37 °C causes an increase in MGO content and a decrease in dihydroxyacetone concentration. However, too high a temperature (≥50 °C) can result in a decrease in the concentration of these components, as well as a deterioration in honey quality [14]. The summary report on the Manuka Honey project, published on the Consumer Insight page at https://www.food.gov.uk/ found that 56% of respondents had heard of Manuka honey, and 22% had purchased it, with 37% of those purchases driven by perceived health benefits. Women were more aware of the properties of Manuka honey (71%) compared to men (54%). Among consumers who were already familiar with Manuka honey, 20% believed it offered health benefits that differed from other types of honey. Among those who believed the honey had beneficial properties, there was no consensus on what those properties might be. The numerical values next to the MGO symbol inform consumers of the methylglyoxal content in milligrams per kilogram of honey. When shown fake Manuka honey labels, 80% of respondents did not know what the numbers on the labels referred to [16].

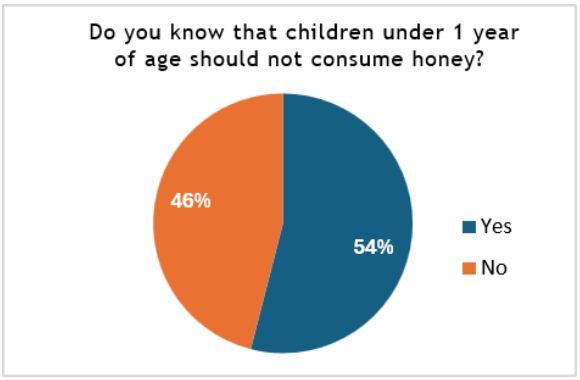

Fig. 9. Knowledge of respondents regarding the consumption of honey by children.

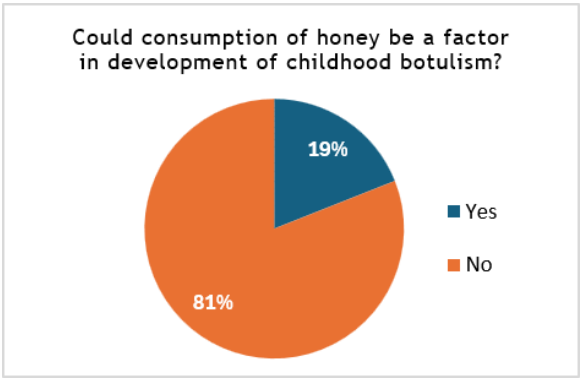

Fig. 10. Respondents' knowledge of factors in the development of childhood botulism.

46% of respondents were unaware that honey and honey-containing products should not be consumed by children under 1 year of age (54% are aware of this) (Fig. 9). Only 19% of respondents know that honey consumption is a factor in the development of childhood botulism, as many as 81% are not aware of this (Fig. 10). During production and processing, honey is exposed to microorganisms present in the environment [17]. Microorganisms present in the soil can reach the surface of the plants and can then be carried by the bees to the

hive, along with the nectar and pollen they take [17,18]. Microorganisms present in the bees' digestive system can also get into the honey. Some of these will be eliminated during dehydration and maturation of the honey [8]. However, bacteria capable of forming spores, including those of the genus *Clostridium*, may remain in the honey [19,20]. The botulism bacillus, *Clostridium botulinum*, is classified as a spore-forming, Gram-positive anaerobic bacteria. The bacteria are the source of botulinum toxin (BoNT), which causes poisoning in humans and animals called botulism [17]. There are different types of botulism, which include infant botulism. This disease is a toxicoinfection and occurs in children under one year of age. It occurs as a result of ingestion of honey contaminated with *Clostridium botulinum* spores [17,18]. Adults and older children already have a fully developed intestinal microflora that provides protection against colonisation of botulism bacilli [21]. The intestinal flora of infants, however, is much less developed and is unable to combat these bacteria [18]. When *Clostridium botulinum* spores enter the stomach and intestines together with food, they are transformed into vegetative cells that form botulinum toxin. It is then absorbed and transported with the blood to the neuromuscular junctions [17,18]. Botulinum toxin inhibits the release of acetylcholine from motor nerve endings and causes neuromuscular blockade. As a result, it leads to inhibition of muscle contraction and the onset of flaccid paralysis [18]. The incubation period is two to four weeks. The initial symptoms of infantile botulism are constipation, lethargy, drooping eyelids, lack of appetite, crying and general weakness [17,18]. If untreated, symptoms progress, leading to paralysis of the muscles of the arms, legs and trunk, respiratory failure and, in extreme cases, death may occur. Recovery from infant botulism can take several weeks or months. This depends on the speed of regeneration of the nerve endings. In most cases, however, there is a complete recovery [18]. The first laboratory-confirmed case of infantile botulism was recorded in 1976 in the United States. The disease occurred after eating honey infected with *Clostridium botulinum* spores [22]. Infantile botulism usually occurs in children between 3 and 20 weeks of age [21]. It is a very rare disease, but it is the most common type of botulism and is associated with very severe food poisoning. It has been reported on almost all continents (except Africa). Moreover, honey consumption is responsible for more than half of its cases [17]. For this reason, experts recommend that honey should not be given to children under one year of age (e.g. in foods, beverages and infant mixtures, baked goods and other foods). In view of the possible risks of introducing honey into children's diets, the public should be made more aware, if only during paediatric consultations, pharmaceutical care or even by putting an appropriate warning on labels. In Iranian studies, less than half (48%) of mothers had heard of infant botulism; 40% of them were aware of the link between honey consumption and the risk of developing the disease, but only 6.5% admitted to knowing the causative agent. The prevalence of honey consumption among infants under 12 months of age was 52% [23].

88% of respondents did not know how honey composition and properties are tested. A small number – 12% have knowledge on this subject (Fig. 11). Only 12% of respondents were able to answer what enzymes are present in honey (Fig. 12).

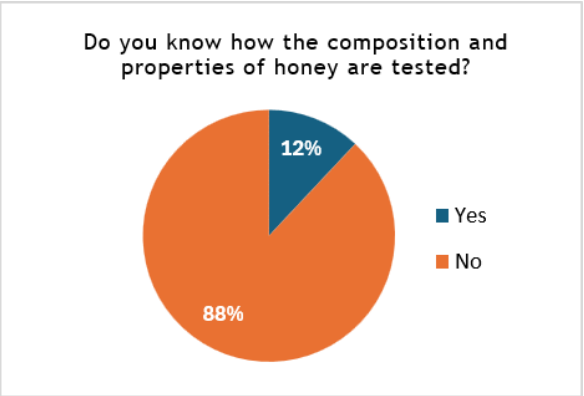

Fig. 11. Respondents' knowledge of honey composition studies.

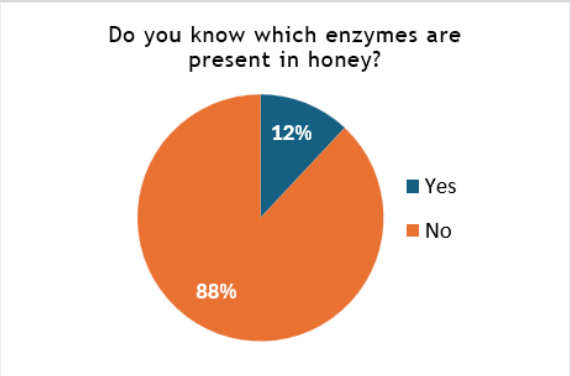

Fig. 12. Respondents' knowledge of enzymes found in honey.

Only 22% of respondents knew that the enzyme, diastase, is present in honey and is deactivated as early as 45°C (7% of respondents) (Figs. 13, 14). Enzymes are the least thermally stable constituents of honey, they are very sensitive to high temperature and lose their activity once a certain value is exceeded. For this reason, they are used for quality control of honeys [24,25]. A very important enzyme is amylase, otherwise known as diastase. It is known that the activity of diastase decreases markedly when honey is heated at a temperature higher than 45°C. Diastase activity is determined to detect the use of too high a temperature during honey processing, adulteration of honey or the use of other unauthorised processes during honey production, which translates into a reduction in the biological properties of the honey [25].

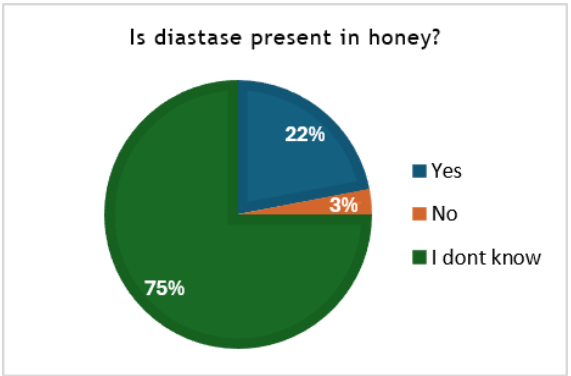

Fig. 13. Respondents' knowledge of the presence of diastase in honey.

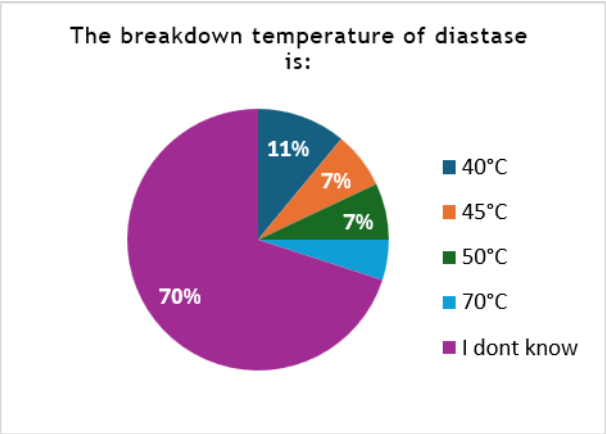

Fig. 14. Respondents' knowledge of the breakdown temperature of diastase.

72% of respondents had heard of honey adulteration (Fig. 15), while 43% of respondents knew what the most common adulteration of this product could be (Fig. 16). The information that 5-hydroxymethylfurfural (5-HMF) analysis is used to detect honey adulteration was known to 18% of respondents (Fig. 17). In contrast, the assessment of the diastatic activity of honeys for 87% of the respondents was unknown (Fig. 18). The HMF content is also an important criterion for the quality of honeys and must not exceed 40 mg/kg, except for industrial honey (industrial honey also known as baking honey has reduced nutritional value due to processes such as mechanical filtration, heating, and other treatments aimed at achieving a clear consistency) [26]. On the other hand, for honeys from regions with a tropical climate, as well as in blends of such honeys, the HMF content must not be higher than 80 mg/kg [26].

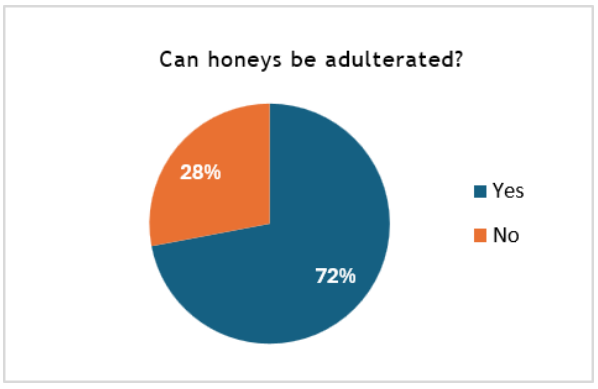

Fig. 15. Respondents' knowledge of adulteration of honeys.

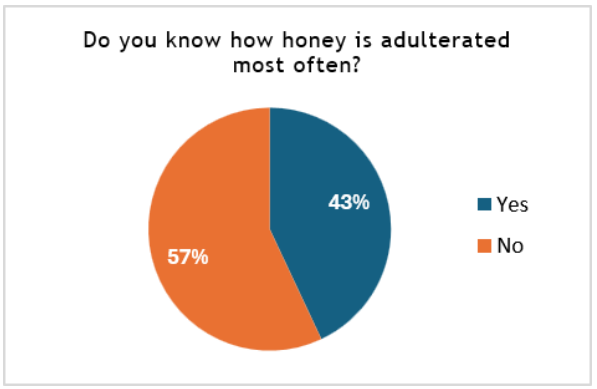

Fig. 16. Respondents' knowledge of the most common types of honey adulteration.

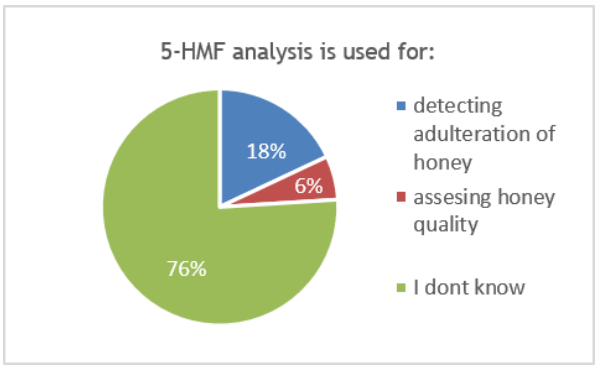

Fig. 17. Respondents' knowledge of 5-hydroxymethylfurfural (5-HMF) analysis.

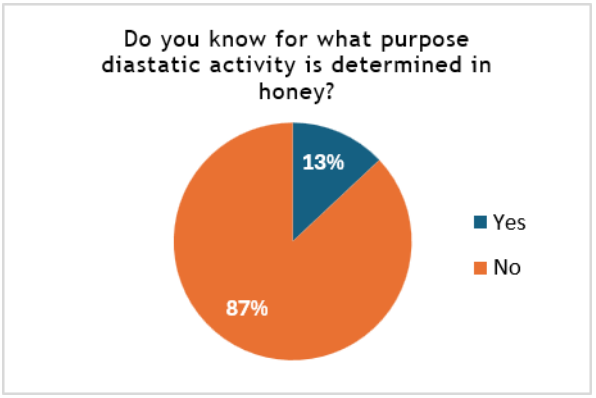

Fig. 18. Respondents' knowledge of diastase activity analysis in honey.

The content of sugars can change during storage. The main components of honey are sugars, which account for about 80% of all compounds in typical honey. First and foremost, there are monosaccharides: glucose and fructose, which account for about 75% of all sugars in honey. Disaccharides, which include maltose, sucrose, and isomaltose, make up 10-15%, while other sugars constitute a much smaller portion of honey. Carbohydrates are responsible for various properties of honey, including viscosity, hygroscopicity, graininess, and energy value. The composition of sugars varies depending on the origin of the honey, both botanical and geographical. The type of flowers from which they originate and their location are significant factors here. Processing and storage of the honey also have an impact [27-29]. In addition, when honey is heated, pentoses and hexoses undergo processes of enolisation and elimination of three water molecules, leading to their breakdown [30]. Undesirable compounds are then formed, including furans. The two main furans formed in this way are furfural and 5-hydroxymethylfurfural. 5-HMF is derived from the breakdown of hexoses such as glucose or fructose, and furfural from pentoses [31]. The content of 5-HMF is a good indicator of its adulteration because high temperature leads to an increase in 5-HMF concentration in honey, as does an extended storage period and the addition of, for example, high-fructose corn syrup [32,33]. To date, a full assessment of the toxicological effects associated with human exposure to elevated HMF is lacking, as the results of in vitro studies are insufficient and sometimes contradictory [32]. 5-HMF exhibits cytotoxic, genotoxic, neurotoxic, mutagenic and carcenogenic effects [32,34-37]. However, a number of papers have also demonstrated beneficial antioxidant, anti-allergic, anti-inflammatory, anti-hypoxic and anti-

hyperuricaemic effects [38-42]. It requires determining how to prevent or at least limit the formation of 5-HMF to safe values for humans and bees.

There are many more degradation products of sugars at high temperatures, for example 2-acetylfuran, isomaltol or maltol. These have the effect of altering the taste and smell of honey, as well as its colour [43]. Initially, the most common way of adulterating honey was the addition of sucrose. The sucrose content in honey must not exceed 5 g/100 g, with the following exceptions:

1) 10 g/100 g – in honey derived from black locust (*Robinia pseudoacacia*), alfalfa (*Medicago sativa*), *Banksia menziesii*, French broom (*Hedysarum*), red gum (*Eucalyptus camadulensis*), *Eucryphia* (*Eucryphia lucida, Eucryphia milligani*), *Citrus* spp.;

2) 15 g/100 g – in honey derived from lavender (*Lavandula spp.*), borage (*Borago officinalis*) [44].

Failure to meet these requirements may indicate that the honey has been adulterated by the addition of syrup containing sugars not typical of honey. Natural honey consists mainly of fructose and glucose, along with small amounts of sucrose and other sugars. Fresh honey may contain a few percent sucrose; during storage, the sucrose is broken down by enzymes present in the honey. Other common adulteration methods included the addition of glucose-fructose syrups, which led to a change in the ratio of monosaccharides in honey. Other cheaper sweeteners such as corn syrup, rice syrup, beet sugar syrup or cane sugar syrup are now also used for this purpose. They are also used in excessive amounts to feed bees [45].

4. Conclusions

Almost all the people interviewed declared that they consumed honey. The frequency of honey consumption was high - daily or several times a week. However, knowledge of honey composition, properties and adulteration was insufficient. It is necessary to conduct educational campaigns focusing not only on the taste and health benefits of consuming honey, but also on knowledge regarding its quality and potential contaminants. This article can help set the direction for future research and educational initiatives in this field.

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