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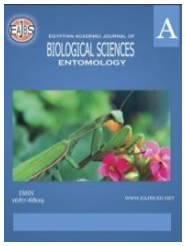

Sugars Profile of Citrus (*Citrus* spp.) Honey for Quality Determination

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ABSTRACT

Honey is considered a broad nutritional substance with nutritional, vital and therapeutic value due to its distinctive ingredients. Therefore, the determination of its purity is of utmost importance. The aim of this study is to investigate the effect of different feed types on sugars profiles of citrus honey. In this work, three types of foods presented to honey bee colonies were studied: invert sugar, sucrose solution and natural nectar. The honey produced from this feeding was characterized by equal levels of glucose and fructose in the case of invert sugar and high level of sucrose in the case of feeding with a solution of sucrose and the ideal composition for nectar of citrus trees that were represented in 42.1%, 35.5%, 0.9% and 1.6% for fructose, glucose, sucrose, and maltose, respectively. This provides a clear imprint of natural honey sugars (sugar profile), and opens the way for further research in this area to uncover ways of adulteration with honey

INTRODUCTION

Citrus honey is one of the unifloral honey (ODDO et al, 2004); a citrus honey favorite for a large segment of honey consumers as a result of its distinctive flavor, as well as the wide geographical distribution of citrus cultivars worldwide

Bee Honey as know that sweet substance from the nectar of plants and the most product famous between all bee products (Farag and Swaby, 2018), honey cost evaluated depend on different tastes and cultures of the customer.

Beekeepers resort to feeding colonies of honey bees out honey flow seasons to keep it out of starvation and malnutrition; it may be included different types of sugars such as high fructose corn syrup, invert sugar and grape syrup (Severson and Erickson, 1984a&b) Nutrition on sucrose may lead to an imbalance in the bacteria located in the honey bee gut, and some strain of bacteria may increase two- to five-fold when bees were fed sucrose. Sucrose fuels the proliferation of specific low abundance primary sucrose-feeders, which metabolism sugars into monosaccharides, and then to acetate. (Taylor *et al.* 2019), and from another point of view high fructose corn syrup (HFCS), causes of high mortality of bee workers related to the high concentration of HMF (LeBlanc *et al*. 2009).

MATERIALS AND METHODS

The aim of this work, to use a sugar profile in citrus honey as an important parameter of detection adulteration. So the present study was carried out in the apiary located at a pre-flowering citrus yield of Hosh Issa –El-bahera Governorate, nine colonies of hybrid carniolan

honeybees (*Apis mellifera carnica*), were prepared and attended for the experiment, all samples were collect and keep at 4ºC until analysis.

Honey Sample Sources:

a. colonies were divided into three groups during the beginning flowering season and first sealed comb was collected for extract honey samples:

1. The first group fed twice a week with 1.0 liter of sucrose solution (1:1).
2. The second group fed twice a week with 1.0 liter of commercial invert sugar.
3. The third group collected citrus nectar only as pour honey without any artificial feeding.

b. Collecting markets honey samples.

Microscopical examination:

Based on the method of Louveaux *et al*. (1978).

Sugar profile:

That included the main sugar (Fructose, glucose, sucrose, and maltose) by ion Chromatography according to Antunes *et al.* (2012)

Statistical analysis:

It was performed using IBM SPSS statistics subscription. A one-way analysis of variance (ANOVA) was used for statistical analysis. Five samples were used for each treatment and each experiment was repeated three times. Means ± Standard error (SE) were obtained from the analysis for each treatment. Data were presented as mean±SE and were compared with Tukey's test at a 5% probability level.

RESULTS AND DISCUSSION

Like other organisms, honeybees need food sources that provide carbohydrates and protein materials that are often available during the honey flow seasons. Therefore, beekeepers provide honey bee colonies with different sources of sugars such as disaccharide like sucrose, monosaccharide like invert sugar (glucose + fructose) and high fructose sugar syrup after the end of honey flow seasons.

There are many ways to adulteration honey in order to increase the profit by raising the produced quantity, especially with the types of honey with unique flavors, from Table (1) that showed the mean of sugars (fructose, glucose, sucrose, and maltose) from three honey bee feeding type (Invert sugar, sucrose and pure honey)

Fructose record significant mean differences between all treatments 42.1±0.3, 37.9±1.2 and 28.4±0.7 for pure honey, sucrose solution and invert sugar respectively; glucose profile show a significant difference s between pure honey and both invert sugar and sucrose solution that record 28.3 ± 2.7^{a} and 27.7 ± 2.8^{a} respectively which are free of significant mean differences between them.

The sucrose profile for three honey treatments was 10.4±0.6b, 1.8±1a and 0.9±0.2a for Sucrose solution treatment, Invert sugar treatment and pure honey respectively, with significant mean differences between them.For all feeding types treatment, there are no significant differences in the percentage of maltose sugar.

It is noted from the previous data in Table 1. & Fig.1., that the percentages of both glucose and fructose sugar are almost equal in honey resulting from the invert sugars with a low percentage of sucrose sugar profile, this is due to the synthesis method by breaking down sucrose sugar by using enzymes, cell type membrane reactor or microfiltration membrane into glucose and fructose (Schnepel and Hoffmann 2013; Tomotani and Vitolo, 2010; Erzinger and Vitolo, 2006 and Severson, *et al.* 1984 **),** unlike the honey produced from sucrose solution or the collected from the flowers nectar.

Table 1. Sugar profile of honey resulting from the feeding of bee colonies on three sources of carbohydrates

Feeding type	**Sugar profile**			
	Fructose(%)	Glucose(%)	Sucrose(%)	Maltose(%)
Invert sugar	28.4±0.7[a]	27.7±2.8[a]	1.8±1[a]	1.9±0.7[a]
Sucrose syrup	37.9±1.2[b]	28.3±2.7[a]	10.4±0.6[b]	1.5±0.1[a]
Pure honey	42.1±0.3[c]	35.5±0.7[b]	0.9±0.2[a]	1.6±0.2[a]

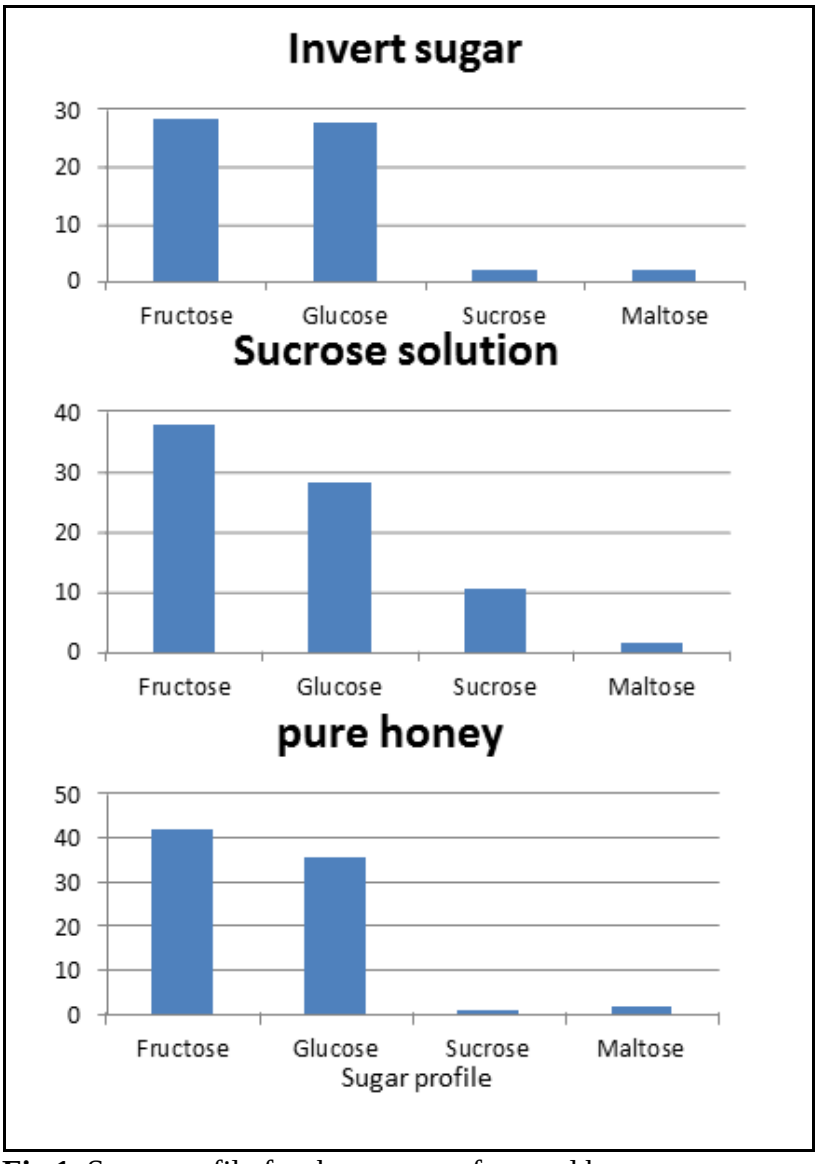

Fig.1. Sugar profile for three types of treated honey

From other point, honey extracted from feeding sucrose solution has relative variation between glucose and fructose, with a high percentage of sucrose sugar due to the inability of enzymes secreted by bees to contain and break down this huge amount of sucrose sugar (Gonza´lez, 2002; Maurizio, 1962; Persano-Oddo, Piazza, &Pulcini, 1999; Oddo et al., 1990 and White, 1979).

production of pure honey (feeding type 3) showed the an ideal profile of honey sugars that fructose represents about 40% and glucose is about 30% and sucrose represents a low

percentage of the total sugar (Abdulkhaliq and Khalid, 2017; Bogdanov, 2016; Zamora and Chirife 2006; Soria et al. 2004; Nour, 1988; El-Sherbiny et al. 1980; Murko et al.,1976).

Table 2. Which displays the profile of the sugar of honey samples collected from local markets and sold as citrus kinds of honey. all samples tested for authenticity (pollen definition), Accordingly, it is sample No. 1. It showed mixing of pollen type which has a different flowering duration, it was citrus (*Citrus spp*. L.) pollen and maize(*Zea mays* L.), Purslane (*Portulaca olaracea* L.) and Germs accompanying the cotton plants (that indicator for cotton honey) The high level of sucrose is an indication of adulteration using sucrose solution during the honey flow season, inside of mixing two types of honey have a different marketing prices

Sample number 2, 3 from analysis shows that both samples contain pollen grains for citrus trees and clover plants (*Trifolium alexandrienum*), with a note that the composition of reducing sugars (fructose + glucose) increase than 65%, the percentage of sucrose ranges between 0.78-1.98%, which corresponds to the specifications Egyptian standard (2005) and European codex alimentarius (2001), Thus, adulteration use mixing of different honey types with the aim of increasing profit.

Commercial samples number 4: It is clear from the sugar profile that reducing sugars are less than 65%, and the values of both glucose and fructose are equal. Thus, it appears that the sample was adulterated with feeding honey bee colonies using invert sugar.

The composition of sugar shows a high percentage of sucrose with a variation in the percentage of both glucose and fructose, which leaves no doubt that honey was adulterated using sucrose solution feeding in honey bee colonies with citrus honey flow duration (sample 4 and 5).

Sample no. 7 with a sugar composition 42.5%, 32.8%, 3.2 % and 2.06% for fructose, glucose, sucrose, and maltose, respectively. Appears ideally sugar profile as a good marker for high-quality natural citrus honey.

Table 2. Sugar profile of citrus honey samples from markets.

Market citrus honey authenticity	Sam. code	Sugar profile			
		Fructose(%)	Glucose(%)	Sucrose(%)	Maltose(%)
Citrus+ cotton	**1**	**35.2**	**26.8**	**13.0**	**2.3**
Citrus+ clover	**2**	**40.5**	**31.7**	**1.98**	**1.86**
Citrus+ clover	**3**	**40.6**	**30.0**	**0.78**	**1.52**
Citrus	**4**	**27.3**	**27.2**	**7.1**	**2.7**
Citrus	**5**	**31.5**	**30.0**	**15.2**	**1.45**
Citrus	**6**	**33.3**	**31.0**	**13.3**	**1.6**
Citrus	**7**	**42.5**	**32.8**	**3.2**	**2.06**

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ARABIC SUMMARY

الصورة التكوينيه لسكريات عسل الموالح كأحد المقاييس المحددة للجودة

رشا محمد أحمد فرج

قسم بحوث النحل- معهد بحوث وقاية النباتات-

مركز البحوث الزراعيه- وزارة الزراعة- الجيزة - مصر

يعتبر العسل مادة غذائية ذات قيمة غذائية وحيوية وعلاجية واسعة بسبب مكوناته المميزة. لذلك ، تحديد النقاء له أهمية قصوى. الهدف من هذه الدراسة هو دراسة تأثير أنواع الأعلاف المختلفة على تركيب السكريات من عسل الموالح. في هذا العمل تم دراسة ثلاثة انواع من الاغذية المقدمة لطوائف نحل العسل: السكر المحول، محلول السكروز والرحيق الطبيعي حيث تميزت الاعسال الناتجة من هذة التغذية بتساوى نسب الجلوكوز والفركتوز فى حالة السكر المحول وارتفاع نسبة السكروز فى حالة التغذية بمحلول السكروز والتركيب المثالى في حالة رحيق ازهار أشجار الموالح التي تمثلت في ٤٢,١ ٪ ، ٣٥,٥ ٪ ، ٠,٩ ٪ و ١,٦ ٪ للفركتوز والجلوكوز والسكروز والمالتوز علي التوالي. مما يتيح وجود بصمه واضحة لسكريات العسل الطبيعي ويفتح المجال لابحاث اخرى في هذا المجال للكشف عن طرق غش العسل