Available online at www.sciencedirect.com
ScienceDirect
Food Chemistry 109 (2008) 891–898
FOOD CHEMISTRY
www.elsevier.com/locate/foodchem

Analytical Methods

Verification test of sensory analyses of comb and strained honeys produced as pure and feeding intensively with sucrose (*Saccharum officinarum* L.) syrup

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Received 2 May 2007; received in revised form 1 January 2008; accepted 12 January 2008

Abstract

The aims of the study were to discriminate comb and strained honeys produced by the standard beekeeping method (control), shaking method (pure blossom honey), and feeding intensively (100 kg/colony) with sucrose (adulterated honey) syrup by using sensory analysis and to develop a method to be used in identification of unknown or suspicion honey samples. In the study, twenty trained panelists assessed honey samples in relation to their properties including taste, odor, color, aroma, viscosity, dissolution in mouth, inflammation in throat, attractiveness, flavor and general impression during four months. There were no differences in odor, viscosity, and dissolution in mouth between comb and strained honey samples which produced by different methods ($P > 0.05$). Discrimination of strained honey by sensory analysis was more reliable when compared to comb honey. The ratio of correctly classified sample was 78.3% for comb and 86.7% for strained honey. The more honey was pure the more discrimination of honey sample by sensory analysis was reliable. In verification test five unknown honey samples were classified 100% in their real groups by using canonical discriminant function Coefficients of each properties evaluated and the projections of the sample points on the plane of the canonical function-1 and function-2.

Keywords: Honey; Pure blossom; Sucrose; Strained; Comb; Sensory analysis; Discriminate; Verification test

1. Introduction

Nectar source, maturation, production methods, climate, process and storage conditions effect quality and content of honey (Bogdanov et al., 2000; Crane, 1979; White, 1978). However the most important aspects of honey are its sensory properties as taste, aroma, odor, dissolution in tamate (Altug, 1993; Piana et al., 2004). Consumers would like to feel the sensory properties of the honey which reflects its botanical origin. Therefore, botanical source, produced region, and level of purity of honey are of greater importance not only for consumers but also for its commercial value (Karabounioti, Thrasyvolou, & Eleftheriou, 2006). For that purposes, biochemical contents, melissopalynology and sensory properties of honey have been used (CODEX STAN 12-1981. Rev.1 (1987), 2001, Bogdanov, Ruoff, & Oddo, 2004; Cozzolino & Corbella, 2003; Gonnet M. & G., 1998; Piana et al., 2004). In Italy Oddo and Bogdanov (2004) and Oddo et al. (2004) modified conventional methods of Gonnet and Vache (1992, 1998) and today harmonized modern techniques have been used (Bruneau, Barbier, Gallez, & Guyot-Declerk, 2000; Kaakeh & Gadelhak, 2005; Piana et al., 2004; Vejsnaes, Theuerkauf, & Wienberg, 2003). International honey commission (IHC) was founded to develop methods and to form implementation principles for honey. Sensory analysis has mainly been used for identification of botanical origin of honey (Oddo & Bogdanov, 2004; Oddo et al., 2004). However verification of the method used for identification or discrimination of honey has not been

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doi:10.1016/j.foodchem.2008.01.019

performed so far. Karabounioti et al. (2006) identified correctly the honey samples belonging to the same plant species of different geographical regions.

In previous studies honey samples used for sensory analysis were collected either market or producers. Information in relation to their purity or content obtained from producers or from their labels, and their production methods were unknown. Also there was no any information in identification of comb honey by sensory analysis. Approximately 85% of the total amount of honey produced in Turkey is blossom honey and is consumed mainly as comb (Guler & Demir, 2005). Another important problem is that some producers have used high amount of sucrose to get higher yield during the main nectar flow period (Basoglu, Sorkun, Löker, Doğan, & Wetherilt, 1996; Silici, 2004; Wetherilt, Basoglu, & Pala, 1993). This situation creates negativeness not only for consumers but also for producers. This necessitates discrimination of pure and adulterated honey.

The present study was designed to discriminate comb and strained honey produced by the standard keeping method (control), shaking method (pure blossom honey), and feeding with sucrose (adulterated honey) by using sensory analysis and to develop a method to be used for identification of unknown or suspicion honey samples.

2. Materials and methods

2.1. Material keeping and data collection

This study was carried out in the beekeeping unit of Research and Application Farm of University of Ondokuzmayis, Faculty of Agriculture in 2004. The honey bee of the region was used as material. Twenty four colonies with 9–10 frame worker bees were selected at randomly from the 140 colonies in the apiary. Elderly sister queens reared from the same colonies by larvae transferring were used. The colonies were equalized in terms of brood frame, frame with honey bee, colony weight and feeding in the spring of 2004. Perisine was used for *Varroa destructor* in the late autumn (the first week of November). Colonies were sheltered in wooden hive in the Langstroth sizes. Data and honey samples were taken from these colonies. Migratory beekeeping system was used in the research. Colonies were in Samsun in the winter and spring seasons in Blacksea region (41°N 17′E), and in the village of Gulacar of Torul town of province of Gumushane (39°N 29′E) which is 470 km far from Samsun in main nectar flow period. The region is rich in plant resources. Thyme (*Satureja thybra* L.), labiatae (*Lamium album*), alfalfa (*Trifilium ambiguum*), şalba (*Salvia forskahler* L.) and geven (*Astragalus microcehalus*) are the major nectary plants.

2.2. Method

2.2.1. Control group honey

Standard beekeeping was applied to the colonies in this group. One kilogram cake was given to each colony in the early spring (end of February). In the beginning of April, spring nurse, beehive internal cleaning, control of the queen bee were realized, surplus frames were taken and arrangement in the hive was made. In March and April, 16 kg syrup (1.5 kg sugar: 1 kg water, w:w) per colony was given to provide the brood efficiency and increase the worker bee population of the colonies. After the transferring process into empty hive at the end of May, colonies were not treated with any chemicals, not given cake and syrup. Foundation comb in standard sizes (42 × 22 cm) was given to the colonies when needed.

2.2.2. Pure blossom honey

All needs of the colonies like feeding and medication in the winter, autumn, and spring was met firstly in a group of hives. After that, 40–45 days before the main nectar flow period, the colonies were shaken to another group of hives (empty hive) together with the queen and worker bees. Shaking was done on 23rd May 2004. After the shaking, only wired frame was given to the hives. A 1 cm-width pure wax comb was fixed to the top bar of the frame as a directive mark for the bee to follow. After these processes, colonies were not medicated, and syrup, cake and foundation comb were not given. One week after the shaking, colonies were moved to Eastern Anatolia Region where they stayed during the main nectar flow period. Honey was harvested on 22nd August 2004. Harvest was made in tent through centrifuge and honey was filtered from a screen of 0.2 mm diameter.

2.2.3. Sucrose honey

One hundred kilogram sucrose syrup was given to each colony during the period of June, July and August. Sucrose syrup was prepared at a rate of 1 kg water: 1.5 kg sugar (w:w). Syrup was prepared in every two days, mixed frequently, and given to the colonies after being waited one day. Colonies were not treated any chemicals, and not given cake. Foundation comb were given to the colonies when needed.

2.3. Sensory procedure

The panel consisted of 20 assessors, 22–25 years old. Assessors were trained in taste, aroma, odor, color, viscosity, appearance, dissolution in palate and appeal of honey at once in a week during four months. During training each week assessors tested different type of honey including pine, chestnut, sunflower, artificial honey, pure blossom honey and commercial honey derived from market. They were also trained in importance of sensory evaluation and issues taken into consideration while assessing the samples. A questionnaire form was developed. Five point scale from 1 to 5 was used for evaluating properties which indicated the worst and the best, respectively (Altug, 1993; Piana et al., 2004). Panelists assessed comb and strained honey at different days; they tested comb honey one day, strained honey another day. Room temperature was

21 °C during evaluation. Each panelist tested 30 g honey in each evaluation cases. To prepare the sample, six gram of comb and strained honey were taken from randomly selected five colonies of each group. The samples of five colonies of each group were mixed and 20 samples were prepared for each group. The medium, light, the amount and presentation manner of sample, utilization of time, evaluation in mouth and the issues in relation to taking honey before test were arranged according to ISO 8586-1. (1993), ISO 8586-2. (1994) and ISO 8589. (1988), Piana et al. (2004). In addition randomly selected five strained honey samples were used for verification test. Sucrose contents of the honeys used for sensory analysis were 3.84 ± 0.16, 4.29 ± 0.14, and 4.75 ± 0.05 g 100 g^{-1} for control, pure blossom and sucrose adulterated groups, respectively.

2.4. Statistical evaluation

Variance analysis was performed by using Kruskal–Wallis and two independent samples Mann–Whitne-U test of none parametric method with Bonferroni correction. Linear discriminant analysis method was used to determine whether samples were discriminated in relation to their sensory properties. Linear discriminant functions of each group and each property, discrimination power of these functions, classification of unknown samples and development of verification model were performed by discriminant analysis. SPSS (13.0, 2004) statistical package was used to evaluate data.

2.5. Verification test

Verification test was used for identification and classification of the production method-unknown sample of groups by using their sensory properties and verification the level of correctness of this classification. In the first stage, discriminant analysis was applied to the all sensory properties of 20 samples to obtain canonical discriminant function coefficients of each property and to find the region of the each additional sample in the coordination system (Cooley & Lohnes, 1971). With this system, standard structure was developed for production method-known honey samples. In the second stage, randomly selected five production method-unknown samples were tested to find the group to which they were belongs. These calculations have been done by EXCEL program.

3. Results

3.1. Strained honey

The results of sensory analysis in term of sensory properties of strained honey of each group are given in Table 1. There were significant differences in taste, color, inflammation in throat and attractiveness, flavor, and general impression among the groups. There were no significant differences in taste, aroma, viscosity, and dissolution in mouth ($P > 0.05$). Control group honey was tastier than pure blossom and sucrose honey. Control group honey also ranked in the first in flavor and general impression. Control and pure blossom honey had higher values in inflammation in throat and attractiveness. In comparison of the mean values, control had the highest value, followed by pure blossom and sucrose honey.

Table 1
Means (±s.e.) of the sensory properties assessed in strained and comb honey samples produced as control, pure and feeding with sucrose syrup methods

Properties	Strained honey			*P*
	Control	Pure blossom	Sucrose	
Taste	4.05 ± 0.887 a	3.67 ± 0.732 ab	3.37 ± 0.681 b	*
Odor	3.56 ± 0.820	3.34 ± 0.812	3.26 ± 0.786	NS
Color	3.94 ± 0.887 b	2.94 ± 0.552 c	4.85 ± 0.366 a	**
Aroma	3.83 ± 0.967	3.55 ± 0.944	3.32 ± 0.657	NS
Viscosity	3.44 ± 0.888	3.28 ± 0.875	3.67 ± 0.988	NS
Dissolution in mouth	3.84 ± 0.745	4.00 ± 0.604	3.52 ± 0.888	NS
Inflammation in throat	3.78 ± 0.833 a	3.67 ± 0.923 a	2.95 ± 0.686 b	**
Attractiveness	4.05 ± 0.745 a	4.12 ± 0.745 a	3.42 ± 0.754 b	**
Flavor	4.05 ± 0.852 a	3.56 ± 0.754 b	2.68 ± 1.174 c	**
General impression	4.22 ± 0.716 a	3.67 ± 0.732 ab	3.00 ± 0.795 b	**
Means	3.88	3.58	3.40	
	Comb honey			
Taste	4.05 ± 0.825	4.40 ± 0.598	3.80 ± 1.056	NS
Odor	4.05 ± 0.759	3.85 ± 0.587	3.55 ± 0.510	NS
Color	4.30 ± 0.732 a	2.40 ± 0.680 b	4.30 ± 0.801 a	**
Aroma	3.75 ± 0.550 b	4.40 ± 0.502 a	3.90 ± 0.852 ab	**
Viscosity	3.80 ± 0.696	3.65 ± 0.745	3.90 ± 0.788	NS
Dissolution in mouth	3.90 ± 0.852	4.35 ±0.671	3.90 ± 0.852	NS
Inflammation in throat	3.65 ± 0.876 ab	4.05 ± 0.605 a	3.35 ± 0.988 b	*
Attractiveness	4.35 ± 0.754	4.20 ± 0.894	4.10 ± 0.967	NS
Flavor	3.45 ± 0.887 b	4.35 ± 0.745 a	3.25 ± 1.096 b	**
General impression	4.05 ± 0.825 ab	4.35 ± 0.671 a	3.60 ± 1.046 b	*
Means	3.94	4.00	3.77	

Values within rows with different letters differ significantly ($^{*} = P < 0.05$, $^{**} = P < 0.01$, NS = none significant).

3.2. Comb honey

Finding in relation to sensory properties of comb honey of each group are given in Table 1. Control, pure blossom and sucrose honey differed significantly in color, aroma, flavor ($P < 0.01$), inflammation in throat and general impression ($P < 0.05$). While pure blossom comb honey had the highest value in aroma, it had the lowest value in color. It was also ranked in the first in inflammation in throat, flavor and general impression, followed by control and sucrose honey. Color was best in control and sucrose honey when compared to pure blossom honey which was below the threshold value.

In this study, three was accepted as threshold value for suitability of honey to the market. While strained honey of control group had above the threshold value in all investigated properties, strained pure blossom honey had below the threshold value in color, and strained sucrose honey had below the threshold value in inflammation in throat and flavor. In comb honey, while control and sucrose group had above the threshold value in all investigated properties, pure blossom honey had below the threshold value in only color.

3.3. Discriminant analysis

Discrimination functions of sensory properties, suitability values, variance levels, and probability levels of discrimination functions of comb and strained honeys are given in Table 2. Percentages of correctly classified samples were significantly different in comb and strained honey, and also in production method.

In strained honey, two discriminant functions correctly classified 100% the samples of all group. First function explained 86.4% and second function 15.4% of total variance. Both discriminant functions were significant in discrimination of samples. But significance level of first function (Wilks lambda, 0.161) was higher than that of second function (0.646). In strained honey, while color (0.722), appearance (−0.261), dissolution in mouth (−0.149) and viscosity (0.078) were related to the first function, general impression (0.694), flavor (0.566), taste (0.384), aroma (0.328) and odor (0.229) related to the second function. There were positive correlations between aroma and taste ($r = 0.733$), general impression and taste ($r = 0.697$), general impression and inflammation in throat ($r = 0.720$), general impression and aroma ($r = 0.696$), aroma and inflammation in throat ($r = 0.623$). As to comb honey, two discriminate functions correctly classified 100% of all samples. First and second discriminant functions were significant in discrimination of samples. First function explained 89.1% of total variance which was higher than that of the strained honey. Second function explained 10.9% of total variance. There were significant correlations between taste and flavor ($r = 0.699$), odor and taste ($r = 0.605$), aroma and taste ($r = 0.588$), dissolution in mouth and taste ($r = 0.595$) (data not presented).

Table 2
The eigen values, explained variance (%), cumulative variance, Wilks' lambda and probability values for strained and comb honey discriminant functions

	Functions	Eigen values	Variance (%)	Total variance (%)	Wilks lambda	*P*
Strained honey	1	3.010	84.6	84.6	0.161	0.001
	2	0.549	15.4	100.00	0.646	0.006
Comb honey	1	2.345	89.1	89.1	0.233	0.001
	2	0.286	10.9	100.00	0.778	0.154

In strained honey, while 14 assessors (70%) grouped the control honey in its real group, four (20%) grouped as pure blossom and two (10%) grouped as sucrose. Eighteen assessors (90%) classified the sucrose honey in its real group, whereas two assessors (10%) classified as control. All assessors (100%) grouped the pure blossom honey in its real group. In comb honey, fourteen assessors (70%) classified the control honey in its real group, two in pure blossom (10%) and four (20%) in sucrose. Eighteen assessors (90%) classified the pure blossom honey in its real group, one (5%) in control, and one (5%) in sucrose. Fifteen assessors (75%) grouped the sucrose in its real group, five (25%) as pure blossom honey (Table 3).

3.4. Verification test

While preparing the honey samples for sensory analysis, randomly selected five samples assessed by five assessors in terms of ten sensory properties. These samples were coded as S_1, S_2, S_3, S_4 and S_5 (Table 4).

Verification test was used in this study to identify pure blossom and adulterated honey samples. Method applied to strained honey. Unknown five samples were classified

Table 3
The numbers (and percentages) of correctly classified honey samples produced in different methods by discriminant functions using the sensory properties of strained and comb honeys

	Original honeys	Predicted group membership			Total
		Control	Pure	Sucrose	
Strained[a]	Control	14 (%70.0)	4 (%20.0)	2 (%10.0)	20
	Pure	0	20 (%100)	0	20
	Sucrose	2 (%10.0)	0	18 (%90.0)	20
Comb[b]	Control	14 (%70.0)	2 (%10.0)	4 (%20.0)	20
	Pure	1 (%5.0)	18 (%90.0)	1 (%5.0)	20
	Sucrose	0	5 (%25.0)	15 (%75.0)	20

[a,b] Correctly classified strained and comb honey samples were 86.7 and 78.3, respectively.

Table 4
The values of sensory properties of production method-unknown honey samples given by assessors

Sensory properties	Production method-unknown honey samples				
	S_1	S_2	S_3	S_4	S_5
Taste	5	4	3	5	4
Odor	4	3	3	4	4
Color	3	5	2	4	4
Aroma	4	3	3	4	4
Viscosity	4	3	4	4	4
DM	4	3	3	5	4
IT	4	3	4	4	3
Attractiveness	5	3	4	5	4
Flavor	4	3	4	5	4
General impression	4	3	4	4	5

DM = dissolution in mouth, IT = inflammation in throat.

Table 5
Standard canonical discriminant function coefficients, the constant description coefficients of sensory properties in strained honey and calculated SCORE Function 1 and 2 for unknown honey sample by EXCEL program

Sensory properties	Canonical discriminant function coefficients		Values of unknown sample	SCORE Function 1	SCORE Function 2
	(α_i)	(β_i)			
Taste (X_1)	0.010	0.019	5	0.050	0.095
Odor (X_2)	0.556	−0.263	4	2.224	−1.052
Color (X_3)	1.385	0.490	3	4.155	1.47
Aroma (X_4)	0.477	0.048	4	1.908	−0.192
Viscosity (X_5)	0.465	−0.082	4	1.860	−0.328
DM (X_6)	−0.199	−0.689	4	−0.796	−2.756
IT (X_7)	−0.419	−0.618	4	−1.676	−2.472
Attractiveness (X_8)	−0.742	−0.217	5	−3.710	−1.085
Flavor (X_9)	−0.369	1.820	4	−1.476	7.28
General impression (X_{10})	−0.234	0.364	4	−0.936	1.456
Constant	−3.407	−3.284		1.603	2.416
Sample coordinates				−1.837	−0.388

DM = dissolution in mouth, IT = inflammation in throat.

by using the functions obtained by discriminant analysis. With this analysis, standard canonical discriminant function coefficients of sensory properties were determined. These functions are descriptive value of each sample produced by different methods. They are the standard functions of sensory properties of pure blossom and sucrose adulterated honeys. Unknown honey samples will be classified by using the first and second standard canonical function coefficients and constant with the description values of each additional sample (Table 5). Therefore, the region of samples in the coordination system was found (Fig. 1). For each sample two score functions were calculated by using Eqs. (1) and (2) given below.

$$\text{SCORE Function 1} = \alpha_0 + \alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5X_5 + \alpha_6X_6 + \alpha_7X_7 + \alpha_8X_8 + \alpha_9X_9 + \alpha_{10}X_{10} \quad (1)$$

$$\text{SCORE Function 2} = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} \quad (2)$$

While calculating these functions, standard first discriminant function coefficient (α_i) of each property multiplied by the value of this property given by assessors (X_1, X_2, X_3,..., X_n) for additional samples. Then added to Function 1 constant coefficient and so SCORE Function 1 was

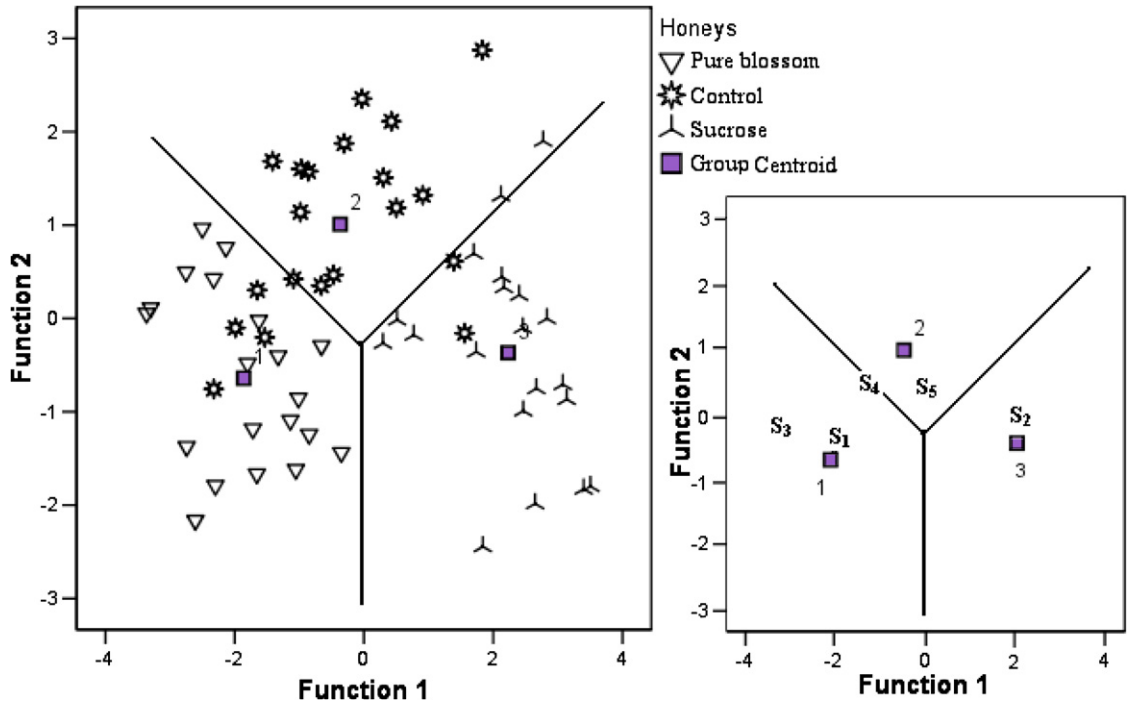

Fig. 1. Discriminant analysis of strained honey samples from different produced methods (on right). Each number (1, 2, and 3) represents produced method centroids and each point represents a sample. Identification of five-unknown honey samples by verification test (on the left).

calculated. SCORE-Function 2 was calculated as similar way (Table 5). In the coordination system SCORE Function 1 is apsis and SCORE Function 2 is ordinate (Cooley & Lohnes, 1971). For example, SCORE Function 1 and Function 2 of sample S_1 were calculated as explained above and found as shown below.

$$\begin{aligned}\text{SCORE Function 1} = {} & -3.407 + 0.010 \times 5 + 0.556 \times 4 \\ & + 1.385 \times 3 + 0.477 \times 4 + 0.465 \\ & \times 4 + (-0.199 \times 4) + (-0.419 \times 4) \\ & + (-0.742 \times 5) + (-0.69 \times 4) \\ & + (-0.234 \times 4) \\ = {} & -1.837\end{aligned}$$

$$\begin{aligned}\text{SCORE Function 2} = {} & -3.284 + 0.019 \times 5 + (-0.263 \times 3) \\ & + 0.49 \times 3 + (-0.048 \times 4) \\ & + (-0.082 \times 4) + (-0.689 \times 4) \\ & + (-0.618 \times 4) + (-0.217 \times 5) \\ & + 1.82 \times 4 + 0.364 \times 4 \\ = {} & -0.388\end{aligned}$$

When the SCORE Function 1 and 2 were put into the coordination system, S_1 grouped as pure blossom honey. The SCORE Function 1 and 2 of the other samples calculated are shown below.

- For sample S_2: SCORE Function 1 = +2.163; SCORE Function 2 = +0.043.
- For sample S_3: SCORE Function 1 = −3.301; SCORE Function 2 = −0.179.
- For sample S_4: SCORE Function 1 = −0.987; SCORE Function 2 = +0.753.
- For sample S_5: SCORE Function 1 = 0.498; SCORE Function 2 = 0.802.

When these values were put into the coordination system, the regions of the samples were found as shown in Fig. 1 (on the right). Thus, it was found that S_1 and S_3 were pure blossom honey, S_2 sucrose, and S_4 and S_5 control. But, S_4 fell in the crossing line of pure blossom honey and control honey. When looked up the real code of this sample, it was seen that it was belong to control group. In order to eliminate this uncertainty, this sample (S_4) was included into the 20 samples (8.3%) and the highest group membership was tested and fount that it was in control group. Furthermore, the group of sample was determined according to the second highest probability by discriminant analysis and this confirmed that it was a sample of control group. Therefore uncertainty of the sample was eliminated.

4. Discussion

Assessors discriminated successfully pure blossom and sucrose honey in terms of many properties. However they were not identified strained and comb honey produced by different methods in odor, viscosity, and dissolution in mouth. Discrimination of strained pure blossom and sucrose honey were more reliable when compared to comb honey. This was attributed to being chewed of comb honey in mouth while evaluating. Another finding is that while identification of comb of control, pure blossom and sucrose honeys in terms of aroma was possible, it was impossible for strained honey. This might be resulted from pollen found in comb, which perceived easily during chewing. High correlation ($r = 0.588$) between aroma and flavor in comb honey supports this assumption. This finding is compatible with the results of Piana et al. (2004), who reported that small amount of aromatic honey changes the aroma of monofloral honey. Aroma was less perceived in sucrose honey which produced by feeding intensively sucrose syrup.

There were differences in color of the honey samples. The color of comb sucrose honey was lighter when compared to pure blossom comb honey and so it received high value in terms of this property, indicating importance of color for sensory evaluation. Bogdanov et al. (2005) stated that color has important effect on consumer preference and price of honey. Color of comb honey in sucrose group ranged from light yellow to bright white (4.85 ± 0.366), cells of comb were full and cupped, which received high value due to these properties. The color value of pure blossom comb honey was very low (2.40 ± 0.680), which under the threshold value. Similar color difference was found for strained honey. But color was darker in comb honey when compared to strained honey. One of the reasons of this result is that in sucrose group bees were fed with intensive sucrose (100 kg sucrose syrup per colony) during the main nectar flow period. They not only received sucrose syrup, but also collected nectar from the plants, resulting full cells with bright color. Another reason of color differences among the groups might be the cells containing pollen. Third reason might be that laying egg by queen in the cell and brood rearing after construction of cells. It was concluded from that high attractiveness of comb honey i.e. full cells and white color is not a proof for high quality and purity all the times. Correctly grouped level of samples was 86.7% strained honey of control, pure blossom and sucrose honey; it was 78.3% for comb honey. This finding indicated that the source of honey or differences among honeys were discriminated well in strained honey. The level of correctly discrimination of honey increased with increasing purity of honey. As a matter of fact, strained and comb of pure blossom honey had the highest correctly classified percentages (100% and 90%, respectively). This is valid more or less for strained and comb of sucrose honey (90% and 75%, respectively). This resulted from the fact that special properties peculiar to these honeys were perceived intensively by assessors.

Level of purity, production method, botanical origin and geographical region of product should be known (Anklam, 1998; Ruoff & Bogdanov, 2004). For that reasons, verification test was used in the study. In most of

the studies discriminant analysis was used successfully for botanical description and discrimination of honey was achieved (Arrone, Micco, & Scala, 2004; Gilbert, Shephard, Wallwork, & Harris, 1981; Rodriquez-Otero, Paseiro, Simal, & Cepeda, 1994). However verification test was not used so far. In this study, it was found that verification test can be used for description of unknown or adulterated honey with high confidence. In the beginning, only one sample (S_4) fell into the crossing line (region), it was proved later that the sample was belong to its real group. This result was in agreement with the result of the other samples. Namely, four out of 20 samples of control were grouped in pure blossom honey. This might be resulted from similarity between two groups in many sensory properties. However, confidence of verification tests valid for honeys that their botanical origin and production methods are known. Data used for verification test in the present study is none parametric. It was thought that if the data used for the test are quantitative as biochemical properties, availability of this test may be high. Discrimination power of the discriminant analysis indicated that this method was the most important method for that purpose. In the study one-fourth of 20 samples (20%) were subjected to verification test and all of them 100% were correctly classified in their real groups. In addition, calculation of SCORE Function 1 and 2 values by using EXCEL program and developing a standard method was achieved for laboratories. First, biochemical contents or sensory properties of unknown samples are determined. Then these values are put in the column of unknown sample values in excel program as shown in Table 5. And so SCORE Function 1 and 2 are found. When these values are put into the coordination system the region of the unknown sample can be grouped or identified.

In order to use this method, information obtained from the label on the cans or producers of honeys was not suitable to determine standard canonical discriminant function coefficients and constant description coefficient values (Table 5). The studies of Piazza and Oddo (2004) and Oddo et al. (2004) on monofloral honeys of Europe and of Karabounioti et al. (2006) on determination of geographical origin of honeys may be good samples for verification test. Anklam (1998) reported that discriminant analysis is the most important instrument for identification and discrimination of honeys with different geographical origin. If many sensory properties are evaluated by skilled assessors and these properties are standardized, it is possible to determine the botanical source, geographical origin and purity of the honeys by using the constant function values belonging to known honeys.

5. Conclusion

The results of the present study indicated that it is possible to discriminate pure blossom honey and adulterated honey obtained with intensive sucrose feeding by using sensory properties. In discrimination of honey through sensory analysis, not only the skill of the assessors but also the type of honey i.e. strained or comb are of high importance.

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