WATER ACTIVITY AND COLOUR PARAMETERS CHANGES DURING STORAGE OF LINDEN AND BUCKWHEAT HONEYS

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ABSTRACT

The aim of the study was to evaluate selected quality parameters of honey: water activity and colour parameters and their changes during storage under different conditions. Also the effect of the botanical origin of honey and filtration process on these parameters were examined.
In both types of honey, filtered and unfiltered, the initial water content was determined by refractometry, initial water activity was determined by the AquaLab and colour parameters L* a* b* were measured using a colorimeter Chroma Meter CR 400. In addition, a measurement of water activity of the tested honeys stored for 90 days under a constant relative humidity in the range of 0,069-0,932 water activity was done.
Analysis of the examined water activity of the honey stored for 90 days showed that storage under conditions of low relative humidity (aw = 0,069-0,548) decreased water activity of honey in relation to their initial water activity, while storage under conditions of high relative humidity (aw>0,548) caused an increase in water activity of honey. It has been also shown that filtration affects the water activity. Storage in different relative humidity conditions and filtration have an impact on the values of the colour parameters of honey, too.

Key words: honey, water activity, colour parameters.

1. INTRODUCTION

Honey is the natural sweet substance produced by honeybees (*Apis mellifera*) from the nectar of plants or from secretions of living parts of plants [6]. In physical terms honey is a saturated mixture of sugars dissolved in the water, with the addition of a specific plant and secretions of bees. According to the literature, in honeys of different varieties about 300 components were found, which belong to the different groups of essential compounds such as: carbohydrates, minerals, nitrogen compounds, essential oils, vitamins and other biologically active substances [8]. Quality and sustainability of honey is determined, inter alia, by the water content. Honey contains an average of 17,2–18,3% water, wherein its content is determined by weather conditions prevailing during the nectar production of

plants, temperature in the hive during honey maturation and biological origin. According to Reg. Ministry of Agriculture concerning requirements for the commercial quality of honey, honey should not contain more than 20% of water [6]. Exceptions are selected types of honey, e.g. heather honey which may contain up to 23% water. However, not the water content should be a parameter denoted during the standard quality analysis [1,2]. On the stability of honey primarily affects the availability of water, characterized by a water activity (aw). The water activity of honeys during storage may vary and may occur many physical and chemical changes. Storing of honey in an atmosphere at too high humidity causes the water vapor adsorption from the environment, which increases the honey water activity (aw).

Another important parameter of the quality is honey colour, which is characteristic to the variety and depends primarily on the presence of carotenoid compounds (mainly β-carotene), xanthophyll pigments, chlorophyll and its derivatives, flavonoids and anthocyanins. Furthermore, the colour of honey affects colloidal substances composed of proteins, beeswax particles, water and bioelements. Storage of honey may change its colour and especially cause darkening. This phenomenon is caused by melanoidins - substances formed in the reaction of sugars, amino acids and vitamin C [8]. The colour of honey is largely determined by the degree of crystallization [4].

The aim of the study was to evaluate selected quality parameters of honey: water activity and colour parameters and their changes during storage under different conditions of humidity. The effect of the botanical origin of honey filtration on these parameters was also examined.

2. MATERIALS AND METHODS

The research material were two varieties of honey: honey lime (A) and buckwheat (B), purchased in the ecological chain stores in Gdynia. The tested honeys were divided into two parts, one of which was subjected to a filtration process. The filtration was carried out after preheating honey samples to a temperature of 45°C (1–2 hours), then the sample was cooled, homogenized and filtered through a filter with a pore size of ≤ 100 microns, at a pressure of 0.3–0.4 MPa. Then, each type of honey (lime A and buckwheat B, filtered F and unfiltered N) was divided into 10 parts for storage in different conditions. In total 40 samples were analysed.

2.1. Evaluation of water content

In both varieties, filtered and unfiltered honeys, the initial water content was determined by refractometry using an Abbe-type refractometer.

2.2. Evaluation of water activity

Determining the initial water activity was performed with AquaLab (Series 3 model TE, Decagon Devices Company USA) with an accuracy ±0.003 at 25 ±1°C. In addition, the water activity of tested honeys A and B, filtered and unfiltered, stored for 90 days under conditions of constant relative humidity (the range of water activity 0,069–0,932) regulated with saturated salt solutions was measured (Table 1). In environments with a water activity above 0.698 crystalline thymol was placed in order to protect against the growth of micro flora. For every area of water activity 2 g (accuracy of 0.0001 g) of each honey sample were weighed in triplicate.

Table 1. The water activity of saturated salt solutions

Salt	The water activity in the temperature 25°C (298 K)
NaOH	0,069
LiCl	0,111
CH_3COOK	0,231
$MgCl_2$	0,330
K_2CO_3	0,440
$Na_2Cr_2O_7$	0,548
KJ	0,698
NaCl	0,754
KCl	0,851
KNO_3	0,932

Source: [7]

2.3. Evaluation of colour parameters

The colour parameters L *, a *, b * was evaluated in CIE International system using Konica-Minolta colorimeter CR 400 for the 2° standard observer and D 65 illuminate. The measurement was performed in the measuring pan made from optical glass (diameter of 34 mm). Colour parameters were analysed in both varieties A and B honeys, filtered (F) and unfiltered (NF) and after 90 days of storage under conditions of constant relative humidity (water activity between 0.069 and 0.932).

2.4. Statistical analysis

The statistical analysis involved the calculation of the basic measures: the mean value and standard deviation. To determine the influence of the type of honey and filtering processes and storage on the analysed parameters the univariate and

multivariate analysis of variance ANOVA were performed. Calculations were performed using Statistica 10.0 (Statsoft Inc.). Statistical hypotheses were verified at the significance level $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

The water activity in the honey may be affected by various factors. To the factors influencing the water activity in honey belong water and monosaccharides contents, and the resulting degree of crystallization [3, 5]. On the water activity can also affect the botanical origin of honey as well as storage. Honey is a supersaturated solution of sugars and therefore crystallizes sooner or later, and this implies a change in water activity. On the other hand heating the honey cause recrystallization, which also affects the water activity of honey. In most types of honey water activity ranges from 0.530 to 0.690 [1]. It was found, that water activity in the studied honeys ranged from 0,567 in filtered buckwheat honey to 0,609 in unfiltered lime honey. A higher initial water content had also unfiltered lime honey.

Table 2. The initial moisture content and water activity of studied honeys

Honey type	Water content [%]	Water actvity [–]
AN	19,20	0,609
AF	18,90	0,595
BN	18,20	0,591
BF	18,40	0,567

Source: Own resources.

It can be seen that initial water activity of filtered honeys was lower than in the same unfiltered. The reason for that could be exposing to the heating before filtration, which could cause changes in some rheological properties of filtered honeys.

It was found that after 90 days of storage in a low humidity of the environment (aw between 0,069 and 0,548) the water activity of tested honeys decreased compared to their initial water activity. However, after exceeding the environmental water activity at 0.69, the increasing in water activity of honeys was observed. The highest final water activity characterized filtered lime honey lime (AF) - aw = 0.925, and filtered buckwheat honey (BF) - aw = 0.926 (fig. 1,2). Probably the filtration process can have a significant effect on crystallisation of honey, and thus on the water activity. During the filtration the crystal nuclei as: pollen, air bubbles and mechanical impurities are removed.

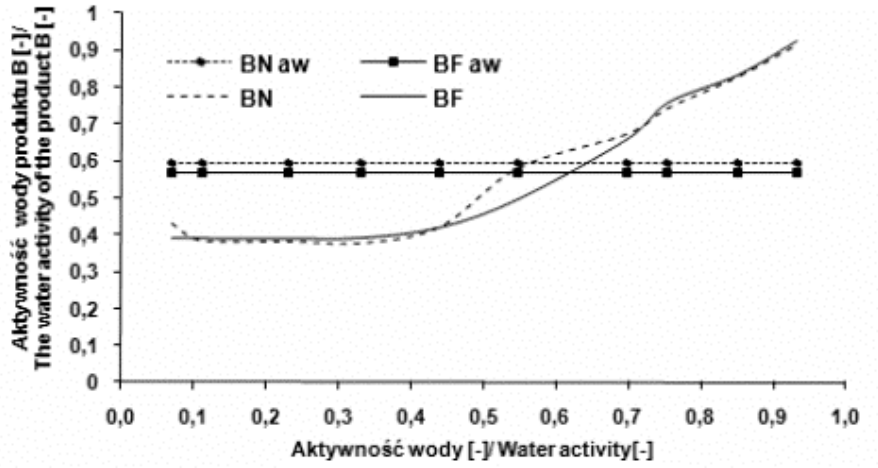

Fig. 1. Changes in the activity of water during storage of buckwheat honey, filtered (BF) und unfiltered (BN)

Source: own research

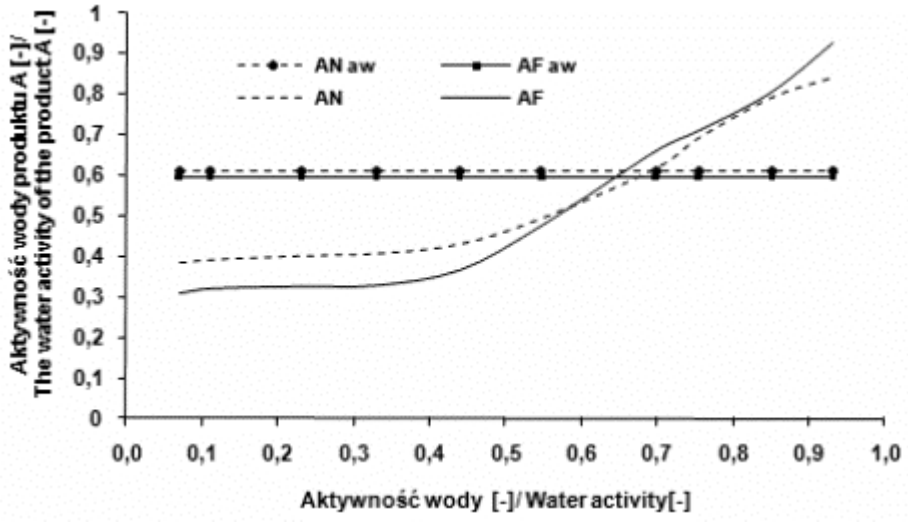

Fig. 2. Changes in the activity of water during storage lime honey, filtered (AF) und unfiltered (AN)

Source: own research.

The study of colour parameters confirmed that the colour is a characteristic feature of the variety. Honey lime were characterized by significantly higher values of all parameters, which means that they were brighter and contain more elements of yellow and red (Table 3.)

Table 3. The average values of the initial colour parameters

Honey	L*	a*	b*
AN	25,93	3,17	9,31
AF	29,22	5,67	16,26
BN	21,94	1,67	4,20
BF	20,41	2,49	2,43

Source: Own research.

The filtration process caused a change in lightness (L *) of both varieties of honey, the lime honey became brighter and buckwheat honey slightly darkened. The value of the parameter a * (redness of colour) regardless of the botanical origin of honey samples increased as a result of filtration, while the value of the parameter b * (yellowness of colour) in lime honey increased and in buckwheat decreased. Analysis of the colour parameters of tested samples showed that storage conditions may also affect the colour parameters, the directions of changes depend on many factors: the initial colour of honey, which is determined by the botanical origin and on the applied processes (Table 4).

Table 4. The change in colour parameters of honeys as a result of storage at different conditions

The colour parameter	Water actvity [–]	Honey AN	Honey AF	Honey BN	Honey BF
L*	0,070	33,365	34,515	25,348	27,065
	0,111	33,460	33,870	27,690	29,533
	0,231	33,758	33,088	27,415	27,460
	0,330	33,148	33,988	27,643	26,868
	0,440	30,028	33,258	26,683	25,870
	0,548	30,160	33,443	26,210	27,533
	0,699	26,800	32,340	23,433	26,780
	0,754	28,670	31,818	24,713	24,280
	0,851	29,608	32,330	23,950	27,468
	0,932	26,198	31,340	23,558	29,203
a*	0,070	-1,363	-1,410	4,603	4,283
	0,111	-1,435	-1,580	3,195	2,410
	0,231	-1,440	-1,493	3,503	2,600
	0,330	-1,285	-1,305	2,618	2,883
	0,440	-0,975	-1,318	3,633	4,213
	0,548	-0,735	-1,033	3,593	2,275
	0,699	0,420	-0,425	3,720	2,498
	0,754	0,453	-0,325	3,485	3,780
	0,851	0,420	-0,318	3,473	1,250
	0,932	1,735	-0,210	2,453	1,390
b*	0,070	12,258	7,945	13,198	12,868
	0,111	10,710	9,100	14,893	12,313
	0,231	13,308	9,323	12,068	14,790
	0,330	13,540	8,655	13,145	14,578
	0,440	12,645	9,288	11,948	11,228
	0,548	11,355	8,150	10,965	13,365
	0,699	8,485	6,593	6,218	9,970
	0,754	7,370	6,540	9,685	8,913
	0,851	10,488	4,565	7,478	10,080
	0,932	8,610	5,333	3,670	9,098

Source: Own research.

It can be seen that during storage under various conditions in most types of honeys value L*decreases with the increasing of the relative humidity – honeys became slightly darker. The exception was filtered buckwheat honey (BF), where there was no such relationship. The value of the parameter a * increased in lime honeys and in buckwheat honeys slightly decreased with the increasing of the relative humidity. On the other hand the value of the parameter b * in most types of honey stored in a low humidity (aw = 0,231-0,330) slightly increased compared to the initial value, but with increasing the relative humidity decreased.

Statistical analysis showed that the filtration process, storage in different humidity conditions as well as variety have impact on the colour parameters values. The combination of these factors is also significantly affected (Table 5).

Table 5. The effect of selected factors on the colour parameters of honey, in the multivariate tests of significance

Factor	The value of the F-statistic	The probability p
Variety	487,69	0,000000
Water actvity a_w	22,52	0,000000
Filtering	77,88	0,000000
Variety* Water actvity a_w	5,74	0,000000
Variety*Filtering	124,46	0,000000
Water actvity a_w* Filtering	7,30	0,000000
Variety* Water actvity a_w* Filtering	6,61	0,000000

Source: Own research.

CONCLUSIONS

1. Conducted research indicates that in the relative low humidity of the environment (water activity ranged from 0,069 to 0,548) the water activity of tested honeys decreased in comparison with their initial water activity.
2. Filtration process influences the water activity, filtered honey stored in high humidity (water activity 0,754-0,932) were characterized by higher values of the water activity, than the same unfiltered honey.
3. Processes, such as storage in various relative humidity conditions and filtration also have a significant impact on the colour parameters of honey and the directions of changes depend on many factors: the initial colour of honey and the applied processes.

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