Effect of dehydration on instrumental sensory characteristics of bee pollen.

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Efecto de la deshidratación sobre las características instrumentals sensoriales del polen de abejas

Efecte de la deshidratació sobre les característiques instrumentals sensorials del pol·len d'abelles.

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ABSTRACT

Colombian beekeeping producers and academic sector are developing research projects for using bee products by developing and improving their nutritional and functional quality, especially new food products with bee pollen inclusion. Bee pollen is a promising raw material for the production of functional foods because of its bioactive characteristics. In this work sensory stability of wet pollen, sun dried pollen and cabin dried pollen was evaluated during accelerated storage at 30, 40 and 50°C, taking into account different parameters such as volatile compounds profile by using a commercial electronic nose, fracturability of bee pollen grains with texture analyzer, colour change in CIELAB scale using a commercial colorimeter and water activity. It was found that electronic nose allows differencing bee pollen samples according to their water activity and distinguishing different volatile compounds profiles presented during storage. Bee pollen samples with a high water activity showed volatile compounds profile major changes during storage as well as their colour change. Bee pollen samples with a low water activity presented a change in their smell associated with fat rancidity, which is directly related to the texture.

Keywords: Dehydration, electronic nose, pollen, shelf-life,

RESUMEN

Los productores apícolas colombianos y el sector académico están desarrollando proyectos de investigación para el aprovechamiento de productos apícolas desarrollando y mejorando su calidad nutricional y funcional, especialmente nuevos productos alimenticios con inclusión de polen de abeja. El polen de abeja es una materia prima prometedora para la producción de alimentos funcionales debido a sus características bioactivas. En este trabajo se evaluó la estabilidad sensorial de polen húmedo, polen secado al sol y polen secado en cabina durante almacenamiento acelerado a 30, 40 y 50°C, teniendo en cuenta diferentes parámetros como perfil de compuestos volátiles mediante el uso de una nariz electrónica comercial, fracturabilidad de abeja granos de polen con analizador de textura, cambio de color en escala CIELAB usando un colorímetro comercial y actividad de agua. Se encontró que la nariz electrónica permite diferenciar muestras de polen de abeja según su actividad de agua y distinguir diferentes perfiles de compuestos volátiles presentados durante el almacenamiento. Las muestras de polen de abeja con una alta actividad de agua mostraron cambios

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importantes en el perfil de compuestos volátiles durante el almacenamiento, así como en su cambio de color. Las muestras de polen de abeja con baja actividad de agua presentaron un cambio en su olor asociado a la rancidez de la grasa, lo que está directamente relacionado con la textura.

Palabras clave: Deshidratación, nariz electrónica, polen, vida útil

RESUM:

Els productors apícoles i el sector acadèmic colombians estan desenvolupant projectes de recerca per a l'ús de productes apícoles desenvolupant i millorant la seva qualitat nutricional i funcional, especialment nous productes alimentaris amb inclusió de pol·len d'abella. El pol·len d'abella és una matèria primera prometedora per a la producció d'aliments funcionals per les seves característiques bioactives. En aquest treball es va avaluar l'estabilitat sensorial del pol·len humit, el pol·len assecat al sol i el pol·len sec de cabina durant l'emmagatzematge accelerat a 30, 40 i 50 °C, tenint en compte diferents paràmetres com el perfil de compostos volàtils mitjançant l'ús d'un nas electrònic comercial, la fracturabilitat de l'abella. grans de pol·len amb analitzador de textura, canvi de color a escala CIELAB mitjançant un colorímetre comercial i activitat de l'aigua. Es va trobar que el nas electrònic permet diferenciar les mostres de pol·len d'abella segons la seva activitat aquàtica i distingir els diferents perfils de compostos volàtils presentats durant l'emmagatzematge. Les mostres de pol·len d'abella amb una alta activitat aquàtica van mostrar canvis importants en el perfil dels compostos volàtils durant l'emmagatzematge, així com el seu canvi de color. Les mostres de pol·len d'abella amb poca activitat aquàtica van presentar un canvi en la seva olor associat a l'enranciment del greix, que està directament relacionat amb la textura.

Paraules clau: Deshidratació, nas electrònic, pol·len, vida útil

INTRODUCCIÓN

Bee pollen is the male gametophyte of flowers important for the reproduction of plants[1]. It is formed by the cluster of pollen obtained by bees from one or more botanical sources. Bee pollen is carried by bees to the hive in which beekeepers collected it through traps[2]. Chemical composition of bee pollen depends on its botanical origin and harvesting seasons[3]. Water content ranges are around 16 to 20% for fresh bee pollen and 4% for dried bee pollen[4]. Protein content is around 20-25%. Bee pollen contains vitamin B, beta-carotene, vitamins C, D and E, minerals (2.5 to 6%), trace elements, growth hormones and antibiotic active substances[5]. Due to the low hives productivity around the world there are few works related to bee pollen processing, like[6-8]. In Colombia, the highest production of bee pollen is around 30 kg of bee pollen per hive per year at Cundiboyacense Colombian highland region, located at 2000-3000 masl[9]. Colombian bee pollen has been extensively studied and characterized. It has significant levels of protein (20.5 - 24.4%), crude fiber (6.4 - 7.2) fat (4.4 - 5.7%), ash (2.2 - 2.3%) [2,10-12] and important amounts of phenolic compounds, flavonoids, carotenoids and antioxidants [2,9-10,12-15]. Considering the valuable nutritional and bioactive contribution of bee pollen, there have been new products development with its inclusion. These include breads preparation with herbs addition, cereal bars, fruit pulps and sauces and granola[16-19]. The new products have an improved nutritional quality compared to commercial products. Similarly, bee pollen has been used as a nitrogen source in fermented beverages from honey[20-25] as well as it was fermented to increase its digestibility, anticipating a potential inclusion in food products with probiotic effects[26-29]. However, the fresh wet bee pollen may have a high microbiological activity[9,12,25-26] that may affect final products quality. Therefore, it is necessary to process it in order to be used in different products[9,27]. The process used to increase its quality is a drying process combined with a subsequent heat treatment[11,13,30]. Drying decreases free water content and water activity, and heat treatments decrease microorganisms that may be present.

Drying processes and heat treatments cause significant sensory changes in food. Although there are many studies that suggest methodologies for food sensory evaluation are time consuming and involve a lot of personnel and material[20,21,31]. However, it is possible to measure objectively some sensory characteristics with new instrumental tools such as the smelling profile by using an electronic nose, texture with texture analyser and color changes with a colorimeter. Those sensory changes measured with electronic devices combined with multivariate statistical techniques allow performing stability studies very fast [32-36].

MATERIALS AND METHODS

SAMPLES:

This study was performed at the Instituto de Ciencia y Tecnología de Alimentos (ICTA) of the Universidad Nacional de Colombia, (Bogotá, Colombia). Wet (1), sundried (2) and artificially cabin dried (3) bee pollen samples were used. These samples were provided by the Apiary Los Cerezos (Viracachá, Colombia). For each type of bee pollen sample, it was used 30±1 g of bee pollen packed in low density polyethylene bags. All samples were stored at 30, 40 and 50±1°C and 65% Relative Humidity. Sampling was performed in duplicate eight times, at 0, 1, 2, 6, 7, 8, 9 and 12 days of storage.

ELECTRONIC NOSE:

Bee pollen samples smelling profile was determined by using a commercial portable electronic nose PEN3 (AIRSENSE Analytics GmbH, Schwerin, Germany) with a 10 semiconductor sensors array: W1C (aromatics), W5S (nitrous oxide and ozone), W3C (aromatics), W6S (H_2, O_2 and CO_2), W5C (alkanes), W1S (methane), W1W (terpenes and organic sulphur compounds), W2S (alcohols), W2W (organic sulphur compounds) and W3S (methane and compounds aliphatic), according to standardized and validated methodology[37].

INSTRUMENTAL SENSORY PROPERTIES:

Colour change was determined in Hunter scale LAB, CIELAB (L, a, b) where scale: L* indicates lightness, a* indicates chromaticity on the green axis (-) and red (+) b* chromaticity in the blue axis (-) and yellow (+), by using a commercial colorimeter MiniScan Spectro model MS / B, fuzzy geometry. Fracturability was determined by a compression test in a texture analyzer TA-XT Plus (Stable Micro Systems, United Kingdom) calibrated with a load of 500 g. It was used at a P/20 cylinder, a compression speed of 0.5 mm/s and a distance of 4 mm. Finally, water activity was determined by using a Fast-Lab water activity (GBX, Ireland). All results were analysed in a PCA (Principal Component Analysis) with MATLAB software (Mathworks, USA).

RESULTS AND DISCUSSION

SMELLING PROFILE

Smelling profile for all samples (wet, sundried and cabin dried bee pollen) was different, and it change according to storage time and temperature (30, 40 and 50°C). Before storage, smelling profile was analysed by principal component analysis and the results are shown in a biplot graph (Figure 1) in which the first two principal components achieved explain 99% of the total data variance. This analysis allows establishing a clear difference in smelling profile between samples wet and dehydrated bee pollen, which indicates the strong influence of dehydration process in smelling profile, and they confirm the electronic nose is a practical approach for pollen classification, even if sampling is performing in the atmosphere[7] or in a product[34].

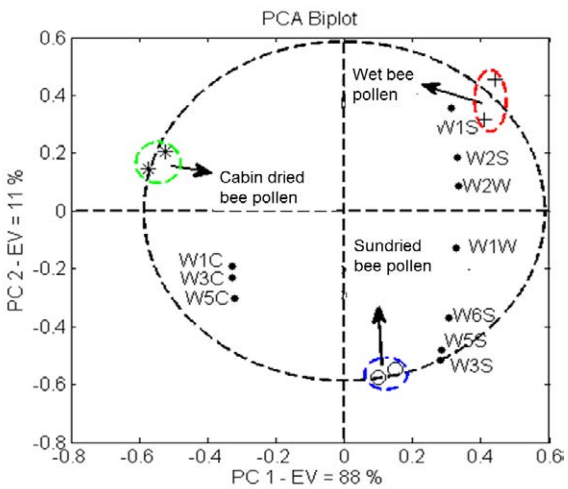


Figure 1. *Smelling profile of bee pollen with different drying processes at the beginning of storage: red wet bee pollen, green cabin dried bee pollen, blue sundried bee pollen*

However, during storage at different temperatures, bee pollen samples follow different degradation processes and these changes are reflected in changes of smelling. Figure 2 is a biplot PCA of smelling profile of wet bee pollen during storage at 30, 40 and 50°C, the first two components explain 90% of the total data variance. Smelling profile of wet bee pollen during storage at 30°C is generally defined by the sensors before reacting with the organic sulphur compounds, (W1W and W2W) nitrous oxide, and methane breathing gases (W5S, W6S and W1S). Those changes may be related to bioprocesses taking place inside bee pollen because presence of molds and yeasts[38]. At 40 and 50°C, smelling profiles for wet bee pollen are represented by sensors that react to aromatic compounds (W5C, W1C and W3C) which could indicate a dehydration process[39]. At 50°C, samples stored at the beginning of storage present a smelling profile with many changes but then it remains stable.

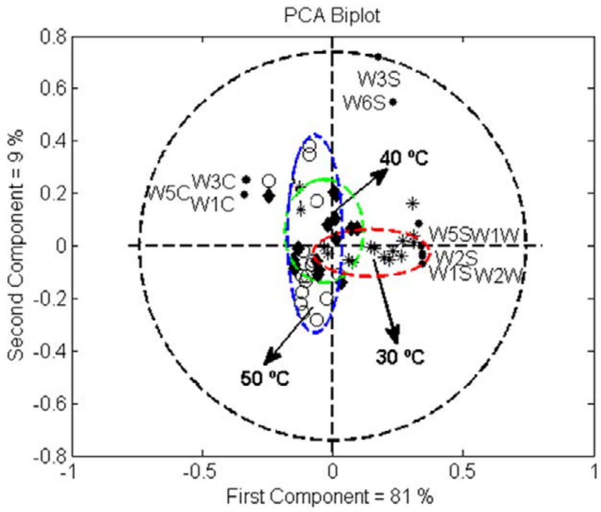


Figure 2. *Smelling profile of wet bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C*

In case of dehydrated pollen, figures 3a and 3b show the behaviour of dried bee pollen during storage at 30, 40 and 50°C. Figure 3a is a PCA biplot of the first two principal components that explain 89% of the total data variance for sundried bee pollen. Figure 3b shows the 90% of the total variance for cabin dehydrated bee pollen. Results show a different behaviour as it was observed during storage of wet bee pollen (figure 2), because dried bee pollen shows higher changes on smelling profile at a higher temperature (50°C), which indicates it is occurring a spoilage associated to lipids rancidity[40], because Colombian bee pollen has a lipid content between 2.8 and 9.7%[2]. Bee pollen samples with a lower water activity (dehydrated cabin) present a fast fat rancidity process. These smelling profiles confirm bee pollen dehydration processes are adequate to prevent spoilage caused by microorganisms. However, an excessive dehydration also causes fats spoilage of bee pollen[11].

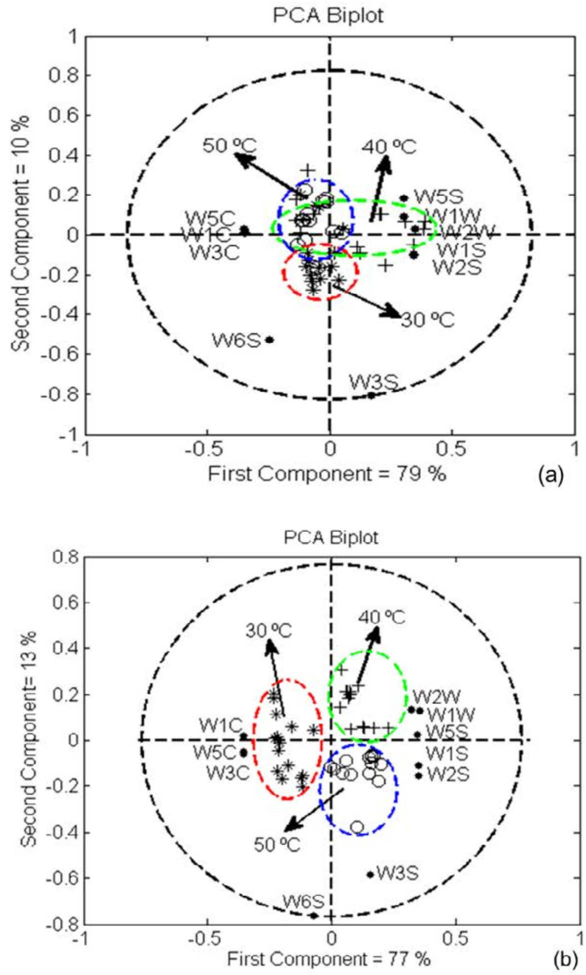


Figure 3. *(a) Smelling profile of sundried bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C* ***(b)*** *Smelling profile of sundried bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C*

INSTRUMENTAL SENSORY ANALYSIS

Instrumental sensory measurements as water activity (a_w), colour changing (L, a, b) and fracturability (hardness) can also differentiate bee pollen according to dehydration process. Figure 4 shows a PCA able to explain 92% of data variance for instrumental sensory determinations of wet, sundried and cabin dehydrated bee pollen. Cabin dehydrated bee pollen had the highest hardness, wet bee pollen had the highest content of water activity and a colour parameter (blue-red chromaticity), meanwhile sundried bee pollen showed the highest lightness and b colour parameter (green-yellow chromaticity).

However, during storage at 30, 40 and 50°C bee pollen presents significant changes that can be seen with all parameters shown in figures 5a, 5b and 5c, where these PCA can explain the 91%, 87% and 82% of data variance for wet, sundried and cabin dried pollen respectively. During storage at 30, 40 and 50°C, colour change is considered the critical variable for wet bee pollen, unlike dried bee pollen, where the spoilage is reflected by significant changes in water activity. So these results confirm not only drying processes but also storage conditions can affect sensory characteristics of bee pollen. In case of wet bee pollen, it is highly susceptible to molds and yeasts spoilage, causing changes in the smelling profile by bioprocesses and changes in colour appearance of fungal mycelia, therefore for preserving it, it has to be stored at temperatures below 4°C. Otherwise, dehydration processes can stabilize sensory properties of stored bee pollen. However, its fat content contributes to rancidity process when its water activity is less than 0.3 and those changes can be detected with an electronic nose. Therefore, the stability of dehydrated bee pollen depends largely on its water activity after dehydration processes and on water steam permeability of the packaging and storage temperature. It is very important to take into account that packaging with a high water permeability may result in rehydration of bee pollen during storage, causing sensory and microbiological growth potential changes, while at high temperatures may cause hardening and rancidity.

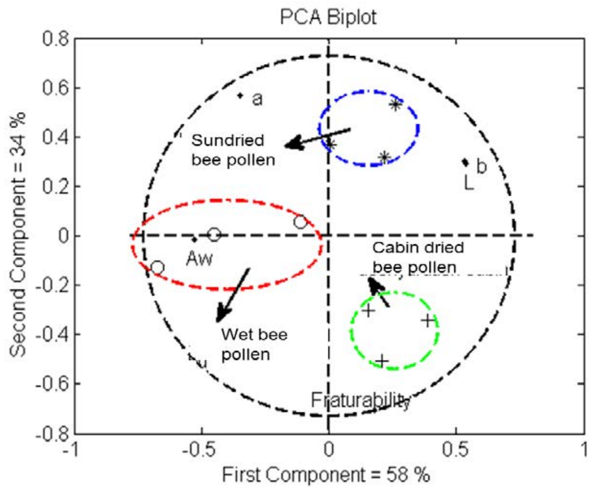
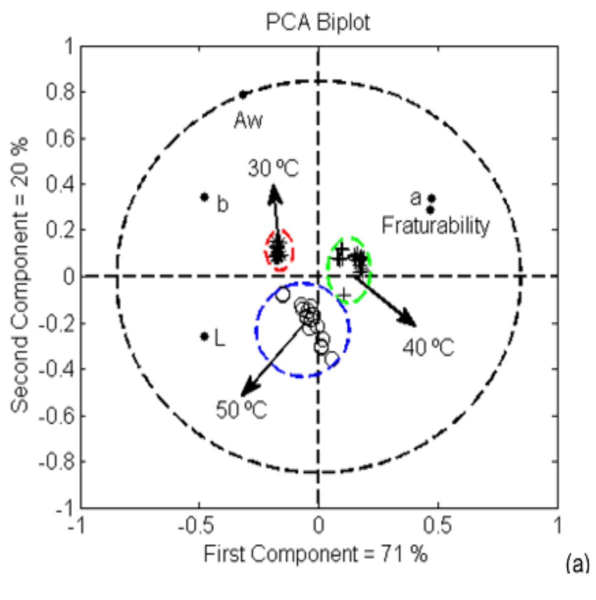


Figure 4. *Instrumental sensory profile of bee pollen with different drying processes at the beginning of storage: red wet bee pollen, green cabin dried bee pollen, blue sundried bee pollen*



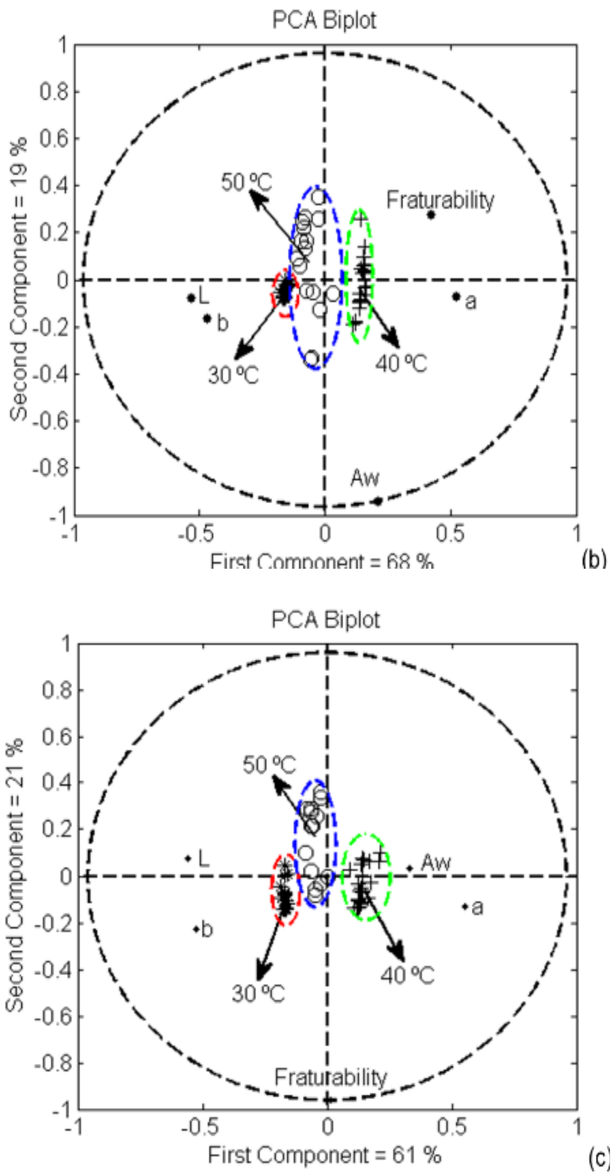


Figure 5. *(a) Instrumental sensory profile of wet bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C (b) Instrumental sensory profile of sundried bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C (c) Instrumental sensory profile of cabin dried bee pollen at different storage temperatures: red 30°C, green 40°C, blue 50°C*

CONCLUSIONS

Dehydration processes cause significant changes in smelling profile and the sensory properties of bee pollen. Colour is the most critical quality variable for wet bee pollen during storage, while water activity and smelling profile are critical for dehydrated bee pollen, which indicate loss of stability. So, it is demonstrated that it is possible to monitor changes that occur when bee pollen is subjected to drying processes and during its storage at different temperatures.

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