BIOCHEMICAL AND STATISTICAL ANALYSIS OF FREE AND BOND WATER RATIO IN JONATHAN APPLES

ANALIZA BIOCHIMICĂ ŞI STATISTICĂ A RAPORTULUI DINTRE APA LIBERĂ ŞI APA LEGATĂ LA MERELE JONATHAN

TRINCĂ Lucia Carmen [1], CĂPRARU Adina Mirela, AROTĂRIȚEI D.[2], CĂLIN M.[1], CHIRUȚĂ C. [1]
e-mail: lctrinca@yahoo.com

Abstract. *Water may exist as free water and bound water in food substrates. Free water is available for chemical interactions and stimulates the development of microrganisms being-not linked by other biochemical compounds in food substrate. Bound water is retained in the food matrix substrate through interactions with functional groups of biochemical compounds and exhibits limited biological activity. Food substrates with the same water content may exhibit different perishability due to changes in the ratio of free water and bound water, hence for technological practice, the study of water forms, as well as of their relationship, provides useful information to estimate the conditions and period of validity .In this paper status of water content in Jonathan apples was studied. Investigations included physico-chemical analysis methods as well as imaging analysis. Statistical calculation showed strong correlation between free and physico-chemically bound water determined by oven drying for pieced or grinded apples.*
Key words: *free water, bound water, Jonathan apples.*

Rezumat. *Apa din substraturile alimentare poate fi apă liberă şi apă legată. Apa liberă este accesibilă pentru interacţiuni chimice şi asigură dezvoltarea microorganismelor nefiind legată de moleculele altor compuşi biochimici din substratul alimentar. Apa legată este reţinută în matricea substratului alimentar datorită interacţiunilor cu grupările funcţionale ale compuşilor biochimici şi are activitate biologică limitată. Substraturile alimentare cu acelaşi conţinut de apă pot prezenta perisabilitate diferită datorită variaţiei raportului dintre apa liberă şi apa legată, astfel încât pentru practica tehnologică studiul formelor de apă şi a raportului acestora oferă informaţii pentru stabilirea condiţiilor şi a perioadei de valabilitate. Lucrarea prezintă date privind raportul principalelor forme de apă la merele Jonathan. Investigaţiile au cuprins metode de analiză fizico-chimică şi analiză imagistică. Calculul statistic a evidenţiat interdependenţe între apa liberă şi apa legată fizico-chimic determinată prin uscare la etuvă pentru mere bucăţi şi mojarate.*
Cuvinte cheie: *apa liberă, apă legată, mere Jonathan.*

INTRODUCERE

Water may exist as free water and bound water in food substrates.

[1] University of Agricultural Sciences and Veterinary Medicine of Iaşi, Romania
[2] "Gr. T. Popa" University of Medicine and Pharmacy Iasi, Romania

(Campeanu et al., 2009). Free water is available for chemical interactions and stimulates the development of microorganisms being-not linked by other biochemical compounds in food substrate. Bound water is retained in the food matrix substrate through interactions with functional groups of biochemical compounds and exhibits limited biological activity.

Food substrates with the same water content may exhibit different perish ability due to changes in the ratio of free water and bound water, hence for technological practice, the study of water forms, as well as of their relationship, provides useful information to estimate the conditions and period of validity (Neamțu et al., 1995).

In this paper status of water content in Jonathan apples was studied. Investigations included physico-chemical analysis methods as well as imaging analysis. Statistical calculation showed strong correlation between free and physico-chemically bound water determined by oven drying for pieced or grinded apples. Water forms and their relationship provides practical information for agriculture, horticulture, biology, medicine (Gherghi et al., 1983). Ratio of free /bound water may be a useful index for assessment of specific physiological processes which characterizing the metabolic condition of a living organism.

MATERIALS AND METHODS

Jonathan apples were purchased from the city market with weight ranging between 81-103 g g and normal, healthy appearance.

Periodic measurements for various types of water monitoring were carried out for 60 apples (by considering the lot of ten apples stored under the same conditions of temperature and humidity).

Determination of free water was performed for twenty days by weighing (every five days) the apples, the difference in mass being attributed to the percentage of free water (Trincă et al., 2013). Bound water was performed by oven drying of the samples. For oven drying. 5 g sample of Jonathan apple (chunks or grinded) have been subjected to drying at 90^0 C temperature until constant mass ($\Delta<10^{-2}$ g).

Water content was determined according to eq.(1):

$$H_2O\ \% = \frac{m - m_1}{m_2} \times 100 \qquad \textbf{(1)}$$

m = mass dish + mass sample before drying, $\mathbf{m_1}$ = mass dish + mass sample after drying, $\mathbf{m_2}$ = mass of the sample.

An AF-S DX Zoom-Nikkon ED 18-70mm, f / 3.5-4.5 G IF was used in order to achieve image processing, while for ensuring the same calibration, photographs were taken by placing apples in a box aiming at keeping the same distance objective - image.

In order to process image analysis the following descriptors were considered: average intensity, smooth, third order moment, uniformity, and entropy, obtained by processing the photos of the apples. The processing stage involved

segmentation, approximation of circle parameters, extraction of circle parameters and extraction of a rectangular area form for the apple (Figure 1).

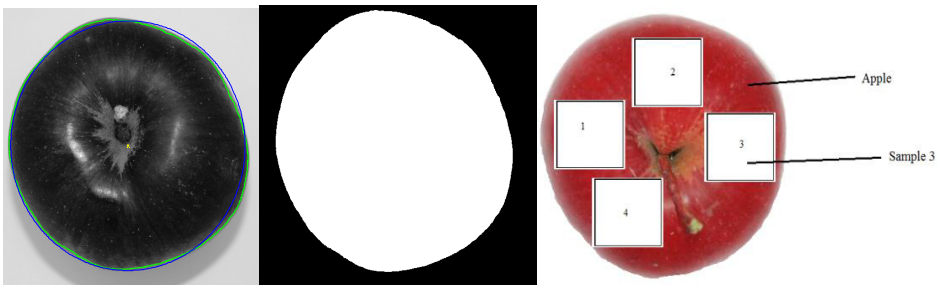

Fig. 1 - The processing stage of Jonathan apples

By MATLAB function the correlation coefficients have been identified for free water versus physico-chemical water in day five and day twenty. For the statistical analysis of the recorded differences it was applied the method of analysis report variances (X) and Pearson correlation coefficient. The determination gradient has been calculated (by considering the case $p < 0.05$ statistically significant). Statistical evaluation was performed using SYSTAT 13 (SYSTAT SOFTWARE, Inc. CHICAGO).

RESULTS AND DISCUSSION

Free water content increased from 1,423% to 5,363 % on the day 20 compared to day 5, which reveals that the main water loss for Jonathan apples variety occurs in the form of free water through perspiration.

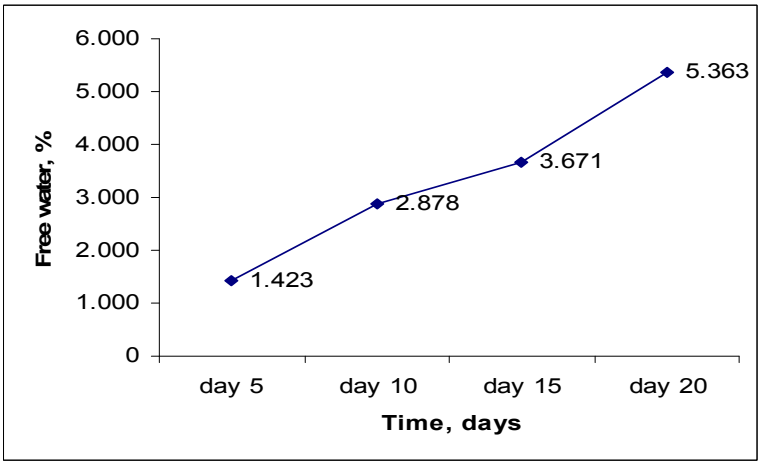

Fig. 2 - Free water loss dynamics of Jonathan apples

Experimental results showed that dehydration of apples was more intense in the first half of the testing period, after which it decreased in intensity, fact noted and in previous experiments (Trincă et al., 2012).

Compared with data from literature (Grădinaru et al., 2006, Slegun et al., 2009, Nistor , 2011, Vesali et al., 2011) in the case of Jonathan apples a moderate loss of free water was registered in the testing period.

The removal of free water highlights the progress of normal metabolic/ physiologic processes in the apples stored.

Free water loss affects the apples freshness by modifying dimensions, skin condition and colour, consistency and juicy or the taste and flavour. (Beceanu, 2010).

Imaging analysis of the main parameters of the texture features (coloration intensity-I, smoothness-S, third ordin moment-μ, density index-DI) showed (fig. 2) a very good correlation (r^2= 0,997) between the loss of free water and the reducing size of apples (DI) and a good correlation (r^2 = 0,886) between the loss of free water and the intensity of the coloration (I) in the experimental period.

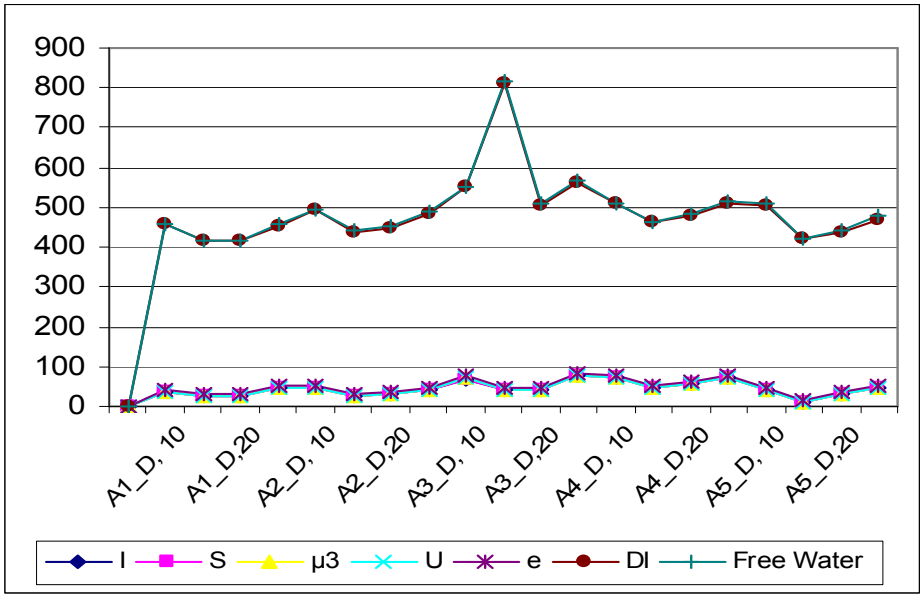

Fig.3 – Variation of the main imagistic parameters related with free water loss in Jonathan apples (Apple_number, Day, number)

Physico-chemical water (determined by oven-drying) decreased with 3,268 % for chunks apples and with 2,676 % for grinded apples on day 20 versus day 5. The analysis of the results revealed as water loss and dehydration increased- also decreased the values of bound water both for grinded and chunks apples.

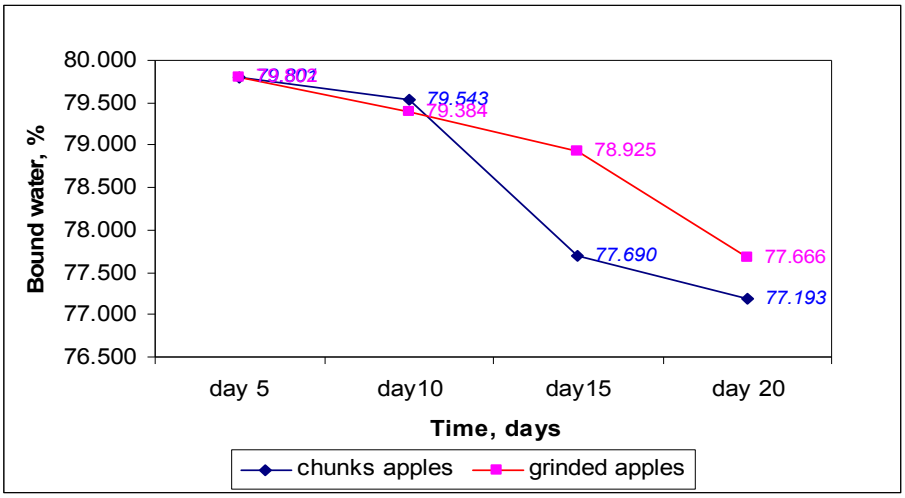

Fig.4 - Bound water loss dynamics (%) of Jonathan apples

Statistical processing of the results for chunk and grinded apples has not revealed a linear correlation between the individual parameters. This fact can be explained by considering the grinding as a process of cellular destruction - difficult to quantify in terms of the amount of intracellular water released. In the case of grinded apples the cellular walls were destroyed - which it caused the release of intracellular water determined as bound water.

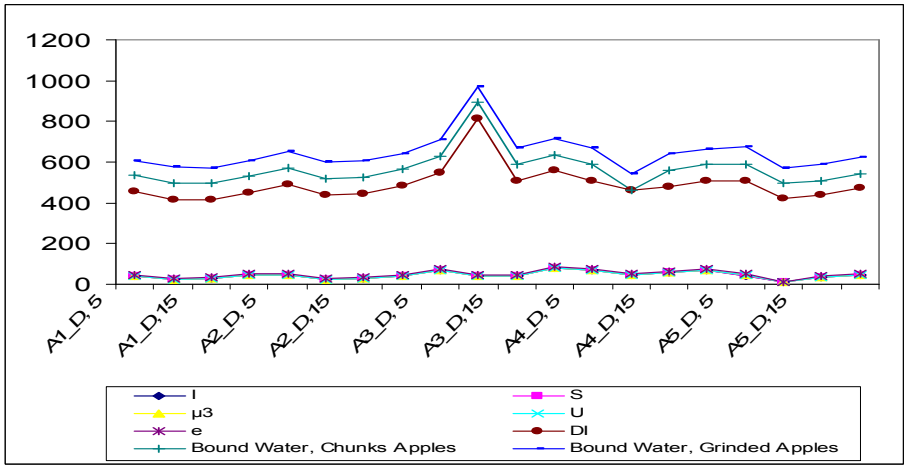

Fig. 5 - Variation of the main imagistic parameters related with bound water in Jonathan apples (Apple_number, Day, number)

Imaging analysis of the texture features (fig. 5) main parameters (coloration intensity-I, smoothness-S, third ordin moment-μ, density index-DI) revealed a very good correlation only between bound water and the reducing size of apples (DI) for both chunks (r^2 = 0,968) and grinded (r^2 = 0,942) apples .

CONCLUSIONS

1. Monitoring of Jonathan apples by imagistic and chemical analysis showed a a very good correlation (r^2= 0,997) between the loss of free water and the reducing size of apples (DI) and a good correlation (r^2 = 0,886) between the loss of free water and the intensity of the coloration (I) in the experimental period.

2. Imaging analysis of the texture feature's parameters revealed a very good correlation only between bound water and the reducing size of apples (DI) for both chunks (r^2 = 0,968) and grinded (r^2 = 0,942) apples .

3. Statistical calculations showed interdependencies between the loss of the free water, content of bound water and the size's changes of Jonathan apples what it may provides the prerequisites for developing predictive models for the considered parameters.

REFERENCES

1. Beceanu D., 2010 - *Tehnologia produselor horticole*, Partea I, Ed. Pim.

2. Campeanu Gh., Neata G., Darjanschi G., 2009 - *Chemical Composition of the Fruits of Several Apple Cultivars Growth as Biological Crop*, Not. Bot. Hort. Agrobot. Cluj 37 (2), Print ISSN 0255 -965X; Electronic ISSN 1842-4309, p. 161-164;

3. Gherghi A., Burzo I., Mărgineanu L., Deneş S., Dobreanu M., Pattantyus K., 1983 - *Biochimia şi fiziologia legumelor şi fructelor*, Editura Academiei Republicii Socialiste România, Bucureşti.

4. Grădinariu G., Istrate M., Zlati C., Dascălu M., 2006 – *Researches concerning the influence of ecological factors upon some apple varieties quality and storage proprieties*, U.Ş.A.M.V., Iasi University Annals, E.S.N.A. XXXVI Annual Meeting, Iasi, Roumania.

5. Neamțu G., Cîmpeanu Gh., Socaciu C., 1993 – *Biochimie vegetală (partea structurală)*, Editura Didactică şi pedagogică, R.A. Bucureşti.

6. Nistor O., 2011 - *Study of the apple parameters variation during refrigeration storage*, The Annals of the University "Dunarea de Jos" Galati.

7. Sleagun G., Popa M., 2009 – *Determination of the moisture content in infrared dried apples,* The Annals of the University "Dunarea de Jos" Galati, Fascicle VI, Food Technology, New Series, Year III, p. 39-44.

8. Trincă L.C., Căpraru A.M, 2013 - *Biochimia Alimentelor, Manual de lucrări practice*, Ed. Pim.

9. Trincă L.C., Căpraru A.M., Arotăriței D., Volf I., 2012 - *Cercetări privind determinarea conținutului de apă pentru merele din soiul Jonathan prin metode clasice şi inovative*, Lucrări Ştiințifice USAMV Iaşi, vol.1 (55), Seria Horticultură, p. 111-116.

10. Vesali F., Gharibkhani M., Komarizadeh M., 2011- *An approach to estimate moisture content of apple with image processing method*, AJCS 5(2), p. 111-115.