

SHELF LIFE STABILITY OF OSMODEHYDRATED WHITE CABBAGE – PCA ANALYSIS

ROK UPOTREBE OSMOTSKI SUŠENOG KUPUSA – PCA ANALIZA

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ABSTRACT

The aim of the present work is to determine the shelf life of osmodehydrated white cabbage in three different osmotic solutions. During 90 days of storage, chemical and color parameters were analysed together with the sensory acceptance and microbiological profile of the osmotic treated (OT) cabbage. Hybrid "Bravo" was considered within this research because of its high yield and wide cultivation in the Province of Vojvodina. Solutions of sucrose and chloride were applied so as sugar beet molasses in OT. OT cabbage was packed in MAP with variation in a gas mixture of 40:60/CO₂:N₂ (atmosphere 1) and 80:20/CO₂:N₂ (atmosphere 2). The shelf-life evaluation had shown good sensorial acceptance and satisfying microbiological quality. The obtained principal component analysis (PCA) was able to present the experimental results. The PCA analysis is easy to implement and could be effectively used for predictive optimization of the osmotic treatment.

Keywords: Cabbage, Osmotic treatment, Shelf-life, PCA, MAP.

REZIME

Cilj ovog rada je da se analizira održivost osmotski dehidriranog belog kupusa. Hibrid "Bravo" je analiziran i podvrgnut osmotskom tretmanu u tri različita osmotska rastvora. Rastvor S1 je zasićen rastvor šaroze i natrijum hlorida u vodi, rastvor S2 je mešavina rastvora S1 i melase šećerne repe u odnosu 1:1 i rastvor S3 je čista melasa sa sadržajem suve materije od 84,05 %. Nakon osmotskog tretmana kupus je pakovan u poliamid/polietilen kese na laboratorijskoj pakerici sa vakuum zaptivanjem uz prethodno uvođenje modifikovane atmosfere u mešavini gasova od 40:60/CO₂:N₂ (atmosfera 1) i 80:20/CO₂:N₂ (atmosfera 2). Tokom 90 dana skladištenja praćeni su mikrobiološki i hemijski parametri, instrumentalno merenje boje i senzorska svojstva. Kod kupusa dehidriranog u sva tri rastvora zabeležen je pad sadržaja ukupnih kiselina i posledično rast pH vrednosti tokom skladištenja, naročito kod rastvora S3. Pakovanje u MAP bez prisutva vazduha dovelo je do pada ukupnog broja mikroorganizama dok je rast kvasaca i plesni u potpunosti inhibiran. Tokom skladištenja dolazi do sukcesivnog smanjenja sadržaja L-askorbinske kiseline u kupusu i retencija je najveća nakon osmotskog rastvora S2 i iznosi 15,25 % nakon skladištenja od 90 dana. Senzorska analiza je pokazala zadovoljavajući kvalitet osmotski dehidriranog kupusa nakon 90 dana skladištenja. PCA analiza je uspešno opisala eksperimentalne rezultate. PCA analiza se može primenjivati u procesu optimizacije osmotskog tretmana u cilju dobijanja željenog kvaliteta finalnog proizvoda i efikasno koristiti u prediktivne svrhe.

Ključne reči: Kupus, Osmotski tretman, Održivost, PCA, MAP.

INTRODUCTION

Agricultural crops such as fruits, spices, vegetables are thermo-sensitive products with high nutritional and phytochemical properties (antioxidant, bioactive compounds, etc.) Fruits and vegetables contain high moisture content (80–95 %) which makes them very susceptible to microbial damage leading to shorter shelf-lives and high postharvest losses (Osae et al., 2020). Food technologists are still looking for methods of processing raw fruits and vegetables which will allow obtaining attractive foods fortified with components that are often lost during thermal and mechanical processing (Ciurzyńska et al., 2016; Kowalska, 2005). Non-thermal pretreatment techniques, such as osmotic treatment (OT), have been considered to be one of the most significant pretreatment technologies available for the preservation of fruits and vegetables (Osae et al., 2019). During OT browning reactions are minimized (Bozkir et al., 2019), while nutritional improvement and new sensorial

characteristics have been previously reported (Cvetković et al., 2019; Siriamornpun et al., 2015; Tolera and Abera, 2017). The most frequently used osmotic solutions are sucrose and sodium chloride (Lech et al., 2018). Some investigations were conducted using sugar beet molasses as the osmotic solution for dehydration of plant origin food (Knežević et al., 2019; Koprivica et al., 2014; Nićetin et al., 2017) and animal origin food (Ćurčić et al., 2015; Šuput et al., 2019). The cabbage (*Brassica oleracea* var. *acephala*) is considered a "superfood" due to the rich content of calcium, folate, riboflavin, vitamins C, K and A (Brito et al., 2020). Consumption of cabbage in the Republic of Serbia is 20 kilograms per capita, which is significantly higher than the world average (Vlahović, 2015). Hybrid Bravo is widely harvested due to its high yield and uniform quality. Previous works reported that MAP significantly reduced the levels of total mesophilic microorganisms on cabbage (Barbosa et al., 2016; Hyun et al., 2015). Within this work white cabbage hybrid, Bravo was osmotically treated, packed in MAP and evaluated during 90 days of storage period.

MATERIALS AND METHODS

Cabbage heads, hybrid “Bravo”, late fall variety, were harvested in northern Serbia (Province of Vojvodina) in the village Futog. Sugar beet molasses was obtained from the sugar factory Pećinci, Serbia. Overall dry matter content in sugar beet molasses was 85.04 %. Cabbage leaves were cut into square shapes with dimensions of approximately 1×1 cm. Solution S1 was a mixture of sucrose and NaCl in the relation of 1.200/350 g/l of distilled water. The second osmotic solution (S2) was a mixture of S1 and molasses in the same quantities with 70 % dry matter. Sugar beet molasses was used as a third osmotic solution (S3). The cabbage leaves were put in a glass jar with osmotic solutions with a material/solution ratio of 1:5 (w/w). The experiments were conducted at the temperature of 20 °C, under atmospheric pressure, for 5h. After OT in three different solutions, washing and draining, 50 g cabbage samples were packed using laboratory vacuum sealer (Audion Elektro, Swissvac) with teflonized heating areas in polyamide/polyethylene (PA/PE) bags of 14 × 20 cm size (0.08 cm thickness, <20 g/m² (24h, 1 ATM) water vapour permeability, and <20 cm³/m² (24h, 1 ATM) oxygen permeability). After vacuuming the content, the chosen gas mixture was inserted before bag heat sealing. The content of the gas mixture was 40:60/ CO₂:N₂ (atmosphere 1) and 80:20/CO₂:N₂ (atmosphere 2). Storage of packed samples was conducted in a refrigerator at 4-8 °C for 90 days for all samples. Colour was determined by a chromameter (Minolta Co., Type CR 400, Osaka, Japan) on the top surface of the samples. Because of the particle dispersion, colour quantifications were measured at five sections of the samples (at the centre and four corners) with a minimum of ten readings per sample, and the results were averaged. Colour characteristics were presented in the CIE L*a*b* system.

The microbiological profile of osmodehydrated cabbage was examined by determining a total number of microorganisms (TN) (ISO 4833, 1991), yeasts and molds (ISO 21527, 2008). The pH of the cabbage was determined by a mobile pH meter (ExStickTM, Extech Instruments, USA). Acidity was determined by the standard method (SRPS ISO 750, 2003). The methodology of the sensory analysis was carried out in accordance with the Guidelines for the Assessment of Food Products by Methods of Scale (ISO 4121, 2003). For L-ascorbic acid (AA) HPLC determination was used as previously reported (Cvetković et al., 2019). The principal component analysis (PCA) has been applied effectively to classify and segregate the different samples. The statistical calculation was performed

using StatSoft Statistical software v.10 (Stat soft Inc., Tulsa, OK, USA)

RESULTS AND DISCUSSION

Table 1 displays the studied quality attributes of OT cabbage dehydrated in three solutions packed in different MAP during 90 days of storage. In all measured samples, a slight decrease in total acidity content was detected during the storage. The lowest acidity content was observed in cabbage Bravo dehydrated in solution S2 after 90 days of storage. MAP slightly restrained the decrease in titratable acidity (TA) values compared to standard cold storage (Sabir et al., 2011). A detected decline in the acidity level can influence consumer’s acceptability and it is associated with quality loss during postharvest storage (Guillén et al., 2006; Zapata et al., 2008).

Raw hybrid Bravo contains 8,89 mg/100g of L-ascorbic acid (AA). The results showed a significant decrease of L-ascorbic acid content during the storage (Table 1). In cabbage osmodehydrated in S1 L-ascorbic acid wasn’t determined after 90 days. In cabbage dehydrated in solution S2 and S3 AA retention at the end of the period was 15.45 % and 14.25 %, respectively. One of the possible reasons for L-ascorbic acid decrease is chemical degradation by oxidative reactions by enzyme activity (Martínez-Romero et al., 2003; Patras et al., 2009; Phisut et al., 2013). Another cause for poor L-ascorbic acid retention is the leaching of water-soluble compounds out from the cell tissues during cutting and osmotic dehydration (Rincon and Kerr, 2010). The microbiological profile of osmodehydrated cabbage samples is expressed by a total number of microorganisms and yeasts and molds as shown in Table 1. At the beginning of the storage period in the MAP, a total number (TN) of microorganisms decreased probably due to the inaccessibility of oxygen (Noseda et al., 2012). At the later storage period re-growth of microorganisms was observed, probably anaerobic microorganisms. The growth of yeasts and molds was inhibited. The PCA analysis was applied and the results are presented in Fig. 1 The first two PCs explained 59.68 % of the total variance in the experimental data. The projection of the factors indicated that L* and h* contributed positively to the first principal component PC1 (30.9 % and 32.6 %, respectively), while a* negatively influenced the PC1 coordinate. The negative influence of b* and C* was observed on the second principal component PC2 (47.4 % and 48.4 %, respectively). The separation between samples could be observed from the PCA graph, in which most samples treated with solution 1 were placed at the right side of the graph, with

Table 1. Experimental data for the shelf-life study of OT cabbage packaged in different MAP.

No. Sample	CO ₂ content (%)	Days	Solution S1					Solution S2					Solution S3				
			AA	pH	AC	TN	YM	AA	pH	AC	TN	YM	AA	pH	AC	TN	YM
1	/	0	7.23	5.49	0.50	1800	nd	7.25	6.26	0.38	6400	300	7.65	6.80	0.40	2100	400
2	40	20	5.85	5.37	0.50	6000	nd	4.97	6.23	0.39	5800	100	6.04	6.42	0.50	600	100
3	40	40	4.46	5.45	0.48	200	nd	4.67	6.14	0.41	650	nd	4.89	6.53	0.43	750	nd
4	40	70	2.29	5.21	0.51	180	nd	2.88	6.0	0.41	680	nd	3.01	6.16	0.47	1100	nd
5	40	90	nd	5.51	0.43	460	nd	1.30	6.36	0.37	1500	nd	1.48	6.59	0.41	2100	nd
6	80	20	5.72	5.66	0.45	5600	100	5.68	6.31	0.34	7500	100	6.01	6.42	0.43	5600	nd
7	80	40	4.32	5.28	0.48	350	nd	4.29	6.20	0.36	650	nd	4.78	6.53	0.39	300	nd
8	80	70	2.93	5.28	0.46	400	nd	2.87	5.97	0.42	1000	nd	2.91	6.15	0.38	800	nd
9	80	90	nd.	5.57	0.41	500	nd	1.41	6.31	0.38	1000	nd	1.09	6.61	0.33	1200	nd

AA- ascorbic acid (mg/100 g); AC-acidity (%); TN-total number of microorganisms (cfu/g); YM-yeasts and molds (cfu/g); nd – not detected

higher L^* and h^* parameters, while samples treated with solution 3 were placed at the left of the graph, with the augment in a^* parameter. Samples located at the bottom side of the graph were characterized by lower processing time (most samples were processed for 20 days). The map of PCA analysis showed that the first principal component described the differentiation among the samples according to L^* , a^* and h^* coordinates, while the second principal component described the variations in b^* and C^* coordinates between samples.

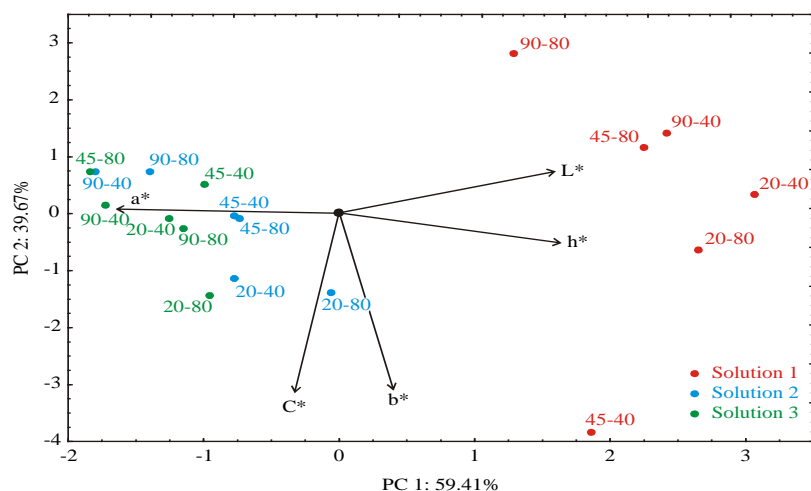


Fig. 1: The PCA biplot diagram, depicting the relationships among OT cabbage samples treated with different osmotic solutions

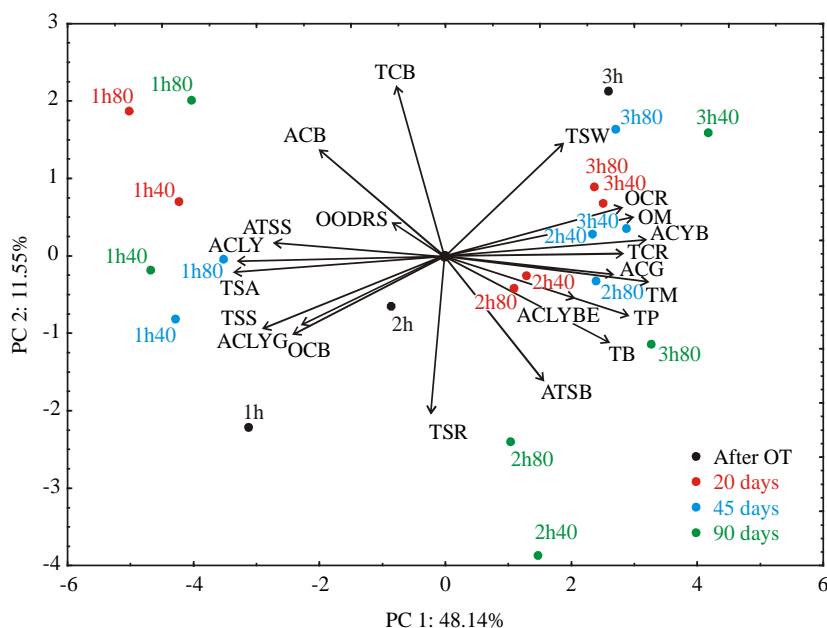


Fig. 2: The PCA biplot diagram, depicting the sensory analysis of OT cabbage samples treated with different osmotic solutions during storage; ACLY-appearance-colour- light yellow, ACLYG -appearance-colour- light yellow-green, ACLYBE-appearance colour light yellow-brown edges, ACYB-appearance colour yellow-brown, ACB-appearance colour brown, ACG-appearance colour grey, OM-odour molasses, OCR-odour caramel, OCB-odour cabbage, OODRS-off odour (rancid, sour), TSW-taste sweet, TSS-Taste sweet-salty, TSA-taste salty, TCB-taste raw cabbage, TM-taste molasses, TCR- taste caramel, TP-taste pungent, TSR-taste sour, TB- taste bitter ATSS- aftertaste sweet-salty, ATSB- aftertaste sweet-bitter, ATS- aftertaste salty, ATB-aftertaste bitter, ATSR-aftertaste sour, ATP- aftertaste pungent, TXCW-texture chewiness, TXTG-texture toughness, TXHD- texture hardness

In order to show the sensory analysis data which could be applied for a better understanding of the properties of OT cabbage samples during storage, PCA results were shown in Fig. 2. The first two PCs clarified 59.68 % of the total variance in the experimental data. The projection of the variables in the factor plane indicated that ACLY, ACYB, ACG, OM, OCR, TSS, TSA, TM, TCR, TP, TB and ATSS contributed mostly to the first principal component PC1 (8.2 %, 7.7 %, 5.4 %, 6.8 %, 5.9 %, 6.3 %, 8.6 %, 7.9 %, 6.0 %, 6.4 %, 5.1 % and 5.6 %, respectively), while ACB, TSW, TCB, TSR, TB and ATSB contributed more to the second principal component PC2 (8.8 %, 10.0 %, 22.2 %, 19.2 %, 5.7 % and 11.9 %, respectively).

CONCLUSIONS

This paper presented the influence of osmotic dehydration process parameters and storage on ascorbic acid content, acidity, colour parameters and microbiological profile of the processed samples. The observed samples were characterized by chemical, microbiological, color and sensory analysis. During the 90 days storage of OT white cabbage hybrid, Bravo packaged in MAP, a slight decrease in acidity and pH increase was observed. During storage in a MAP total number of microorganisms decreased. The cabbage treated in molasses and chloride /sucrose solution and packed in MAP with 80 % CO₂ gas mixture showed the highest retention of L-ascorbic acid during storage. Sensory analysis showed acceptable consumable characteristics of stored osmodehydrated cabbage. Solution type has a significant influence on pH and acidity, storage period on the total number of microorganisms and gas mixture content has no significant influence on analyzed parameters.

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