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Review
Pregledni rad

PROLONGATION OF OPTIMAL TECHNOLOGICAL QUALITY OF PACKAGED DRIED FRUITS
PRODUŽENJE OPTIMALNOG TEHNOLOŠKOG KVALITETA UPAKOVANOG SUŠENOG VOĆA

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SUMMARY

The world market has great interest in dried products, especially fruits, which production is widely spread in the region of Balkan. Dried fruits are very susceptible to biochemical changes during storage, due to low water content, as well as low a_w value. The "shelf life" of these products depends on a_w value. To keep optimal technological quality of dried fruits, it has be needed to ensure optimal, exactly defined quality of packing, which can provide satisfactory quality of dried fruits, during the storage. The aim of this work was to define the quality of packaging material and conditions of packaging using vacuum and modified atmosphere, to provide the successful "shelf life" of packaged dried fruit.

***Key words**: Dried fruits, packaging materials, biochemical changes during storage.*

REZIME

Na svetskom tržištu postoji velika zainteresovanost za sušenim proizvodima naročito od voća, široko rasprostranjene sirovine u regionu Balkana. Sušeno voće, zbog niskog sadržaja vode i male aw vrednosti, predstavlja proizvod vrlo osetljiv na biohemijske promene tokom skladištenjaOdrživost ovih proizvoda zavisi od aw vrednosti.

Da bi se zadržao optimalni tehnološki kvalitet sušenog voća, potrebno je obezbediti i optimalni, tačno definisani kvalitet ambalaže koji će omogućiti da se upakovani kvalitet sušenog proizvoda održi što je duže moguće do momenta upotrebe.Cilj ovog rada je da definiše kvalitet ambalažnih materijala i uslova pakovanja u vakuumu i modifikovanoj zaštitnoj atmosferi kako bi uspešno ispunili zahteve održivosti upakovanih sušenih proizvoda.

***Ključne reči**: sušeno voće ,ambalažni materijali, biohemijske promene tokom skladištenja.*

INTRODUCTION

Dried fruits are products sensitive to biochemical changes during storage due to low water content (Loncin, M, 1968; Gvozdenović, J, Curaković, M, 1993; Nijhuis, H, at all,1998; Sablani, S, at all, 2005; Achour, M, 2005).

During drying, the moisture content of product is lowered whereas other substances in it concentrates and forms a pressure of water vapor which is defined as water activity (a_w) of the product (Pavelić, A, 1979; Heiss, R, 1980; Varšanji, I, 1985).

Water activity has particular relevance in food preservation. The shelf-life of a dried product depends on its hydration status.

The measure of hygroscopicity of a product i.e. its capacity to take up water from the external environment, is the relation between the relative humidity of air surrounding the product and water content of packaged product at a given temperature and is called sorption isotherm.

Nutritive value, textural properties, color, odor, and taste are largely dependent on product's water activity, the active surface of product, and the critical tolerance limit in the quality change based on the sorption isotherms. The increase of water content and changes of water activities also depends on the barrier properties of packaging materials (Heiss, R, 1980; Labuza, T, Saltmarch, M, 1980; Gvozdenović, J, 1981; Gvozdenović, J, Curaković, M, 1993; Gvozdenović, J, at all. 1982, Dirim, S,at all, 2004; Aknabi,T, at all, 2006).

Effect of moisture on the quality changes of packaged product

Food products can be classified into four groups according to their water activities and shelf-lives:

– Low moisture food products (LMFP), dried, water activity ranging from 0 to 0.6 which corresponds to the water content up to 10%,

– Intermediate moisture food products with (IMFP), water activity ranging from 0.6 to 0.9 which corresponds to the water content of 10-50%,

– High moisture food products with (HMFP), water activity ranging from 0.9 to 1.0 which corresponds to the water content above 50%.

Food products have very different shapes of sorption isotherms. The shape of sorption isotherms depends on the water affinity of hygroscopic substances present in the product (Heiss, R, Eichner, K, 1971; Loncin, M, 1968; Lewicki, P, 2004).

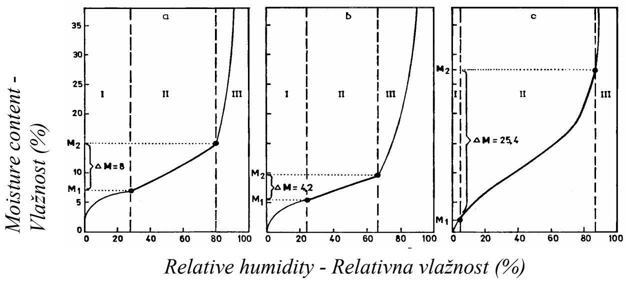

Fig. 1. Types of sorption isotherms for food with different water-binding properties
Sl. 1. Vezanost vode kod različitih proizvoda prema sorpcionim izotermama

Three different areas can be detected in the sorption isotherm curves according to the degree of water binding in the product:

– Section I, strongly bound monolayer,

– Section II, less strongly bound water layers adsorbed on the previous monolayer,

– Section III, capillary, solvent and free water.

Rockland, L, B, (1969) has classified food according to the shapes of their sorption isotherms and the stability spans of activities versus water contents i.e. according to the width and slope of plateaus:

Maximal (the widest) stability span (group c) – products like rice, bran i.e. products with high proportion of starch and cellulose and low content of proteins and soluble low-molecular compounds.

Minimal (the narrowest) stability span (group b) – products rich in proteins and soluble compounds with low content of starches and cellulose such as walnut, tomato powder and perishable powders of fruits and vegetables.

Dried fruits contain high amounts of soluble compounds and show intermediate stability span (group a), with dominating ascending curve.

According to Heiss, R, and Eichner, K, (1971) at usual storing temperatures of 20°C and relative humidity below 72-75%, food is not susceptible to microbial spoilage.

The lowering of water content in the presence of carbohydrates and proteins i.e. their decomposition products like peptides and amino acids can cause the reaction of non-enzymatic browning in the product.

Further lowering in the water content leads to the reactions of auto oxidation.

These reactions reach a maximum at certain water content in the product depending on the thermodynamic effect of diffusion inhibition at low water contents, whereas dilution effects occur at high moisture contents. Moreover, for each food, there is an optimal area of equilibrium moisture content at which the sum of all quality changes is minimal and the product has the longest shelf-life.

According to Pavelić, A, (1979) the water content of fresh fruits and vegetables is approximately 90% and aw is 0.97. Dried fruits have water content 20% and aw in the range 0.72-0.80.

Maximal water content at which microbial growth does not occur in dried fruits ranges from 18-25%, in vegetables 14-20% whereas in highly perishable products such as powdered milk, it is 8%.

MATERIAL

Barrier properties of packaging materials and packing

In dehydrated vegetables, lipid and hydrolytic oxidation, together with nonenzymic browning (in case of green vegetables) chlorophyll degradation, are the major modes of deterioration.

In dehydrated fruits, the major mode of deterioration is nonenzymic browning (Heiss, R, 1980; Labuza, T. P, Saltmarch, M, 1980; Samaniego - Esguerra, C.M.L, Boag, I. F. and Robertson, G.L, 199; Man, C. M. D. and Hones, A, A, 2000; Eskin, N. A. M. and Robinson, D, S, Eds, 2001).

The packaging materials used for dried fruit must have appropriate barrier properties regarding oxygen, nitrogen, carbon dioxide, electromagnetic radiation especially the ultra violet spectrum.

Dried products packaged in the metallic packaging, if proper airtight seals are formed, are protected from photo oxidative changes and moisture transfer.

Photo oxidative changes are characteristic for products packaged in glass containers and depend on the color of glass.

Dried products packaged in polymeric packaging materials are susceptible to light, oxygen and water vapor whose permeation rate depends on the barrier properties of materials and their combinations (Heiss, R,1980; Gvozdenović, J, 1987, 2002; Gvozdenović, J, Curaković, M,1993; Varšanji, I, 1985; Tadić, M, i sar, 1991; Nijhuis, H, at all, 1998; Risbo, J, 2003; Dirim, S, at all 2004).

The importance of correct formation and closing of package

One of the factors that significantly affect the quality of packaged product is correct usage and formation of packaging. Poor hermetic closures increase oxygen diffusion into the packaging due to large difference in the partial pressures between the external environment and the package inside.

Good formation of packaging means formation of good seals on the primary packaging layer. Leak paths of seams and closure interfaces must be avoided.

In order to lower the oxygen concentration inside the packaging, the product is deaerated prior to packaging or vacuum packaging can be used (elimination of air). The lowering of partial pressure of oxygen can be achieved using modified atmospheres. This technique uses nitrogen, carbon dioxide or their mixtures to modify the internal atmosphere of a packaging. In the case of packaging with nitrogen, the diffusion of oxygen from outside can occur after lowering the partial pressure of the filling gas due to permeability of packaging material or poor seal quality (Gvozdenović, J, 1981; Gvozdenović, J, i sar, 1989, 1990, 2002; Lazić, V, i sar,1993; Gvozdenović, J, Curaković, M, 1993; Živanović, R, 1996; Vasiljević, M, 1999).

Packaging under modified atmosphere

With the aim of shelf life prolongation, dried fruit was packed in packaging materials of appropriate barrier properties under protective and controlled atmosphere.

Since the 1970 and the widespread availability of polymeric packages, this approach has been applied to consumer packs and given the name modified atmosphere packaging (MAP) because the atmosphere surrounding the food is modified but not controlled.

MAP can be defined as the enclosure of food in a package in which the atmosphere inside the package is modified or altered to provide an optimum atmosphere for increasing shelf life and maintaining quality of the food (Devlieghere, F, at all, 2002; Devlieghere, F, Debevere, J, 2003). The normal composition of air is 78.08% nitrogen, 20,95% oxygen, 0,93% argon, 0,03% carbon dioxide and traces of nine other gases in very low concentrations. The three main gases used in MAP are O_2, CO_2, and N_2 either singly or in combination.

Oxygen promotes several types of deteriorative reactions in foods including fat oxidation, browning reactions and pigment oxidation. Most of the common spoilage bacteria and fungi require O_2 for growth. For these reasons, O_2 is either excluded or the level set as low as possible.

Removing the oxygen from the packaging unit and forming nitrogen pressure, the possibility of packed products oxidation is decreased. Packaging materials with adequate permeability of nitrogen molecules should be chosen (Brody, A. L, 2000).

Nitrogen has a lower density than air and a low solubility in water and other food constituents, making it a useful filler gas in MAP to counteract package collapse caused by CO_2 dissolving in the food. Nitrogen indirectly influences the microorganisms in perishable foods by retarding the growth of aerobic spoilage microbes but it does not prevent the growth of anaerobic bacteria (Devlieghere, F, at all, 2002; Devlieghere, F, Debevere, J, 2003).

Carbon dioxide is the most important gas in the MAP of foods because of its bacteriostatic and fungistatic properties. It inhibits the growth of many spoilage bacteria, the degree of inhibition increasing with increasing concentration.

The gas mixtures used for MAP of different foods depends on the nature of the food and the likely spoilage mechanisms. Where spoilage is mainly microbial, the CO_2 levels in the gas mix should be as high as possible, limited only by the negative effects of CO_2 (e.g. package collapse) on the specific food. Typical gas compositions for this situation are 30 to

60% CO_2 and 40 to 70% N_2. For oxygen sensitive products, where spoilage is mainly by oxidative rancidity, 100% N_2 or N_2/CO_2 mixture (if microbial spoilage is also important) are used.

Quality forming of thermoseals of polymer packaging is also important for the stability of packed dried fruits. Therefore, the optimal adjustment of temperature, pressure and duration of sealing process is necessary. In that way, the incompactness and micro porosity of packaging on seals is prevented, which enable the diffusive flow of nitrogen molecules, due to effects of egalization of partial pressures and concentration of nitrogen molecules compared to the outside.

The choice of packaging under modified atmosphere is closely related to the water activity

of product, since it predicts food stability with respect to deteriorative reactions that lead to quality loss (Brody, A, L, 2000). Therefore, a distinction should be made between three categories of foodstuffs:

-dry products,

-intermediate moisture products and

- high moisture products.

Shelf life of dry products is usually limited by oxidation phenomena; nitrogen employed to reduce the O_2 contend in the packaging will therefore be commonly used.

Instant potato flakes, dehydrated vegetables, coffee, oilseed, dried fruits, will be conditioned in this way. Without using an antioxidant, it is thus possible to increase threefold, or even fourfold, the shelf life of these products stored at ambient temperature.

The conservation of intermediate moisture products is more difficult. There is still a risk of oxidation, and addition, it is necessary to prevent and delay the development of molds.

In response to this twofold constraint, usually N_2/CO_2 mixtures with a high CO_2 content (required to counteract molding) are used: pure CO_2, 50% CO_2/, 50% N_2 mixture.

However, these results will depend on numerous factors:

- type of contaminating flora,
- quantity of microorganisms present prior to packaging,
- handling and sanitary conditions
- content of additives,
- water activity contained in the product (aw) and
- storage temperature (Karol, M, 1974; Heists, R, 1980; Gvozdenović, J, Curaković, M, 1993; Brody, A, L, 2000).

RESULTS AND DISCUSSION

Our previous investigations on the quality changes of packaged dried products (Gvozdenović,

J, 1981, 1987; Gvozdenović, J, Curaković, M, 1989, 1993, 1995; Gvozdenović, i sar. 1982, 1988, 1989, 1990, 1993 , 1995, 1996, 1997, 1999, 2002, 2007), revealed that the stability of packaged product depends on many factors:

– Active surface of product (powdered tomato, strawberry, orange, garlic, celery, paper, sliced carrot, sliced apple, apple chips);
– Initial technological quality of product;
– Type of packaging material used,
– Quality of seals,
– Type and conditions of packaging.

There were differences in the quality of apples depending whether they were sliced or in the form of chips (Gvozdenović, J, i sar, 1988, 2006, a, b, 2007, a, b, c, d).

– The dried sliced apples had aw 0.73 and water content 17.86%.
– The dried apple chips had aw 0.40 and water content 8.0%.

At water activities and water contents measured in the sliced apples the growth of xerophilic mould is enabled therefore application of appropriate packaging material with low water vapor permeability and good seal forming features are necessary.

The water activity and water content of applied chips inhibit most of the food spoilage microorganisms. However, at the water activity 0.4 the rate of non-enzymatic browning reaches its maximum and photooxidation reactions can be initiated therefore packaging materials with high light and oxygen barrier properties should be used. More advanced protection of such perishable product could be achieved by using vacuum packaging techniques or combinations of inert gasses.

CONCLUSION

The quality maintenance of shelf-life prolongation of packaged product can be achieved by using adequate combination of packaging materials as well to use high quality materials.

Beside that, products susceptible to photooxidative changes and non-enzymatic browning require good sealing properties of materials and the ability to form airtight seals to stop non-defined transmissions between the package and external environment.

In the case of highly perishable products sensitive to microbiological spoilage, vacuum packaging and modified atmosphere packaging is necessary.

In this way, changes in the critical quality characteristics of product are diminished and good quality is maintained during the storage period.

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REFERENCES

[1] Achour, M: A new method to assess the quality degradation of food products during storage, Journal of Food Engineering (2005), p. 125-127.

[2] Akanbi, T.C, Adeyemi, R. S, Ojo, A: Drying characteristics and sorption isotherm of tomato slices, Journal of Food Engineering 73(2006), p. 157-163.

[3] Brody, A.L: Packaging: part IV - Controlled / Modified Atmosphere/ Vacuum food packaging, Wiley Encyclopedia of Food Science and Technology, 2nd ed, Fracis,F, J, Ed,Wiley, New York, 3(2000) pp.1830-1839.

[4] Dirim, S.N, Ozden, O.H, Bayindirli, A, Esin, A: Modification of water vapour transfer rate of low density polyethylene films for food packaging, Journal of Food Engineering 63 (2004) p. 9-13.

[5] Gvozdenović, Jasna: Ispitivanje podobnosti kompleksnih ambalažnih materijala i ambalaže za pakovanje instant paradajza, Magistarski rad, Tehnološki fakultet, Novi Sad, 1981.

[6] Gvozdenović, Jasna, Curaković, M, Vujković, I: Primena kombinovanih ambalažnih materijala za pakovanje dehidriranih proizvoda,VI Kongres o ishrani naroda Jugoslavije, Novi Sad, Savremeno pakovanje 23(1982)5, s.20-24.

[7] Gvozdenović, Jasna: Uticaj osobina semipermeabilne višeslojne ambalaže na promene kvaliteta praha maline, Doktorski disertacija, Tehnološki fakultet, Novi Sad ,1987.

[8] Gvozdenović, Jasna, Curaković, M, Lazić, Vera, Vujković, I: Metode, uslovi i rezultati ispitivanja kvaliteta termovara kod formiranja plastične i višeslojne ambalaže, I Kongres prehrambenih tehnologa i nutricionista Hrvatske, Prehrambeno-tehnološka i biotehnološkoj revija, 27(1989)1, s. 18.

[9] Gvozdenović, Jasna, Curaković, M. Lazić, Vera, Vujković, I. Ispitivanje uslova za termičko zavarivanje plastične i višeslojne ambalaže, Prehrambeno tehnološka i biotehnološka revija, 28(1990)1, s. 33 – 38.

[10] Gvozdenović, Jasna, Curaković, M.: Vlijonic upakovki, islovi upakovanija I prodol žitelnosti hranenija na izmenie vlagosordržanija sušenoj malini, Nacionalnaja naučno hemičeskaja konferencija, Plovdiv, 1989.

[11] Gvozdenović, Jasna, Curaković, M: Ambalaža i njen uticaj na održivost sušenog voća i povrća, (Monografija), Tehnološki fakultet, Novi Sad , 1993.

[12] Gvozdenović, Jasna, Curaković, M: The influence of Packaging and Storage Time colour of Dehydrated Raspberry, Acta Alimentaria, 24(1995)3, s. 257- 268 .

[13] Gvozdenović, Jasna, Curaković, M, Lazić, Vera: Influence of protective characteristics of composite packaging-somposite containers on the quality changes of sweet ground red pepper, volII od 9th Congres of Food Science and Technology, 99, Budapest, 1995.

[14] Gvozdenović, Jasna, Curaković. M, Lazić, Vera: Change of Nutriitive Value of Powdered Garlic During Storage, 16.International Congress of Nutrition, 251, Montreal, Canada, 1997.

[15] Gvozdenović, Jasna, Curaković, M, Lazić, Vera: Stability of nutritive Characteristics of packed tomato powder, the 8th. European Nutrition Conference, Lillehammer, Norway, 49(1999).

[16] Gvozdenović, Jasna, Popov-Raljić, Jovanka, Curaković M: Investigation of caracteristic Colour Stability of Powdered Orange Base Juice, Food Chemistry 70(2000) s. 291-301.

[17] Gvozdenović, Jasna, Curaković, M., Lazić, Vera: Dehydrated fruit packafing and packing conditions, PTEP - Journal on Processing and Energy in Agriculture, Novi Sad, 6(2002)1-2, pp 34-38.

[18] Gvozdenovic, Jasna, Aljilji, Ajka, Svrzic, Gordana, Tepic, Aleksandra, Lazic,Vera : Influence of protective haracteristics of packaging materials on packed dried fruits, 2nd international congress on bioprocesses in food industries, Patras, Greece: University of Patras, Greece, 2006.

[19] Gvozdenović, Jasna, Lazić, Vera: Influence of characteristics of monomaterials and combined packaging materials on packed dried fruits, PTEP - Journal on Processing and Energy in Agriculture, Novi Sad, 10(2006)1-2, pp 32-36.

[20] Gvozdenović, Jasna, Lazić, Vera, Svrzić, Gordana: Influence of packaging materials protective characteristics on the quality change of dried apples, PTEP - Journal on Processing and Energy in Agriculture, Novi Sad, 11(2007)3, pp.112-115.

[21] Gvozdenović, Jasna, Lazić, Vera, Ailji, Ajka: Biochemical Change of Packed Dried Apples, 10th European Nutrition Conference, FENS 07, Paris, 2007.

[22] Gvozdenović, Jasna, Aljilji, Ajka, Lazić, Vera, Tepić, Aleksandra, Svrzić, Gordana: Influence of Protective Characteristics of Packaging Material on Packed Dried Fruits, Acta periodica Technologica, 38(2007), s. 21-28.

[23] Gvozdenović, J, Lazić, V: Change the nutritive value during the storage of packed tomato powder, 2 nd International congress on food and "Food for future", Istambul, 2007

[24] Gvozdenović Jasna, Lazić, Vera: Packaging and durability of food stuffs, PTEP - Journal on Processing and Energy in Agriculture, Novi Sad, 12(2008)1-2, pp. 27-30.

[25] Heiss, R: Verpackung von Lebensmitteln, Springer Verlag, Berlin-Heidelberg-New York, 1980, p. 306.

[26] Heiss, R, Eichner, K: Moisture content and shelf life, Fd Manufacture, 53(1971) p.35-42.

[27] Labuza, T.P., Saltmarch, M.: Properties of water related to food quality and stability. – In: Rockland, L.B. and Stewart, G.V. (Eds). The nonenzymatic browning reaction as affected by water in foods. Academic Press, London, New York, San Francisco, 1980, p. 360.

[28] Lazić, V, Curaković, M, Gvozdenović, J, Vujković, I: Influence of semipermeability of packaging materials and packagings on the atmosferein the packaging, Proceedings , 397- 399 , The 11th International Chemical Equipment Desing and Automation, CHISA 93', Prague, 1993.

[29] Lewicki, P, P: Water as the determinant of food engineering properties, Journal of Food Engineering 61(2004) p. 483-495.

[30] Loncin, M.: Influence of activity of water on the spoilage of foodstuffs, Journal of Food Technology, 3(1968), p. 131-142.

[31] Nijhuis, H, H, Torringa, H, M, Muresan, S, Yuksel, C: Approaches to improving the quality of dried fruit and vegetablles, Tehnology 9(1998) p. 13-20.

[32] Pavelić, A: Intermediate moisture foods, PTR, 17(1979)4, 190.

[33] Risbo, J: The dynamics of moisture migration in packaged multicomponent food systems I:shelf life predictions for a cereal–raisin system, Journal of Food Engineering 58(2003) p. 239-246

[34] Sablani, S. S, Kasapis, S, Rahman, M. S: Evaluating water activity and glass transition concepts for food stability, Journal of Food Engineering (2005) p.139-142.

[35] Varsanyi, I: Packed food quality changes during storage, Paper presented at Symposium on aseptic Processing and Packaging of Foods, Proceedings, Tylosand, Sweden, 1985.

[36] Vasiljević, Miomira: Uticaj zaštitnih svojstava različitih ambalažnih materijala na očuvanje kvaliteta upakovanog praha za negazirano bezalkoholno piće od narandže, Specijalistički rad, Tehnološki fakultet, Novi Sad, 1999.

[37] Živanović, Roberta: Uticaj zaštitnih svojstava ambalaže na kvalitet dehidriranog belog luka, Magistarski rad, Tehnološki fakultet, Novi Sad, 1996 .

[38] Ajka Aljilji: Promena kvaliteta upakovane sušene jabuke, Magistarski rad, Tehnološki fakultet, Novi Sad, 2007.

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