

THE USEFULNESS OF NATURAL CONCENTRATED FRUIT JUICES AS OSMOTIC AGENTS FOR OSMO- DEHYDRATED DRIED FRUIT PRODUCTION

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A B S T R A C T

The study was undertaken to check the usefulness of concentrated fruit juices as osmotic agents which could replace sucrose in production of osmo-convectively dehydrated dried fruit. The experiment was done on sour cherry fruit, which were dehydrated in the following osmotic solutions: concentrated apple juice (AJ), mixture of concentrated apple and sour cherry juices (AJ + SCJ), deacidified, concentrated apple juice (DeAAJ) and sucrose solution (S) as a control. After osmotic dehydration the fruit were convectively dried and then subjected to sensory assessment and chemical analyses. Dehydration effect of all osmotic agents used was comparable. In all the combinations investigated dry matter increases during osmotic drying were similar as in the control and allowed to produce osmo-convectively dried fruit of comparable, decent texture properties. The application of concentrated fruit juices (AJ and AJ + SCJ) slightly intensified sensation of cherry taste and aroma and allowed adjusting the flavour profile according to consumer's preferences and destination of the final product. However, osmo-dehydration with concentrated fruit juices resulted in a significant decrease in anthocyanins' content in dehydrated sour cherries. Taking overall effect into consideration as well as economic factors, the results of the experiment presented do not justify recommendation of fruit juices as a single osmotic agent in osmo-dehydrated dried fruit production. However, the obtained results do not exclude the purposefulness of fruit juice application in production of dehydrated fruit, especially as supplements influencing their flavour characteristics.

Key words: sour cherries, osmotic dehydration, dried fruit, nutritional value, fruit snack

INTRODUCTION

Searching for alternative forms of sour cherry fruit utilization is very important, especially in Poland which is one of the biggest producers of this fruit, as the popularity of traditional products (such as compote) is lowering systematically. Offering consumers' new, attractive product, which is in consistency with modern trends of healthy diet, can result in increasing sour cherry consumption. Pitted sour cherries, enriched with sugar, after drying resemble raisins but they are bigger and more sour and have an excellent sour cherry taste (Szymczak and Płocharski, 1999). Because of high antioxidant activity, sour cherries (better than other fruit) protect human organism against adverse environment influence, what was so far insufficiently appreciated (Wang et al., 1997; Tosun and Ustun, 2003). The antioxidant activity of sour cherries is comparable to that of cranberries, blackberries and blueberries (Halvorsen et al., 2002), whereas their availability and possibility of culinary application is much higher. Significant amount of fibre, potassium and folic acid and high antioxidant activity cause that this product can be an attractive snack with functional properties, which can be offered as a candy substitute (Rastogi et al., 2002; Aguilera et al., 2003). It is worth mentioning that processed sour cherries are still a valuable source of antioxidants if the characteristic red colour is retained (Rechner et al., 1999). The main obstacle in promoting such

product is the addition of sucrose, indispensable for neutralizing sour taste characteristic of sour cherry fruit (Lenart, 1996; Kowalska et al., 2000). In the study presented the usefulness of concentrated fruit juices as osmotic agents replacing sucrose in production of osmo-convectively dehydrated sour cherries was investigated. Using fruit juice instead of sucrose solution was aimed at increasing the nutritional value and naturalness of obtained product, which can be offered as a snack with a high nutritional value.

MATERIAL AND METHODS

As experimental material sour cherries of 'English Morelo' cv., picked at the commercial harvest maturity in Experimental Orchard of the Research Institute and Pomology and Floriculture in Dąbrowice, were used. Fresh fruit were washed, pitted and frozen in plastic bags in a thin layer and than stored at -25°C until processing. Directly before processing the temperature of fruit was raised to -5°C. As dehydration agents, the following osmotic solutions were used: concentrated apple juice (AJ), mixture of concentrated apple and sour cherry juices (AJ + SCJ), deacidified concentrated apple juice (DeAAJ) and sucrose solution (S) as the control. Concentrated apple and sour cherry juices were produced by ZPOW Ogród Polski and Alpex enterprises. The deacidified concentrated apple juice was prepared in cooperation with pharmaceutical company Polfarmex S.A. (Kutno, Poland), where malic acid was removed from regenerated apple juice on ion exchange

columns and then again concentrated (deacidified apple juice was a by product during natural malate production).

The concentration of all osmotic agents used was 65 Bx. Proportion of fruit and osmotic solution was 1:4 and dehydration was done for 2 hours in beakers placed in shaking water bath (Julabo SW 22, frequency 100 rpm, amplitude 20 mm) at 40°C. After osmotic dehydration, fruit were drained, rinsed with cold distilled water and then gently blotted on a filter paper. After that the fruit were spread in monolayer on stainless sieves and dried in convective drier with horizontal air flow (2.5 m s^{-1}) at 65 °C during 8 hours, what allowed obtaining final moisture content of about 25%. The experiment was carried out in two technological replications and was repeated for fruit harvested in three successive seasons, 2005, 2006 and 2007.

Analyses of fruit quality

In all combinations the dehydration process was monitored and the dried material obtained was subjected to sensory assessment and chemical analyses. Soluble solid content (by refractometric method), dry matter (by gravimetric method) and titratable acidity were measured both in raw material and after its dehydration. Total anthocyanins content was quantified spectrometrically according to Wrolstad (1976) at all stages of technological process as a measure of antioxidant activity. Moreover, for products obtained in 2006 and 2007, the quantitative and

qualitative sugar analysis was done. For that, dried sour cherries were disintegrated in liquid N_2 and extracted with water. Sugar analysis in water extract was done on HPLC equipped with Aminex HPX87C column with pre-column and differential refractometric detector (Agilent 1100). The mobile phase was water at a flow rate of 0.6 ml min^{-1} and temperature 80°C.

The sensory quality of dried sour cherries was evaluated by a profiling method in the group of 11 experts, trained and having extensive experience in performing sensory assessment of dried horticultural products. The experts assessed 16 qualitative traits using an unstructured 100 mm linear scale. The results were transposed into 0-10 point scale, where “0” denoted lack of a given trait or a bad level, while “10” indicated an intensive sensation or a high quality. The following attributes were evaluated: sour cherry aroma, skin toughness, flesh consistency, overall texture, taste of sour cherry (sweet, sour, caramel, astringent), flavour and overall quality defined as sensory impression of balance and harmony of all attributes and their interactions.

The data were elaborated statistically using STATISTICA 7.1 software package (Stat Soft Inc., Tulsa, USA). The differences between means were determined by the analysis of variance (ANOVA) and Duncan’s multiple range test at $p = 0.05$.

RESULTS

Dehydration effect

Using concentrated fruit juices as osmotic agents allowed obtaining

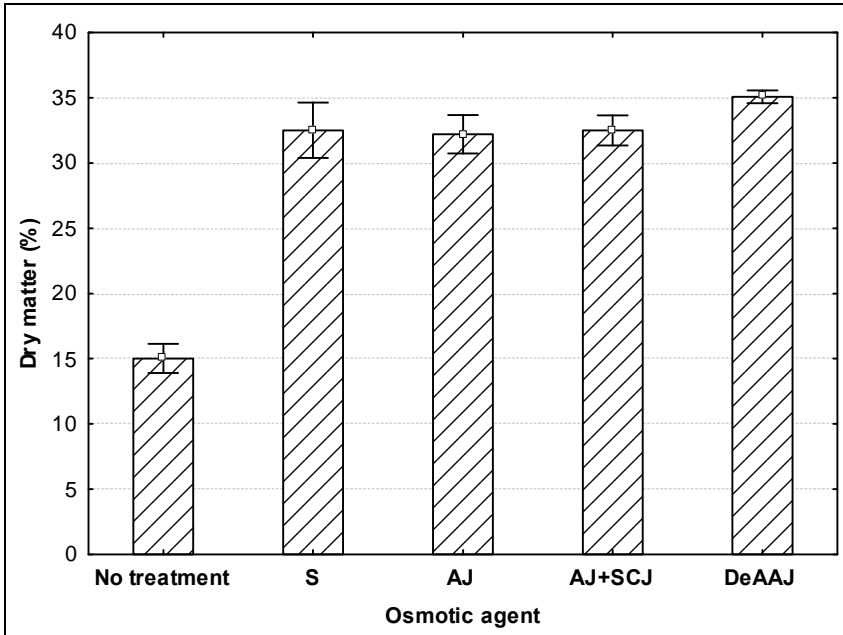


Figure 1. Dry matter contents in untreated fruit, fruit dehydrated with sucrose syrup (S), concentrated apple juice (AJ), mixture of concentrated apple and sour cherry juices (AJ + SCJ) and deacidified, concentrated apple juice (DeAAJ). Means for three seasons (2005-2007)

similar dehydration effect as in the case of sucrose (Fig. 1). During two hours of sour cherry dehydration their dry matter content increased from 15% to over 34%. The differences between all the treatments were not significant.

Sensory assessment

After convective drying the obtained batches of dried sour cherries were characterized with typical aroma of sour cherry fruit of moderate intensity, which was estimated between 3.9 and 4.6 in 0-10 points scale (Tab. 1). Although there was a tendency towards higher score of sour cherry aroma sensation

in samples treated with juices (AJ and AJ + SCJ), the differences were not statistically significant. The same relations were found for sour cherry taste sensation. The overall texture of all investigated products was assessed quite well (over 6 in 0-10 points scale), that was the result of a good, delicate consistency (2.6-3.0 points) but relatively hard skin (4.2-4.7). Significant differences were found in traits which contribute to flavour perception, which allows to divide the investigated samples into two subsets: of sweet and tart profiles. The dried cherries dehydrated in fruit juices, both apple (AJ) alone and a mixture of apple and sour cherry

Table 1. Sensory assessment of selected quality traits of osmo-convectively dried sour cherries. Means for three seasons (2005-2007)

Osmotic agent	Sensory attributes*										
	Sour cherry aroma	Skin toughness	Flesh consistency	Overall texture	Sour cherry taste	Sweet taste	Sour taste	Caramel taste	Astringent taste	Flavour	Overall quality
S	3.9 a **	4.6 a	3.0 a	6.2 a	5.3 a	5.6 c	3.8 a	0.9 b	0.4 a	6.6 a	6.5 a
AJ	4.6 a	4.5 a	2.7 a	6.4 a	5.8 a	4.1 b	5.8 b	0.4 a	0.9 b	6.2 ab	6.4 a
AJ+SCJ	4.6 a	4.7 a	2.9 a	6.2 a	5.9 a	3.5 a	6.4 b	0.4 a	1.2 b	5.7 b	6.0 a
DeAAJ	4.0 a	4.2 a	2.6 a	6.5 a	5.5 a	5.6 c	3.9 a	1.0 b	0.3 a	6.7 a	6.7 a

* sensory attributes (in 10-point scale),

sour cherry aroma: 0 - insensible, 10 – very intensive; skin toughness: 0 - soft, tender, 10 – tough, leathery; flesh consistency: 0 – soft, tender, 10 – hard; overall texture: 0 – bad, 10 – very good; sour cherries, sweet, sour, astringent, caramel taste 0 - insensible, 10 – very intensive; flavour: 0 - tasteless, 10 – very tasty; overall quality: 0 – bad, 10 – good, well harmonized

** means marked with the same letter do not differ significantly at $p \leq 0.05$ according to Duncan's test

(AJ + SCJ), were perceived as significantly more acidic and less sweet than fruit treated with sucrose (S) or deacidified apple juice (DeAAJ). Products of tart profile (AJ, AJ + SCJ) had significantly higher astringency taste, which probably influenced lower flavour appreciation (5.7 and 6.2 points as compared to 6.6 and 6.7 for more sweet products). The overall quality of sweeter products dehydrated in sucrose solution (S) and in DeAAJ were judged on 10-points scale at 6.5 and 6.7, respectively, while products of the tart profile obtained 6.4 (AJ) and 6.0 (AJ + SCJ) points. However, the differences were not statistically significant.

Dietary value

The selected parameters of chemical composition that influenced dietary values of dried sour cherries are given in Table 2. The samples perceived as more sweet (S and DeAAJ), had in fact significantly more total sugars than these of the tart profile. Irrespective of an experimental combination, no sucrose was found in the final products, even in the fruits infused with this compound. Sucrose must have been hydrolyzed to monosaccharides during drying, probably due to a combined effect of increased temperature and high acidity of the processed fruit. Glucose/fructose ratio differed significantly in the fruit dehydrated with sucrose and concentrated fruit juices. The highest ratio (1.07) was recorded in the control sample (S), while the lowest in the fruit dehydrated in

apple juice and deacidified apple juice (0.61 and 0.56). Furthermore, the dried cherries infused with fruit juices contained more organic acids, while the fruit treated with cherry juice had more sorbitol.

Anthocyanins retention as a measure of antioxidant potential

Comparing the total anthocyanins contents in the final products (Tab. 2), it is clear that the use of apple juices (AJ and DeAAJ) decreases the pigments' retention as compared to sucrose treatment. Taking into consideration both dehydration and drying stages (Fig. 2), it can be concluded that the drying stage is more destructive. Just after dehydration the amount of anthocyanins was similar for sucrose and apple juice treated fruit. In the case of sample dehydrated with the mixture of apple and sour cherry juice (AJ + SCJ), the level of anthocyanins was significantly higher, which was probably caused by cherry juice uptake during dehydration process or by slowing down the anthocyanins migration from the fruit tissue into the osmotic medium. Although dried fruit treated with the mixture containing concentrated sour cherry juice (AJ + SCJ) had the highest content of anthocyanins, relative retention of these compounds during drying was the highest in the fruit dehydrated with sucrose solution in all the seasons investigated.

DISCUSSION

The application of concentrated fruit juices as substitutes for sucrose during production of osmo-convectively

Table 2. Content of selected compounds in osmo-convectively dried sour cherries. Means for two seasons (2006 and 2007)

Osmotic agent	Glucose [g·kg ⁻¹]	Fructose [g·kg ⁻¹]	Sucrose [g·kg ⁻¹]	Sorbitol [g·kg ⁻¹]	Glucose/Fructose ratio	Total sugars [g·kg ⁻¹]	Acidity as citric acid [g·kg ⁻¹]	Total anthocyanins [mg·kg ⁻¹]
S	292 b*	272 b	0.0	28 a	1.07 c	574 b	28.1 a	1770 b
AJ	186 a	307 c	0.0	36 a	0.61 a	509 ab	46.4 b	1300 a
AJ+SCJ	206 a	236 a	0.0	58 b	0.87 b	470 a	49.3 b	2160 c
DeAAJ	195 a	349 d	0.0	38 a	0.56 a	562 b	21.4 a	1440 a

*means marked with the same letter do not differ significantly at $p \leq 0.05$ (Duncan test)

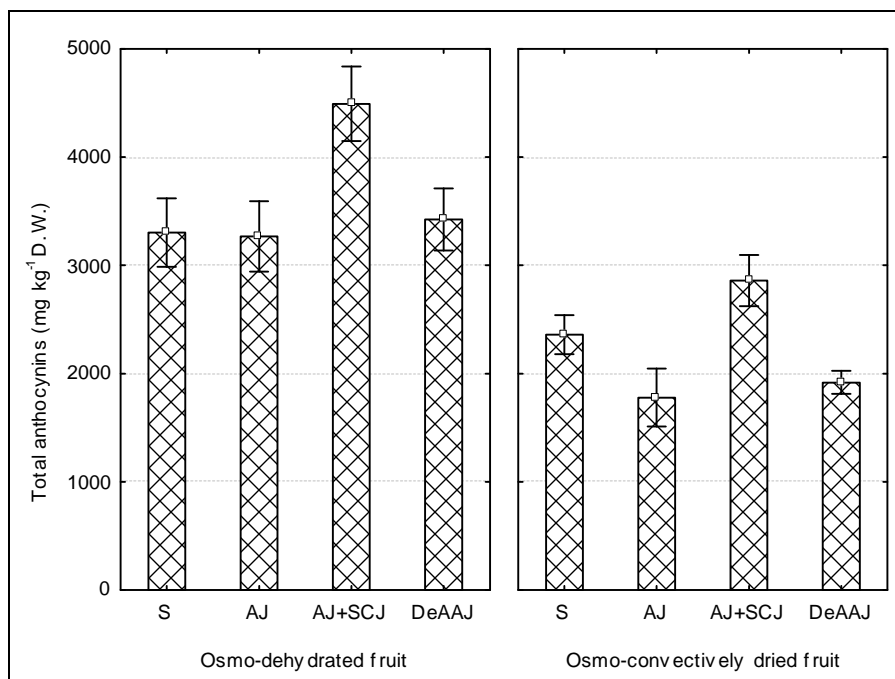


Figure 2. The effect of osmotic agents on anthocyanin content in cherry fruit after osmotic dehydration followed by convective drying. Means for two seasons (2006–2007)

dried sour cherries increased fructose/glucose ratio, intensified sensation of cherry aroma and allowed adjustment of the flavour profile according to consumer preferences and destination of the final product. Unfortunately, considering changes of antioxidant activity expressed as anthocyanins content, it was found that the use of fruit juices as osmotic agents instead of sucrose solution resulted in higher anthocyanins losses. This unfavourable phenomenon was probably caused by higher fructose contents. As contrasted with sucrose, which at low concentration had a protective effect on anthocyanins' stability in processed berry fruit (Nikkhah et al., 2007), fructose was indicated as a factor lowering the pigment's stability. According to Rubinskiene et al. (2005), fructose has a greater effect on anthocyanins degradation than glucose. Hubbermann et al. (2006) proved that fructose, especially at higher temperatures, can accelerate anthocyanins decay due to the formation of sugar degradation products. Using concentrated cherry juice in a mixture with apple juice can diminish the adverse fructose action, but simultaneously decreases the flavour appreciation. Taking into consideration comparable sensory quality of products obtained using concentrated fruit juices and sucrose (Tab. 1) but a better retention of bioactive compounds in samples treated with sucrose (Fig. 2), the results of the experiment presented do not justify recommendation of fruit juices as self-contained osmotic agents, especially after considering economic issue.

However, the obtained results do not exclude the purposefulness of fruit juice applications in dried fruit production, especially as supplements influencing flavour characteristics.

CONCLUSIONS

1. Concentrated fruit juices can be considered as sucrose substitute. In all investigated combinations the observed dry matter increases were the same as for sucrose and allowed to produce osmoconvectively dried fruit of comparable, decent texture properties.
2. The application of concentrated fruit juices (AJ and AJ + SCJ) slightly intensified sensation of cherry taste aroma and allowed adjustment of the flavour profile according to consumer preferences and destination of the final product.
3. Osmo-dehydration with concentrated fruit juices resulted in a significant decrease of anthocyanins content in dehydrated sour cherries. Taking overall effect into consideration as well as economic factors, the result of the experiment presented do not justify recommendation of fruit juices as a single osmotic agent in production osmotically dehydrated dried fruit
4. However, the obtained results do not exclude the purposefulness of fruit juice applications in dried fruit production, especially as supplements influencing the flavour characteristics of dehydrated fruits.

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OCENA PRZYDATNOŚCI NATURALNYCH ZAGĘSZCZONYCH SOKÓW OWOCOWYCH JAKO CZYNNIKA OSMOTYCZNEGO W TECHNOLOGII WYTWARZANIA SUSZU OWOCOWEGO

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S T R E S Z C Z E N I E

Podjęte badania miały na celu ocenę przydatności zagęszczonych soków owocowych jako czynnika osmotycznego, który mógłby być wykorzystany jako substytut sacharozy w procesie produkcji owoców suszonych sposobem osmotyczno-konwekcyjnym. Kombinacje doświadczalne stanowiły wiśnie odwadniane w następujących roztworach osmotycznych: zagęszczony sok jabłkowy (AJ), mieszanina zagęszczonego soku jabłkowego i wiśniowego (AJ + SCJ), odkwaszony a następnie zagęszczony sok jabłkowy (DeAAJ) oraz sacharoza (S) jako czynnik kontrolny. Po zastosowaniu obróbki osmotycznej owoce suszono konwekcyjnie a następnie poddawano ocenie sensorycznej i analizom chemicznym. Oceniając zdolność badanych czynników do odwadniania osmotycznego stwierdzono, że mogą one być rozpatrywane jako substytut sacharozy. We wszystkich badanych kombinacjach uzyskano podobny wzrost zawartości suchej substancji umożliwiając uzyskanie suszu osmotyczno-konwekcyjnego o porównywalnych i zadowalających właściwościach tekstury. Zastosowanie zagęszczonych soków (AJ i AJ + SCJ) nieznacznie zintensyfikowało odczucie smaku i zapachu wiśniowego oraz umożliwiło celowe kształtowanie profilu smakowego w zależności od preferencji odbiorców oraz przeznaczenia suszu. Zalety te w konfrontacji z porównywalnie wysoką jakością sensoryczną i lepszym stopniem zachowania substancji bioaktywnych w próbkach odwadnianych z użyciem sacharozy nie uzasadniają rekomendowania soków owocowych jako samodzielnych czynników osmotycznych, szczególnie po uwzględnieniu aspektów ekonomicznych. Jednakże uzyskane wyniki nie wykluczają celowości wykorzystania skoncentrowanych soków owocowych, zwłaszcza jako dodatku kształtującego cechy smakowitości odwadnianych owoców.

Słowa kluczowe: wiśnie, odwadnianie osmotyczne, owoce suszone, wartość odżywcza, przekąska owocowa