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USE OF DIRECT OSMOSIS AS FRUIT AND VEGETABLES DEHYDRATION

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INTRODUCTION

Osmotic dehydration consists of removing a percentage of the moisture by immersing fruit and vegetable pieces in a hypertonic solution. Since this solution has higher osmotic pressure, and hence lower water activity (a_w), between solution and food a driving force for water removal arises, while the natural cell wall acts as a "semi-permeable" membrane. As the membrane is only partially selective there is always some leakage of solute from the solution into the food and from the food into the solution. Direct osmosis dehydration is therefore a simultaneous water and solute diffusion process.

The quantity and the rate of water removal depends on several variables and processing parameters. In general it has been shown that the weight loss in osmosed fruit is increased by increasing solute concentration of the osmotic solution, immersion time, temperature, solution/food ratio specific surface area of the food and by using a low pressure system. The osmotic solution used must have a low a_w and moreover the solute must be harmless and have a good taste. Concentrated sucrose solution (50-70°Brix) and corn syrups have been the most commonly used [5].

Sodium chloride is an excellent osmotic agent for vegetables but its use in concentration of fruit pieces is limited since a salty taste is imparted in the food.

Some of the stated advantages of direct osmosis in comparison with other drying processes include low energy requirement, minimized heat damage to colour and flavour of the food, less discoloration of the fruit by enzymatic oxidative browning.

MATERIALS AND METHODS

Fruit (apple, strawberry, peach, apricot, cherry, kaki, Hard Black cherry, raspberry) and vegetables (carrot, pumpkin) were manually peeled and cut into uniform cubes (1 × 1 × × 0.6 cm). As osmotic agents corn hydrolized starch syrups (70°Brix) (Frudex and Glicosa, produced by FRAGD, Milan) were used. The chemical and physical properties of the syrups are referred to in Tab. 1.

Table 1. Properties of commercial syrups used in osmotic concentration experiments

Syrup	Carbohydrates %				pH	a_w
	dextrose	fructose	maltose	polysaccharides		
Frudex	52	42	3	3	4.5	0.73
Glicosa	30	—	46	24	4.7	0.82

Samples were analyzed prior, during and at the end of the osmotic process. Water content was determined by drying under vacuum at 75°C for 12 hr. water activity was evaluated at 25°C with an electric hygrometer (Hygroskop DT Rotronic, Zurich) calibrated with saturated solutions of different salts. Prior to a_w determination the samples were cut into small particles and equilibrated for 24 hrs. The following variables were determined for each sample: % water content, (WC); water loss, (WL), (g/100 g fresh product); solid gain (S. G), (g/100 g. fresh product); % weight reduction (WR); % total solid (TS).

Air drying after osmosis was performed in a laboratory oven with forced circulated air at room temperature.

RESULT AND DISCUSSION

In each osmotic experiment samples of fruit or vegetable were analyzed for changes in water content (a_w, WC, WL) and solid content (TS, SG). An example of the changes of these parameters during osmotic treatment of apple cubes in frudex 70°Bx at 25°C, is shown in Fig. 1. In the first hours of the process the most important mass transfer takes place, afterwards the food-solution system tends to reach the equilibrium.

The osmotic process can be remarkably accelerated increasing osmotic solution temperature (HTST, high temperature short time osmosis) [6]. In Fig. 2 and 3 the times to obtain three different levels of % weight reduction (W. R.) are shown as a function of solution temperature, for apple and carrot respectively. The percentage of weight reduction in the apple and carrot samples after a few minutes HTST osmosis was the same as that given by some hours' treatment at room temperature. Moreover, HTST osmosis consents to combine the dehydra-

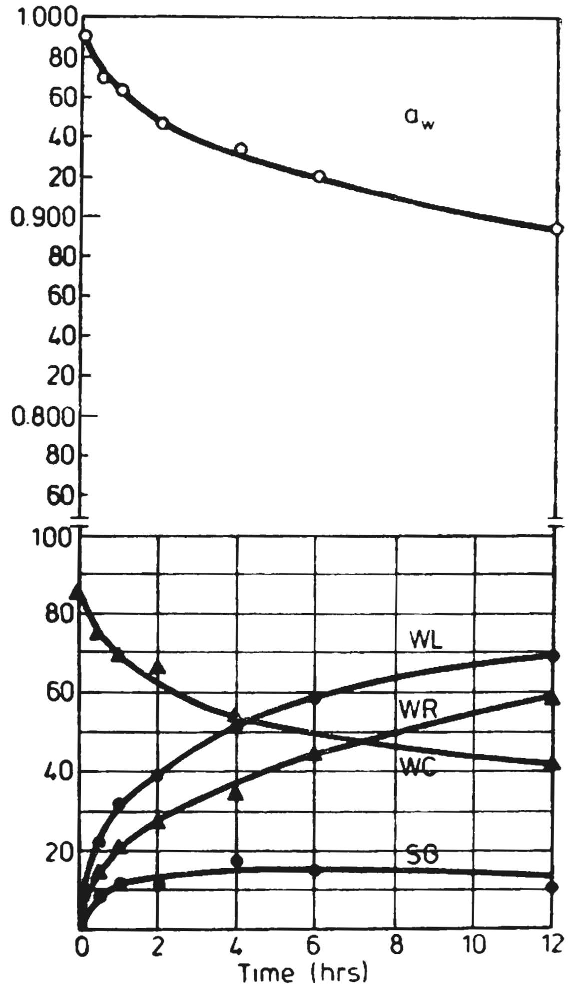

Fig. 1. Evolution of some parameters vs time, during osmotic concentration (e.g. apple cubes in frudex at room temperature)

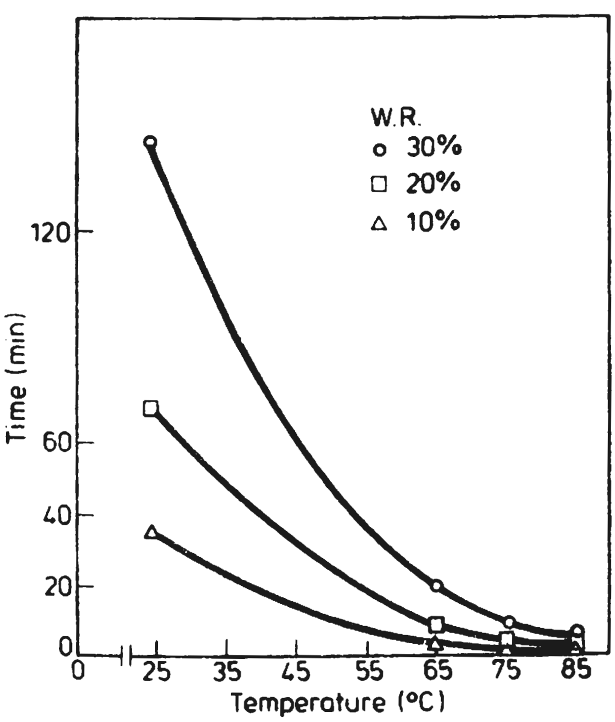

Fig. 2. Time (hrs) to realize a prefixed % weight reduction as a function of temperature of osmotic solution in apple cubes

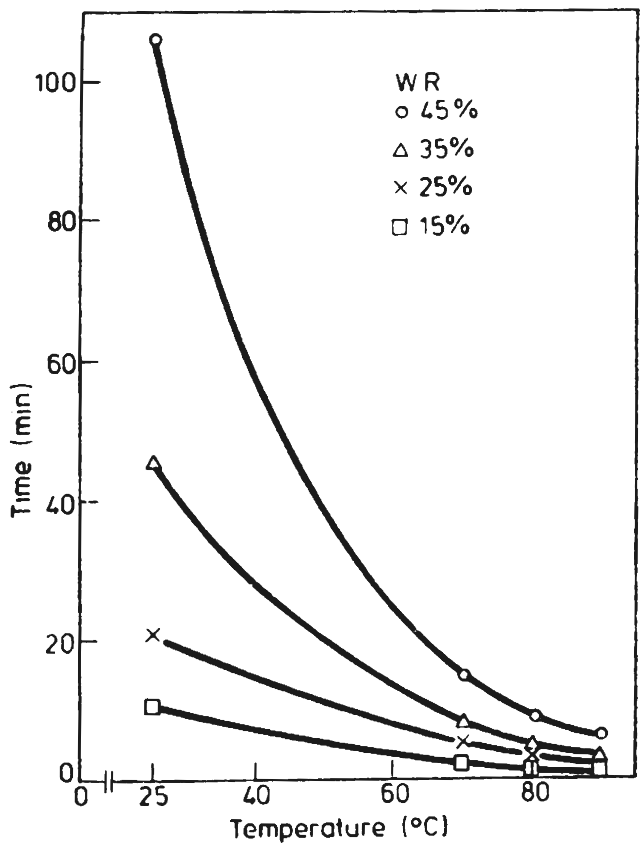

Fig. 3. Time (hrs) to realize a prefixed % weight reduction as a function of temperature of osmotic solution in carrot cubes

ting effect of the osmotic treatment with the "blanching" effect of the high temperature [6].

Different kinds of fruits and vegatables were tested to verify their behaviour to direct osmosis concentration. Table 2 shows for several products changes in water and solid content, before and after an osmotic treatment (6 hrs at room temperature). The a_w values of the osmosed products resulted in the range 0.91 (carrot) and 0.95 (hard black cherry, whole fruit). These a_w values allow an increasing of food shelf life, but in order to obtain self stable products, osmosed materials must be submitted to other preservative processes as freezing, pasteurization, drying.

Table 2. Characteristics of fresh and osmosed materials (6 hrs) in frudex (F) or glicosa (G) at room temperature)

Product	Fresh		After 6 hrs osmosis				
	WC %	a_w	WR %	Wlg	SGg	WC %	a_w
Strawberry (F)	88.7	0.991	52.6	56.8	4.1	63.3	0.954
Peach (F)	91.6	0.994	48.8	55.1	5.1	63.4	0.949
Apricot (F)	89.4	0.982	46.5	51.1	4.6	69.9	0.946
Apple (F)	86.2	0.990	50.3	58.2	7.9	54.5	0.909
Cherry (F)	79.1	0.971	30.1	34.3	5.1	68.6	0.931
Kaki (F)	80.2	0.980	45.5	49.4	4.1	68.4	0.950
Hard Black Cherry* (F)	84.9	0.978	29.1	36.1	4.9	69.8	0.953
Raspberry* (F)	85.7	0.983	30.2	35.2	3.8	65.0	0.926
Carrot (G)	87.8	0.984	68.3	70.1	5.2	53.2	0.912
Pumpkin (G)	90.1	0.980	55.2	61.3	3.9	67.6	0.924

* whole fruit

A number of authors have suggested osmotic dehydration as a means to both reduce water load and improve product quality in drying operations such as vacuum drying (7; 1), freezed (3; 2) or air drying [4].

In Figs 4 and 5 are shown changes in water content vs time of osmotic concentration and air drying of apple and carrot respectively. All the processes were performed at room temperature; drying was also conducted for fresh materials. Osmosed products as compared to fresh ones, when subjected to air drying presented a lower drying rate due to water removal and solid uptake during osmosis. However, to obtain intermediate moisture derivatives (a_w = = 0.5-0.6), osmosed material required less than half the drying time in respect to fresh fruit and vegetables.

CONCLUSION

Direct osmosis appears to be a successful method of concentrating fruit and vegetables. The osmosed products in general display a reduced a_w value, very good texture and high aroma and color retention.

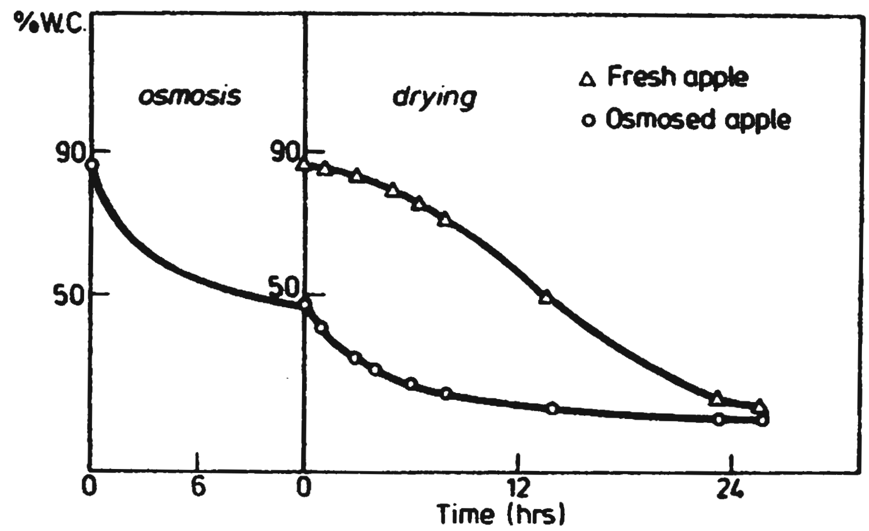

Fig. 4. Changes in water content (W.C.) vs time of osmotic concentration and air drying in apple cubes

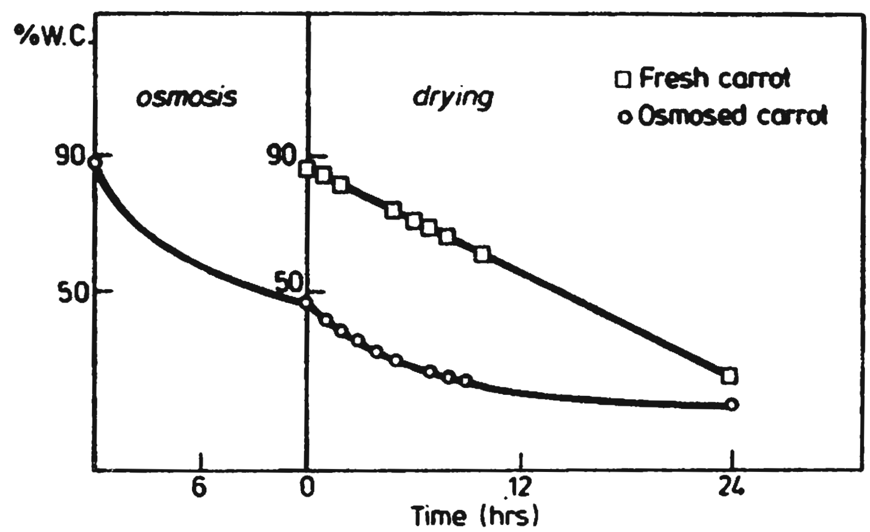

Fig. 5. Changes in water content (W.C.) vs time of osmotic concetration and air drying in carrot cubes

As pretreatment prior drying, direct osmosis is particularly useful when the energy source is unable to give high temperature air drying. Other advantages of osmotic concentration of foods are: high moisture removal in non-evaporative way; total solids increase; loss of acidity and improved quality of dried product.

At last, by HTST osmosis concentration effect can be combined to enzymatic inactivation (blanching), thus precluding the use of sulphur dioxide in dried fruit and vegetables.

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WYKORZYSTANIE BEZPOŚREDNIEJ OSMOZY W PROCESIE SUSZENIA OWOCÓW I WARZYW

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S t r e s z c z e n i e

Bezpośrednia osmoza jest procesem zagęszczania bez odparowania. Zachodzi ona w kawałkach żywności zanurzonej w roztworze hypertonicznym. Ponieważ roztwór ten wykazuje wyższe ciśnienie osmotyczne i wskutek tego niższą aktywność wody (a_w) pomiędzy roztworem i żywnością powstają siły usuwające wodę, gdyż naturalna błona komórkowa działa jak półprzepuszczalna membrana.

Owoce i warzywa były częściowo odwodnione przez zanurzenie w syropie skrobiowym kukurydzianym (70 Bx), w temperaturze pokojowej (25°C) i w wysokiej (powyżej 70°C). Mierzono ubytek wody, przyrost suchej masy i obniżenie aktywności wody w próbkach w stosunku do czasu suszenia.

Bezpośrednia osmoza wykorzystywana była jako metoda wstępnego suszenia przed suszeniem powietrznym. Uzyskane wyniki wskazują, że produkty takie miały smak słodki, nie kwaśny i lepszą teksturę, barwę i zapach. Zastosowanie osmozy w wysokiej temperaturze przez krótki czas pozwala na uzyskanie łącznego efektu blanszowania i suszenia.