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The Use of Skim Milk Permeate in the Preparation of Spray Dried Beverages Part I—Orange Beverage

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ABSTRACT

Permeate was obtained by ultrafiltration of reconstituted skim milk (10% TS) and then concentrated by reverse osmosis and evaporation under vacuum to 27% TS. Orange juice was concentrated by vacuum evaporation to 18% TS and mixed with concentrated permeate at the rate of 1:3. Artificial colour was added and the mixture was spray dried at 160°C and 92°C inlet and outlet temperatures, respectively. Sugar was added to the resultant powder (1:1) by dry mixing; the powder was packed in polyethylene bags in airtight containers and stored at room temperature for 6 months. Changes in the chemical composition and physical properties of the powdered beverage were then followed. Also, organoleptic properties of the powder were evaluated by a taste panel with the reconstituted beverage (15% TS).

Changes in the physical properties of the powder during storage were a decrease in occluded air and powder density and an increase in interstitial air, hygroscopicity and moisture content. The wettability of the powder slightly improved during storage. The composition of the beverage was almost unchanged during storage except in its vitamin contents where variable losses were detected.

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INTRODUCTION

The production of dehydrated foods offers several advantages. Dehydration decreases the costs of transportation and storage—particularly in foods of high moisture content—and, in most cases, increases the shelf life of the product.

Attempts to prepare dehydrated fruit juices, particularly citrus juices, have been the subject of several studies (Gupta, 1978; Owades, 1980). In most processes for the production of dehydrated juices a concentrated juice is blended with a drying aid which is usually a carbohydrate. The drying aid is generally added in order to improve the drying rate, to prevent the product from sticking to the walls of the dryer, to reduce hygroscopicity and to maintain flowability in the dry powder (Varsel, 1980).

Abd El-Salam *et al.* (1984) showed that milk permeate powder was constituted mainly of lactose and that its physical properties render it of choice in the formulation of spray dried beverages based on fruit juices.

The present paper describes the formulation of a dry beverage based on orange juice and permeate blends, and the changes in its composition and properties during storage.

MATERIALS AND METHODS

Preparation of concentrated permeate

Permeate was prepared by ultrafiltration of reconstituted skim milk (10% TS) and then concentrated by reverse osmosis (Abd El-Salam *et al.*, 1984). The permeate was further concentrated by evaporation under vacuum at 60 °C until the total solids content (TS) reached 27% as determined by an Abbe refractometer.

Preparation of orange juice

Orange juice was obtained from Baladi variety fruit using a press juicer. The juice was strained through cheese cloth and further clarified by centrifugation at 3000 rpm for 10 min. The juice was concentrated by evaporation under vacuum to 18% TS.

Preparation of colouring solution

Food grade yellow (code No. 19140-4 yellow) and red (code No. 4720-3 red/19140-yellow) colours were obtained from Aro Misr Co., Egypt. One per cent solutions were prepared from each, and 22 ml of the yellow colour solution were mixed with 3 ml of the red one.

Preparation and spray drying of orange juice/permeate mixture

One part of the concentrated orange juice was mixed with three parts of concentrated permeate solution. One millilitre of the colour solution was added to 100 ml of the orange juice/permeate mixture and then spray dried using a mini spray dryer, Buchi 190 (Buchi Lab Tech., AG, Switzerland), under the following conditions: (i) inlet and outlet temperatures of 160°C and 92°C, respectively. (ii) air flow of 400–600 ml/min, (iii) aspiration and feed setting adjusted to 8 and 4, respectively.

Preparation of powdered beverages

The powdered orange juice/permeate was mixed with an equal weight of cane sugar and blended in a coffee grinder. The fine powder was packed in polyethylene bags, sealed and stored at room temperature (20 ± 5 °C) in airtight containers for 6 months.

Methods of analysis

Chemical analysis

The moisture, ash, total N (Ling, 1963), calcium and magnesium (Natillianas & Whitney, 1964), phosphorus (Snell & Snell, 1949), citrate (Marier & Baulet, 1960), total reducing sugar (IDF, 1967), vitamin C (AOAC, 1975), riboflavin (Rashid & Potts, 1980), thiamin (Melnick & Field, 1939), nicotinic acid (Melnick & Field, 1940) and sodium and potassium were determined by flame photometry in the prepared beverage.

Physical properties

The powder bulk density, particle density, occluded and interstitial air, hygroscopicity and wettability were determined according to Niro Atomizer (1978).

Sensory evaluation
The beverage powder was reconstituted at the rate of 15 %. A panel of the laboratory staff (ten people) were asked to judge the acceptability of the resultant product for: colour and flavour (overall, acidity, saltiness and other undesirable flavours).

Three replicates were made from the beverage powder and analysed for chemical composition and physical properties when fresh and monthly during storage.

RESULTS AND DISCUSSION

Preparation of orange-based beverage powder

Mixtures of concentrated orange juice/permeate were prepared with varying ratios from 1:1 to 1:4. The colour intensity of these mixtures decreased with decreasing amounts of orange juice in the mixture. On the other hand, the mixture (1:4) had a noticeable saltiness that overcame the orange taste.

Spray drying of these mixtures showed that considerable losses occurred in orange juice/permeate mixtures (1:1 and 1:2) due to adherence of streaky powder to the walls of the cyclone. Also, the resultant powder was very hygroscopic. This can be attributed to the high fructose content originating from the orange juice. The addition of carboxymethylcellulose (0·05 % and 0·1 %) to the 1:1 mixture failed to improve the drying of this solution. On the other hand, the powder properties were much improved by increasing the permeate concentration in the mixture (1:3 and 1:4). Therefore, these two ratios were considered the most promising for drying orange juice.

The powders formed from 1:3 and 1:4 mixtures were reconstituted at different ratios (10 %, 15 % and 20 %, respectively). Those prepared from 1:4 mixtures were characterized by an overall salty taste and faint colour. On the other hand, beverages from the 1:3 ratio were characterized by a faint colour and a flat taste. The addition of sugar intensified the flavour of the beverage and was considered acceptable to all panelists when equal amounts of sugar and orange/permeate powder were reconstituted at 15 % TS. To improve the colour of the prepared beverage, the addition of food grade artificial colour was found to be necessary. Different concentrations of the yellow and red colours were mixed with reconstituted beverage and then matched with the original orange juice. A mixture of 22:3 yellow to red gave the most satisfactory results.

The final formula and preparation of beverage based on orange/permeate powder, as described in the 'Materials and Methods' section, was accepted by the taste panel.

Chemical composition of beverage powder

Table 1 shows the chemical composition of freshly prepared beverage based on orange juice. The beverage was made up of 41·6% to 42·8% reducing sugar, principally lactose originating from permeate. The low ash content of the beverage was due to the inclusion of 50% cane sugar in its preparation. The beverage was characterized by low acidity due to the presence of a high concentration of Na and K. The high K content of the beverage can be attributed to the high K content of the orange juice—1500–2000 ppm (Nagy & Attawy, 1980), while the high Na content originated from permeate. The high Ca and Mg contents of the beverage mainly originated from the permeate.

The beverage powder contained 49·4 to 74·4 mg of vitamin C per 100 g. Orange juice was reported to contain 50–70 mg/100 ml of vitamin C

TABLE 1
Chemical Composition and Vitamin Contents During Storage of Dried Beverage Based on Orange Juice

	Fresh	*Months*					
		1	*2*	*3*	*4*	*5*	*6*
Total solids (%)	97·61	97·58	97·67	97·56	97·53	97·55	97·53
Ash (%)	3·43	3·38	3·32	3·29	3·25	3·23	3·19
Total reducing sugars (%)	42·4	41·9	41·9	41·2	41·0	40·8	40·9
Acidity (%)	0·16	0·21	0·22	0·22	0·22	0·21	0·22
Ca^{++} (mg/100 g)	433	433	433	433	433	433	433
Mg^{++} (mg/100 g)	120	120	120	120	120	120	120
P (mg/100 g)	219	211	213	211	201	202	189
Vitamin C (mg/100 g)	60·7	55·7	49·6	46·0	44·6	43·4	41·9
Riboflavin (mg/100 g)	1·06	0·38	0·146	0·086	0·009	0·003	0·00
Thiamine (mg/100 g)	1·06	0·88	0·75	0·39	0·32	0·25	0·15
Nicotinic acid (mg/100 g)	1·63	1·30	1·11	0·58	0·48	0·44	0·33
Na^{+} (mg/100 g)	453						
K^{+} (mg/100 g)	492						
Citrate (g/100 g)	1·74				1·97	1·83	1·65

(Nagy & Attawy, 1980), suggesting that the vitamin C content of the powdered beverage originated principally from the orange juice and that it was not affected by the drying conditions.

The riboflavin content of orange juice was reported to be very low (Nagy & Attawy, 1980). Therefore, the riboflavin content of the beverage originated principally from the permeate. The thiamin and nicotinic acid contents of the prepared beverage were 1·06 and 1·63 mg/100 g, respectively, suggesting that the prepared beverage can be considered a good source of both vitamins. The powdered beverage contained an average total N of 0·373 %, probably in the form of NPN and originating from permeate and orange juice.

Physical properties

Table 2 shows the physical properties of the orange based beverage. It is apparent from these results that the powder bulk density of the prepared beverage was higher than that given for permeate powder (Abd El-Salam *et al.*, 1984). This may be due to the dry mixing step followed in the preparation of the beverage that reduces the particle size of the spray dried powder.

The beverage powder was less hygroscopic than permeate powder (Abd El-Salam *et al.*, 1984) being 7·93 in the former and 13·7 in the latter. The

TABLE 2
Changes During Storage in the Physical Properties of Dried Beverage Based on Orange Juice

	Months						
	Fresh	*1*	*2*	*3*	*4*	*5*	*6*
Poured bulk density (g/cm^3)	0·75	0·632	0·639	0·625	0·615	0·613	0·613
Loose powder bulk density (g/cm^3)	0·726	0·714	0·707	0·683	0·688	0·689	0·688
Tapped powder bulk density (g/cm^3)	0·984	0·938	0·923	0·910	0·909	0·909	
Powder bulk density (g/cm^3)	1·09	1·11	1·09	1·11	1·11	1·07	1·11
Hygroscopicity (%)	7·93	8·00	7·25	7·23	7·83	8·50	8·50
Total moisture (%)	2·39	2·42	2·33	2·44	2·47	2·50	2·61
Free water (%)	1·54	1·72	1·75	1·77	1·85	1·95	2·05
Wettability (min)	4·24	3·94	3·43	3·26	2·89	2·45	2·41
Particle density (g/cm^3)	1·43	1·47	1·50	1·52	1·57	1·54	1·48
Occluded air (%)	5·65	5·40	2·24	1·52	0·62	0·54	
Interstitial air (%)	31·2	35·9	41·2	42·1	42·6	42·2	42·2

hygroscopicity of beverage powder falls in the range of non-hygroscopic materials (10%), suggesting good keeping quality of the prepared beverage.

The beverage powder contained occluded and interstitial air, while permeate powder was devoid of the former (Abd El-Salam *et al.*, 1984). This suggests that the addition of orange juice changes the structure of the formed powder, entrapping air within the formed particles. The occluded air formed 10% of the total air in the powder. The volume of interstitial air in the beverage powder was much less than in permeate powder (Abd El-Salam *et al.*, 1984) probably due to reduction in particle size of the beverage powder. The wettability of the beverage indicates low solubility.

Changes in the chemical composition of beverage powder during storage

The changes in the composition of orange-based beverage powder during storage for 6 months are shown in Table 1. It is obvious from these results that most of the changes occurred in the vitamin content of the powder.

TABLE 3
Loss Percentage During Storage in the Vitamin Contents of Dried Beverage Based on Orange Juice

	Months					
	1	*2*	*3*	*4*	*5*	*6*
Vitamin C	8·30	18·3	24·2	26·5	28·6	31·0
Riboflavin	64·2	86·2	91·9	99·2	99·7	100
Thiamine	16·9	29·0	63·2	69·8	76·1	85·9
Nicotinic acid	20·3	31·9	64·4	70·8	72·8	79·6

Table 3 shows the loss (%) in the vitamin content of the beverage during storage. The vitamin C content gradually decreased with storage showing a loss of 31·0% after 6 months. This indicates that vitamin C was reasonably stable under the conditions described. The riboflavin content of orange-based beverage rapidly decreased, showing complete destruction after 6 months of storage. This may be attributed to photo-oxidation as the beverage was stored in transparent plastic bags. Also, the thiamine and nicotinic acid contents of the beverage decreased with storage but at a slower rate compared with riboflavin.

Changes in the physical properties of prepared beverage during storage

The changes in the physical properties, during storage for 6 months, of the orange-based beverage are shown in Table 2. These changes were slight. Thus, the bulk density of the powder slightly decreased; hygroscopicity, total and free moisture slightly increased all through the storage period. The most noticeable change in the physical properties of the beverage powder occurred in the wettability, occluded and interstitial air. Thus, the occluded air decreased considerably, interstitial air increased and wettability was improved. This suggests partial agglomeration of powder particles during storage.

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