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EGG POWDER BY FOAM-MAT DRYING

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Egg powder has been prepared using the foam-mat technique. Various aspects in the production of egg foam and subsequent drying have been studied. It was found that a ¼" thick layer of foam having density between 0.20 to 0.26 gm/ml had low spreading and drainage problems and yielded good quality product when subjected to dehydration. Of the several drying temperatures used, 70°C was found to be the optimum. Egg powder prepared under the above conditions had fine quality as revealed by the solubility and organoleptic tests.

Key words: Egg; Dehydration; Food foam.

INTRODUCTION

Many liquid foods can be converted to stable foams which, when dried rapidly in a current of hot air, yield instant powders of good quality. The drying of foam is fast due to moisture movement by capillary action in the liquid film separating the foam bubbles and the resultant dry material has porous structure permitting ready reconstitution of the product. This foam-mat drying technique which was originally developed by Morgan *et al.* [1] has been applied to a number of liquid or semi-liquid foods to produce instant food powders [2-8].

Bergquist [9] has reported 'foam' belt drying of whole egg and yolk but detailed information regarding foam formation, its stability and subsequent drying is not available in the published literature. Studies, therefore, were undertaken to standardize conditions for the production of egg foam suitable for drying and obtaining a good quality product.

MATERIALS AND METHODS

Preparation of foam. Foam was prepared with a special machine similar to an egg beater, designed and developed at the PCSIR Laboratories, Lahore. Fresh eggs were procured from a local market and washed to remove adhering dirt, faeces etc. They were then broken manually in accordance with the procedure described by Jacob [10]. The yolks and whites were mixed in a Hobart Food Mixer using wire whip attachment to obtain a uniform pulp. The pulp was passed through a strainer with 0.024 in. performations to remove challazae and shell fragments. It was desugared using DeeO Takamine, glucose oxidase-catalase (BDH, Chemical Division, Poole, England) according to the procedure described by Scott [11]. The pulp was then pasteurised at 60° for 3 minutes and cooled to the required temperature for foaming.

For foaming purpose, 300 g of the egg pulp was whipped for various periods of time and the foam evaluated for density and drainage according to the procedures described by LaBelle [12] after making a slight modification as below.

Density. A known volume of the foam was carefully transferred to a graduated beaker taking care to exclude any accidental voids. The beaker was filled to 75 ml mark, weighed and density determined.

Drainage. Egg foam, produced at a given temperature, was transferred to a 100 ml graduated cylinder and held at the same temperature for 60 min. to note the drainage. Periodic observations of the liquid level near the bottom of the cylinder established the drainage rate. This was expressed as the percentage by volume of liquid phase that separated in 60 min. at that temperature.

Following factors were studied with respect to the foaming of whole egg:

(i) Effect of foaming time on density and drainage.
(ii) Effect of foaming temperature on density and drainage.
(iii) Drainage as a function of time and temperature.

Drying of foam. The egg foam representing each drying trial was spread evenly on stainless steel trays as a thin layer/mat with the help of a simple spreading device. The trays loaded with the foam were dried in a cross-flow cabinet dryer (Mitchell Dryars No. 6298/59, Manchester). Optimum foam density for the purpose of drying was determined by applying foams of various densities as a thin layer (about ¼") and drying at 60°. Similarly, layer thickness was optimised by applying separate layers of thickness 18", 1/4" and 3/8" and keeping the density constant (0.25 gm/ml). Suitability of a condition was judged by subjective observations such as ease of spreading, low drainage and rapid reconstitution of the product. The samples were then prepared using the optimum conditions and drying at 55°, 60°, 70° and 80° in separate experiments.

In order to study the water removal during dehydration, moisture loss was estimated by periodically weighing the trays, which carried an initial load of foam of known weight. Drying curves were then drawn from the initial solids content, tray load and moisture loss during various intervals of time. The dried material was removed from the tray with a scraper blade in a low humidity environment. It was pulverized by passing through ordinary steel rolls (clearance-3 mm) increasing thereby the bulk density of the product. The product was then sieved to obtain 20 mesh powder which was packed in air tight containers and stored in a reffigérated environment for subsequent analysis and organoleptic evaluation.

Analytical assay. Moisture in the samples was determined according to AOAC (1980) [13]. Solubility was determined as the water value basically according to the method described by Thistle *et al.* [14]. Two grams of egg powder were throughly suspended in 100 ml distilled water for one hour and filtered through Whatman No. 1. An aliquot (20 ml or more) of the filtrate was evaporated just to dryness at 90-100° in an air oven and then dried at 70° in a vacuum oven (26-28" Hg) to a constant weight. From the weight of the residue, solubility was calculated as below:

$$\% \text{ Solubility} = \frac{\text{Wt. of residue (g)}}{\text{Aliquot taken (ml)}} \times 3{,}000$$

Microbiological assay. Microbiological tests were performed according to the standard methods for the examination of foods [15].

Organoleptic tests. Conventional egg omelette was used for organoleptic evaluation of the product. The omelette was prepared by the following recipe.

Egg powder = 22 g; water = 80 ml; salt = ½ t.s.f., chillies = ¼ t.s.f., onion slices = 25 g and sufficient cooking oil.

Egg powder was soaked and thoroughly dispersed in water alongwith salt and chillies to make a uniform slurry. It was allowed to stand for 5 minutes. Then onion slices were added, and the mass worked up as usual for the preparation of omelette. The omelette prepared from different samples was evaluated for colour, texture and taste by a panel of six trained judges on a 10 point Hedonic scale. For comparison purpose, judges were also presented omelette prepared from fresh eggs alongwith experimental samples, all under coded names.

Statistical analysis. Solubility data and organoleptic scores were subjected to analysis of variance to find significant differences [16].

RESULTS AND DISCUSSION

The density of foam produced by whipping the egg pulp for various lengths of time indicate that the density decreases (indicating an increase in the quantity of foam) with an increase in the foaming time (Table 1). The drop in

Table 1. Effect of foaming time on the foam density and drainage rate of whole egg. (Foaming temperature = 30°).

Foaming time (min.)	Foam density (g/ml)	Drainage rate (vol. %) 60 min. @ 30°C
0	1.026	–
1	0.240	81
2	0.200	77
3	0.180	63
4	0.17	54
5	0.165	52
L.S.D.* (5 %)	0.018	1.7

*Least significant difference.

density is maximum during the early stages, which decreases after 3 min. foaming period. The drainage rates also decrease with a decrease in the foam density. Similar trend was observed by Hart *et al.* [17] during foaming of apple and orange concentrates.

The effect of pulp temperature on the foam density and drainage is shown in Table 2. It was observed that foamability of egg increased with an increase in temperature as indicated by the density of foam which is 0.20 g/ml at 30° as against 0.26 g/ml, at 15°. The drainage, measured after 15 min. interval, was faster in the beginning which gradually decreased during the subsequent intervals of time. The drainage at 30° was found to be 51 % during the first ½ hour while it was 26 % during the latter ½ hour interval. The drainage rate was 2½ times faster at 30° then that at 15°.

Preliminary studies indicated that egg foam having a density between 0.20 – 0.26 g/ml was suitable for drying. High density foam had drainage and subsequent drying problems while low density foam (i.e. below 0.20 g/ml) was

Table 2. Egg foam density and drainage at different foaming temperatures (Foaming time = 2 minutes).

Foam characteristics	Foaming temperature	
	15°C	30°C
Density (g/ml)*	0.26[a]	0.20[b]
Drainage (vol %)*	10	36
After 15 min.	10	36
After 30 min.	19	51
After 45 min.	26	67
After 60 min.	32[a]	77[b]

*Means in a row followed by different letters are significantly different ($P < 0.01$).

stiff and difficult to spread. It was also noted that the freshly formed foam yielded better quality product on dehydration. Any delay in dehydration resulted in drainage and affected the quality of the end product. It was further observed that the thicknesss of the foam-mat had a direct bearing on the quality of the end product. Thus 1/8" mat was good for drying purposes but there was difficulty in preparing and spreading so thin a layer of foam. On the other hand, 3/8" thick mat had drainage problems. A ¼" thick layer of egg foam was found to be optimum for drying purpose.

Fig. 1 shows the drying curves of egg foam at various temperatures. It is obvious from the curves that the rate of drying was quite fast in the beginning which slowed at the later stages. For example, in the 60° curve the original moisture content of about 74 % was reduced to 47 % and 25 % in 30 min. and 60 min. respectively. Thus, about 2/3rd of the total moisture was removed during the first

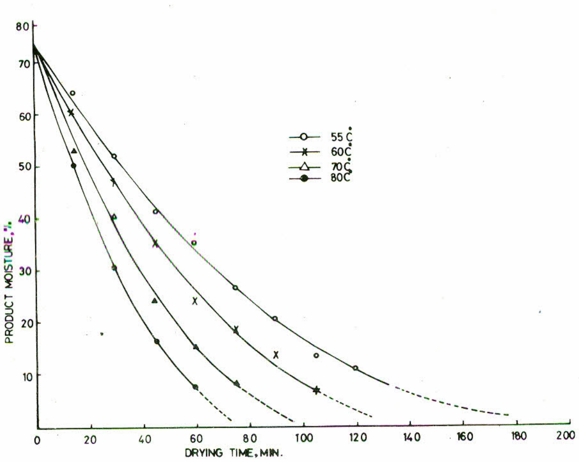

Fig. 1. Drying curves for egg foam (density, 0.24 g/ml; layer thickness, ¼ in).

30 min. while 90 min. were needed for removing the remaining moisutre. Our results in this respect are in agreement with those reported by Berry *et al.* [8] in the case of foam-mat drying of orange juice. From the drying curves it is seen that the time required to dry the foam to 3 % at 55°, 60°, 70° and 80° respectively was 175, 125, 96 and 72 minutes.

The results of the organoleptic tests for four samples dried at 55°, 60°, 70° and 80° are shown in Table 3

Table 3. Organoleptic scores and per cent solubility values of foam-mat dried egg powder processed at different temperatures.

Drying temp. (°C)	Organoleptic scores[1,2]			% Solubility
	Colour	Texture	Taste	
55	7.5[a]	7.5[a]	8.2[a]	91.7[a]
66	7.4[a]	7.6[a]	8.1[a]	91.5[a]
70	7.6[a]	7.4[a]	7.7[a]	90.6[a]
80	7.5[a]	7.5[a]	6.7[b]	89.0[b]
Fresh egg	8.7[a]	8.2[a]	8.2[a]	100[3]

1. Means of 6 judgements – 9-10 excellent, 7-8 good, 5-6 satisfactory, 3-4 poor, 1-2 inedible.
2. Means within columns followed by the same letter are not significantly different ($P < 0.05$).
3. Solubility of fresh egg has been taken as 100 %.

alongwith % solubility values. It is clear from the results that drying of egg foam at 55°, 60° or 70° did not cause any significant differences in colour, texture and taste scores of the reconstituted product when compared with fresh egg. Drying at 80°, however, resulted in a significant reduction ($P < 0.05$) of taste score. The colour and texture scores were not significantly different from each other in case of all the four samples. It is also clear that % solubility values for the sample dried at 80° was significantly lower ($P < 0.05$) than those of the samples dried at 55°, 60° and 70° while the difference among the solubility values of the latter samples is insignificant. This adverse effect on solubility and taste is, perhaps, due to some physico-chemical changes brought about during processing. The solubility of the egg powder is regarded to be a well known criterion for a good quality product; higher the solubility, better is the quality [18].

From the foregoing discussion, it can be said that drying of egg foam at temperatures as high as 80° has undesirable effect on quality and should be avoided. On the other hand, dehydration at a low temperature of 55° or 60° is uneconomical because of longer drying times.

Therefore, 70° may be regarded as the optimum temperature for drying of egg foam.

Microbiological evaluation. Total viable count in various samples was found to range between 8000 to 15000 microbes per gram. Coliform bacteria were detected in the samples but the number did not exceed 8 per gram. These figures are well within the permissible limits [19]. Salmonella was not detected in any of the samples.

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