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# FOAM-MAT DRYING OF SOME LIQUID FOODS

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Conditions that were successful in foam-mat drying of various liquid foods have been described. Dilute juices had to be concentrated prior to foam formation. The foams were produced using a foaming machine developed locally. Various permissible additives were tested for production and stabilisation of foams for the purpose of dehydration. Optimum conditions with respect to foam thickness, drying temperature and drying time have been indicated. The products, in general, were organoleptically acceptable.

*Key words:* Drying, Dehydration, Food powder.

## INTRODUCTION

Food drying processes involving the use of vacuum are quite expensive, thus limiting their application on industrial scale. The foam-mat drying process is of particular interest because it enables the removal of moisture from heat-sensitive food materials by heating at moderate temperatures without the use of vacuum. This technique has been applied to various liquid foods to produce instant powders [1-4]. The details of the process are covered by patents [5-7] in which specialised equipment has been used for the production and drying of fruit/vegetable juice foams. Generally, a liquid food, with or without the aid of a stabilizer, is whipped into a stable foam which is dried in a stream of hot air yielding good-quality food powders. Since large surface is exposed to the air stream, most water is removed from the product within very short time. The resultant dry material has a porous structure which is easily scratchable from the drying surface and is readily rehydrated an addition of water.

In our earlier communication [8], dehydration of various vegetables was reported. The present paper describes the conditions in relation to the preparation, stabilization, spreading and subsequently drying of various food foams in the laboratory.

## MATERIALS AND METHODS

(a) *Food preparation.* All the food materials for this study were procured fresh from local sources and prepared in the form of fluids, where necessary. Juice or pulp was extracted using standard equipment and procedure for the purpose. Dilute juices, extracts and milk were concentrated in a laboratory evaporator (climbing film, quickfit) to the required Brix. The pulp, paste or concentrate, prepared as above, was stored at or below refrigeration temperatures until required for foam-mat drying experiments.

(b) *Additives.* Many foods (e.g. egg pulp, beef extract, concentrated milk etc.) naturally contain soluble proteins and monoglycerides and produce stable foams when whipped. No additive is necessary during foaming of these foods. In other foods, however, foam does not produce or if produced, at all, is unsatisfactory. It is here that something has to be added to induce foaming and impart stability so that the foam structure does not collapse during the drying process. Various additives used in the present study were modified soy protein or albumen (MSA), glyceryl monostearate (GMS) and egg albumen (EA) as foaming agents and methyl cellulose (MC) as a foam stabilizer or thickener. The foaming and stabilizing agents were prepared as follows:

*Modified soy albumen.* (D-100, Gunther products Inc., Galesburg, III, USA). A 10% aqueous solution was prepared and kept refrigerated. The solution was added to the cold food before whipping.

*Distilled glyceryl monostearate.* (Myverol 18-00, Distillation Products, Industries, Rochester, N.Y.) A measured amount of water was heated to 68$^{o}$ and the required amount of Myverol 18-00 was added with stirring. On a water bath at 70$^{o}$, this suspension was whipped for 3 min. with a kitchen mixer. The resultant white, creamy suspension was poured into small containers and cooled to room tempeature. This stock was made fresh every 24 hr and maintained at room temperature. A 10% solution was usually made up. It was blended with the food by hand mixing. The preblended mixture was then whipped at high speed to produce the foam.

*Methyl cellulose (BDH, England).* A weighed quantity of methyl cellulose was dispersed in a small amount of hot water and diluted to the desired volume with cold water. Generally a 5% suspension was used.

(c) *Apparatus.* A Hobart food mixer with wire whip attachment was used for stirring or mixing the additives. Foams were prepared by an electric foaming machine designed and developed at the PCSIR Laboratories, Lahore. It consisted of a special assembly of blades geared by an electric motor at 1400 RPM. A 2-litre bowl containing about 500 g liquid food could be fitted to the machine so that on attachment the blades partially dipped in the material. The whole assembly could be dismounted for the purpose of washing. Foam was prepared at various temperatures by operating the machine for a few minutes. The quality of the foam was evaluated with respect to density and drainage in accordance with the procedure described by La Belle [9].

The foam was evenly spread on stainless steel trays with the help of a simple spreading device and dried in a cabinet dryer (Mitchell Dryers No. 6298/59, Manchester) at specified temperatures. At the end of the drying cycle, the trays were shifted to a low temperature, low-humidity chamber ($15^{o}$, 25% RH) where the material could be easily scrapped off the trays. The dried material was desified by a pair of rolls (clearance, 3 mm) and packed in air tight containers.

## RESULTS AND DISCUSSION

Tables 1 and 2 give conditions that were successful in converting some indigenous liquid foods to stable foams that could be dried in a stream of hot air. These conditions were arrived at by hit and trial method. The conditions were in fact, dependent upon the type of foaming equipment, time and temperature of foaming and solids content of the food sample. In preliminary trials, ordinary kitchen mixers were used to prepare the foam. The quality, however, was not satisfactory for the purpose of dehydration as both foam density and drainage were high, ($C < 0.5$ g/ml and drainage $< 10\%$ in 100 min. at $25^{o}$). The Hobart mixer was successful but prolonged whipping was required for obtaining a stable foam. The PCSIR foaming machine owing to its high-shear generated foam of fine quality and stability as its drainage rate was no more than 5% in 100 min. at $25^{o}$. It produced dehydration-worthy foam in a very short time (2-3 min.) as against the other equipment which took more than 10 min. and in some cases upto 30 min.

Generally, the dilute liquid foods had to be concentrated to around the solids contents listed in Table 1. Methyl cellulose (@ about 1%) was used for increasing the viscosity of plum, grape and citrus fruit concentrates, while other

Table 1. Conditions for foaming of various liquid foods

| Commodity | Soluble solids (%) | Additive** | Quantity of additive (% dsb) | Foaming temp. ($^{o}$C) | Foam density*** (g/ml) |
|---|---|---|---|---|---|
| Banana pulp | 20 | GMS | 2.0 | 20 | 0.45 |
| Beef extract | 50* | – | – | 40 | 0.36 |
| Egg pulp | 25* | – | – | 25 | 0.22 |
| Grape juice conc. | 36 | MC<br>MSA | 1.0<br>1.0 | 20 | 0.20 |
| Grape fruit juice conc. | 25 | MC | 1.0 | 25 | 0.22 |
| Guava pulp | 10 | GMS<br>MSA | 2.0<br>2.0 | 20 | 0.45 |
| Lemon juice conc. | 25 | MC | 1.0 | 20 | 0.27 |
| Malt extract | 80* | EA | 3.0 | 25 | 0.40 |
| Mango pulp | 22 | GMS | 3.0 | 25 | 0.62 |
| Milk, whole | 35* | – | – | 40 | 0.35 |
| Orange juice conc. | 24 | MC | 1.0 | 10 | 0.35 |
| Plum juice conc. | 25 | MC | 1.5 | 25 | 0.26 |
| Tomato paste | 15 | GMS | 2.0 | 25 | 0.50 |

* Total solids. ** Additives. GMS: Glyceryl monostearate MSA: Modified soy albumen EA: Egg albumen MC: Methyl cellulose.
*** Foaming time : 2-3 min.

Table 2. Conditions for the dehydration of various food foams

| Commodity | Foam thickness (mm) | Drying temp. ($^oC$) 1st stage | 2nd stage | Drying time* (min.) | Remarks |
|---|---|---|---|---|---|
| Banana pulp | 7 | 80 | 65 | 150 | Reconstitutes readily; taste and colour, good; flavour; mild |
| Beef extract | 5 | 80 | 65 | 100 | Reconstitutes readily; taste, flavour and colour, good |
| Egg pulp | 7 | 70 | 60 | 100 | Reconstitutes readily; taste, flavour and colour, good |
| Grape juice conc. | 5 | 70 | 60 | 120 | Lumps form on soaking; taste and colour, acceptable; flavour, missing |
| Grape fruit juice conc. | 5 | 70 | 60 | 100 | Lumps form on soaking; taste flavour and colour, acceptable |
| Guava pulp | 7 | 80 | 65 | 120 | Reconstitutes readily; taste and colour, acceptable; flavour, good |
| Lemon juice conc. | 5 | 70 | 60 | 120 | Lumps form on soaking; taste, flavour and colour, acceptable |
| Malt extract | 5 | 70 | 60 | 150 | Reconstitutes readily; taste flavour and colour, acceptable |
| Mango pulp | 5 | 70 | 60 | 150 | Lumps form on soaking; taste and colour, acceptable; flavour, mild |
| Milk, whole | 7 | 80 | 65 | 100 | Reconstitutes readily; taste and colour, good |
| Orange juice conc. | 5 | 70 | 60 | 100 | Scrapping, difficult; reconstitutes readily; taste and colour, good; flavour, mild. |
| Plum juice conc. | 5 | 70 | 60 | 150 | Lumps form on soaking; taste and colour, acceptable; flavour, missing. |
| Tomato paste | 5 | 70 | 60 | 150 | Reconstitutes readily; taste, flavour and colour, good |

* Time for 1st stage drying was 60 min; remaining time being for 2nd stage drying and final moisture content of products, about 2-3%.
** The refreshed foods were evaluated for taste, flavour and colour by a panel of 6 judges on a 10-point Hedonic Scale.

foods needed foaming agents @ 2 to 3%. In certain cases a combination of agents was more suitable. No additive was, however, used with milk, egg pulp and beef extract.

Most foods could be foamed at room temperature (20-25$^o$) but there were exceptions. Orange juice needed refrigeration before foaming while milk and beef extract were foamed at an elevated temperature (40$^o$).

The effect of whipping time on densities of some foams is shown in Fig. 1. It would be noted that there was a sharp decrease in the density of each foam in the first 2 or 3 min. of whipping after which it tended to become constant at a lower level. In the case of tomato foamed with GMS the density started increasing after 5 min. of whipping and it appeared to level off at a higher density value of 0.52 g/ml corresponding to a 10 min. whipping period. The increase in density beyond 5 min. clearly showed overwhipping. Similar observations have been made by Hart *et al.* [1]. and La Belle [9]. Since whipping beyond 2 min. and in certain cases 3 min. did not bring about an appreciable reduction in the density values (in fact, a reversal in the case of tomato paste), a period of 2 to 3 min. whipping could be regarded as optimum. Foam densities for various foods have been listed in the last column of Table 1. It was observed that if the density deviated much from the listed values, the foam proved unsuitable for drying purpose. High density foam had drainage and subsequent drying problems while low density foams were stiff and difficult to spread on the drying surface. It was also noted that the freshly formed foam yielded better quality product on dehydration. Any delay in drying resulted in drainage and affected the quality of the end product.

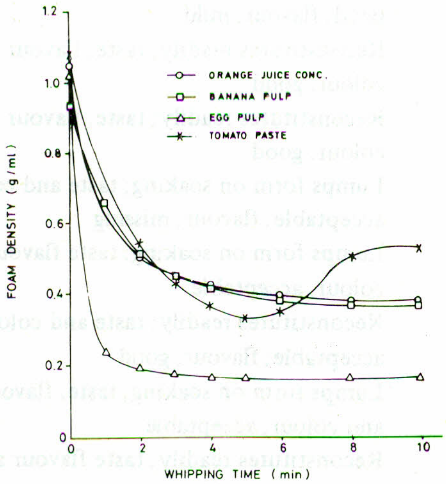


Fig. 1. Foam desnity vs whipping time.

Thickness of foam layer during dehydration had a direct bearing on the quality of the end product. Thinner layers than those listed in Table 2 were very good for drying purposes but there was difficulty in their uniform application over the entire surface of the drying trays. Contrary to this, thicker layers had drainage problems.

Dehydration of foams was carried out in two stages. The first stage consisted of drying for 1 hr. at $70^{0}$ followed by the second stage for the remaining period at a lower temperature of $60^{0}$, so that the total drying times were as shown in Table 2. Higher temperatures could be used but the quality was spoilt due to scorching of the product except for milk, beef, banana and guava which tolerated initial temperatures as high as $80^{0}$. The final moisture content was about 2-3%.

Some loss of flavour during drying was noticed with all the food products. However, the flavour could be improved by the addition of locked flavour in suitable amounts.

A few quality attributes have been recorded in Table 2 showing that most products refreshed readily and were good or acceptable organoleptically. Some high acid fruit juice powders formed lumps on soaking and were slow to reconstitute. Mango juice was found to be difficult to dry using the foam-mat technique.

The above mentioned findings provide a basis for further work in the area. Investigations to obtain products of improved quality and stability from each commodity, is in progress and will be reported in a future communication.

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## REFERENCES

1. M.R. Hart, R.P. Graham, L.F. Ginnette and A.I. Morgan, J. Fd. Technol., **17**, 1302 (1963).
2. R.E. Berry, O.W. Bisset, C.J. Wagner Jr. and M.K. Veldhuis, Fd. Technol., **19**, 426 (1965).
3. R.E. Berry, C.J. Wagner Jr., O.W. Bisset and M.K. Veldhis, J. Fd. Sci., **37**, 803 (1972).
4. M.A. Rzepecka-Stuchley, A.M. Bryjidyr and M.B. McConnel, J. Microwave Power, **11**, 215 (1976).
5. A.I. Morgan Jr. and L.F. Ginnette, US Pat 2, **955**, 086 (1960).
6. A.I. Morgan Jr. and L.F. Ginnette, US Pat. 2, 955, 943 (1960).
7. A.I. Morgan Jr., J.M. Randall and R.P. Graham, US Pat 2, 967, 109 (1961).
8. M. Jamil, A.F.M. Ehteshamuddin, N. Mohammad and M. Awar, Pakistan J. Sci. Ind. Res., **29**, 470 (1986). (1986).
9. R.L. La Belle, Fd. Technol., **20**, 89 (1965).