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INVESTIGATION OF THE FOAMING PROPERTIES OF SOME FOOD PROTEIN PREPARATIONS

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Abstract

The foaming properties of 10 different protein isolates and protein preparations (wheat germ-, barley germ-, maize germ protein, lentil-, pea-, soy protein, ovalbumin, bovine serum albumin = BSA, casein and lysozyme) were investigated using volumetric and conductometric methods. According to the volumetric method casein and BSA had the best foaming power. Good foaming power was observed with maize germ-, soy-, pea-, barley germ proteins and ovalbumin. The foam forming ability of wheat germ protein and lysozyme was the lowest.

On the basis of conductometric results the proteins investigated may be divided in to the same three groups: However, within the group some changes in the order of proteins may occur. In calculating the linear correlation between the two methods an improvement of correlation ($r = 0.93$) was achieved by modifying the evaluation of conductometric curves.

Maize germ-, soy and lentil protein showed the best foam stability and barley germ protein the lowest one according to conductometric results. The correlation between the foam stability data obtained by the two methods is very poor.

Keywords: protein preparations, foaming properties.

Introduction

Proteins, as isolates or concentrates, are necessary ingredients for many food processes, where they perform specific functions. The actual demand for new protein additives will depend on many factors such as price, availability of animal proteins, the rate of development of new food products, consumer acceptance, nutritive value of new proteins but principally on their functional properties.

Foaming or whipping, i.e. the capacity to form stable foams with air (or other gas) is an important functionality of protein preparations. Many food products are foams from a colloid-chemical point of view (e.g. whipped cream, whipped toppings, suffles, some confectionery products, etc.).

A variety of methods have been proposed to produce and characterize protein foams. Review papers (KINSELLA, 1976; GASSMANN et al. 1987)

principally describe three procedures for determining the foaming capacity of proteins: whipping, shaking or sparging (WANISKA and KINSELLA, 1979). One important difference between these methods is the amount of protein required for foam production. The amount of protein ranges from 3 to 40 % for whipping, around 1 % for shaking horizontal graduated cylinders containing the protein dispersion and ranges from 0.01 to 2 % for spraying of gas through perforated disks into protein dispersions.

A principally new method was established to estimate the foaming properties of proteins from the conductivity of foams using a simple apparatus consisting of a glass column with the conductivity cell by KATO et al.(1983).

A close correlation was observed between the initial conductivity of foams and the foam volume of 11 native proteins. In addition, a close correlation was obtained between the foam stability determined from changes in the conductivity and foam volume with the time of 11 heated, denatured native proteins, suggesting that foam stability can also be estimated from changes in the conductivity of foams.

Criteria used for evaluation of foaming properties vary with investigators, but essentially they involve measurement of the volume of foam obtained from a known volume (and concentration) of protein solution. The term foaming power (FP) is widely used to characterize foam forming ability of proteins. This may be expressed as the proportion of gas phase in the foam (WANISKA and KINSELLA, 1979). LIN et al. (1974), DEV and QUENSEL (1986), LOPEZ and FALOMIR (1986) measured the increase of the volume of protein solution expressed in per cents of the initial volume. ELDRIGE et al. (1963) expressed the increase of volume of foam as 'foam expansion', which was defined by the ratio of the density of the starting suspension to that of the final whip. YASUMATSU et al. (1972) investigated foaming properties by shaking protein solution and FP was expressed as the volume of the foam formed.

Foam stability (FS) is determined by measuring the loss of liquid resulting from destabilization, i.e. leakage, measuring volume decrease or density increase with time. Different methods have been used for determining foam stability in whippability tests. LIN et al. (1974) measured the volume of foam in a graduated cylinder at different time intervals after whipping as one index of stability. ELDRIGE et al. (1963) measured the amount of liquid leaking from a fixed volume of foam at 30 min or 2 hrs after whipping. The volume of foam 10 min and 2 hrs after shaking was reported as foam stability by LAWHON et al. (1972).

The aim of our experiments was a comparative measurement of foaming properties of some protein preparations potentially used in food production.

Materials and Methods

Six protein isolates (wheat-, barley-, corn germ protein, pea-, lentil and soy protein) and four well-defined proteins (ovalbumin, bovine serum albumin = BSA, casein and lysozyme) were investigated. The barley- and corn germ protein isolate was prepared using the method of NIELSEN et al. (1973), the pea and lentil protein isolate by a procedure of HSU et al. (1982). Soy protein isolate was prepared according tto he method of CHARALAMBOUS and DOXASTAKIS (1989) and wheat germ protein isolate by a procedure described by KORPÁCZY (1976). The ovalbumin, BSA, casein and lysozyme were products of REANAL Fine Chemicals Factory, Budapest, Hungary.

Determination of Foaming Properties

Two methods were used, a volumetric one and the conductometric procedure of KATO et al. (1983). The same apparatus (See *Fig. 1*) was used for both methods. The concentration of protein solutions was 0.1 %(w/v). The samples were dissolved in 0.1 M phosphate buffer (pH = 7.4). The time of aeration was 2 minutes using an air flow velocity of 90 cm^3/min. The volume of the foam (V_0) was determined after stopping the aeration (foaming power = FP) and the decrease of volume in time was observed. In the conductometric method the conductometric curve was registered under the same foaming conditions as mentioned above. The value of the conductivity (c_i) immediately after stopping the aeration was used for characterizing the foaming power (FP).

The foam stability (FS) was expressed in the case of the volumetric method as follows:

$$FS = V_0.\Delta t/\Delta V,$$

where ΔV = decrease of foam volume during Δt time interval. In the case of the conductometric method FS was calculated according to KATO et al. (1983) as follows:

$$FS = c_0.\Delta t/\Delta c,$$

where c_0 = extrapolated value of the conductivity at zero time based on the linear segment of the conductivity-time curve (See *Fig. 2*).

Experiments were also carried out to investigate the effect of air flow and protein concentration on the results of measurements.

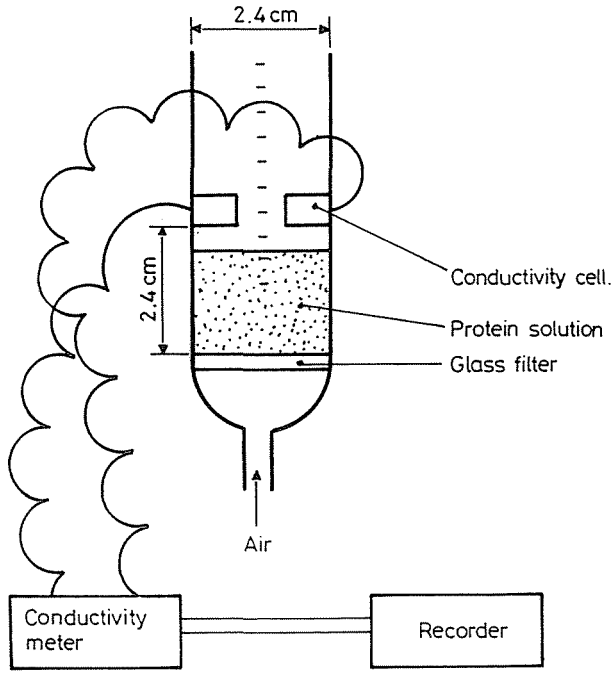

Fig. 1. Apparatus for the measurement of the conductivity of foams

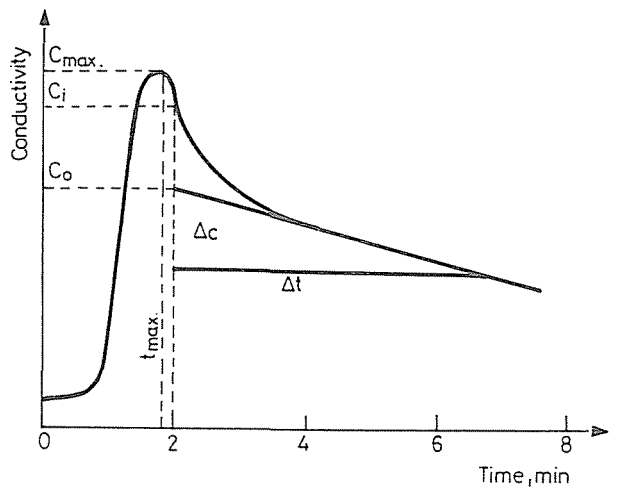

Fig. 2. The change of the conductivity with time

Results and Discussion

The foaming power values of the investigated protein preparations, and proteins determined by volumetric and conductometric method are summarized in *Table 1.* According to the volumetric method casein and BSA had the best foaming properties. Good foaming power was observed with maize germ-, soy-, pea-, barley germ proteins and ovalbumin. The foaming properties of wheat germ protein and lysozyme are the poorest.

Table 1
Foam power of solutions of different protein preparations

Samples	V_0[cm^2]	c_i[mS]	$\frac{c_{max}}{t_{max}}$ $\frac{mS}{min}$
Barley germ protein	40.00±1.20	1.11±0.02	1.74±0.22
Peas protein	43.29±0.78	1.00±0.07	1.87±0.08
Wheat germ protein	15.86±0.11	0.59±0.09	0.30±0.05
Maize germ protein	46.42±1.22	1.24±0.06	2.09±0.20
Lentil protein	42.58±1.14	0.94±0.03	2.28±0.16
Soybean protein	45.86±2.13	1.67±0.08	1.99±0.09
Ovalbumin	31.62±1.14	1.12±0.03	1.40±0.11
Bovine serum albumin	48.39±2.62	2.90±0.20	2.42±0.20
Lysozyme	2.50 ±0.00	0.60±0.00	0.54±0.06
Casein	53.67±0.29	2.03±0.07	3.09±0.05

On the basis of conductometric result (c_i values) the investigated proteins may be divided in to the same three groups. Nevertheless within the groups some changes in order of proteins occur. Calculating the correlation between the results of the two methods a correlation coefficient of 0.67 was found.

Studying the possibility to reach a better correlation between the two methods we have found that using the ratio of maximal conductivity value (c_{max}) and the time needed to reach this value (t_{max}) for the characterization of FP measured by conductometric method, the correlation may be improved.

The correlation coefficient obtained comparing V_0 and c_{max}/t_{max} values was quite high ($r = 0.93$). This is represented in *Fig. 3.*

The foam stability data are represented in *Fig. 4.* Maize germ protein, soy- and lentil protein showed the best stability and wheat germ protein the lowest. Stability data calculated on the basis of volumetric results (FS $= V_0.\Delta t/\delta V$) are seen also in *Fig. 4.* The correlation between the data measured by the two methods is very poor. We tried to find a way to improve the correlation using a modified evaluation. It was found that using for the characterization of FS by volumetric method a ratio of V_0 and

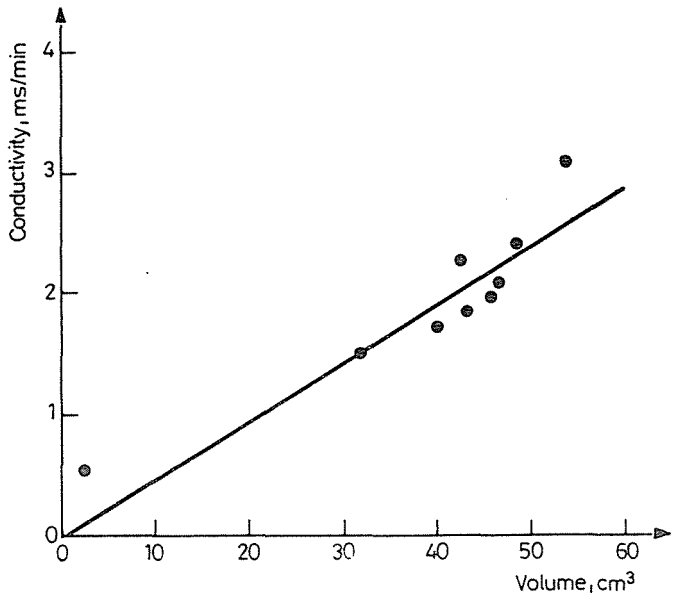

Fig. 3. Relationship between foam power of protein solution determined by modified conductometric method and by volumetric method

V_{10} (foam volume 10 minutes after stopping the aeration) the correlation was much better (*Table 2).* Nevertheless, further experiments are needed to find a reliable comparison of FS values determined by volumetric and conductometric methods.

Table 2
Foam stability (FS) of six protein preparations determined by conductometric and modified volumetric method

Sample	Foam stability	
	Conductometric $FS=c_0.\Delta t/\Delta c$	Volumetric $FS=V_{10}/V_0.100$
Barley germ protein	0.98	16
Pea protein	0.83	80
Wheat germ protein	0.38	28
Maize germ protein	0.95	98
Lentil protein	1.06	42
Soybean protein	1.02	92

We investigated additionally also the effect of aeration on the foaming properties. BSA was used as test sample. Aeration flows of 90, 150, 200, 250,

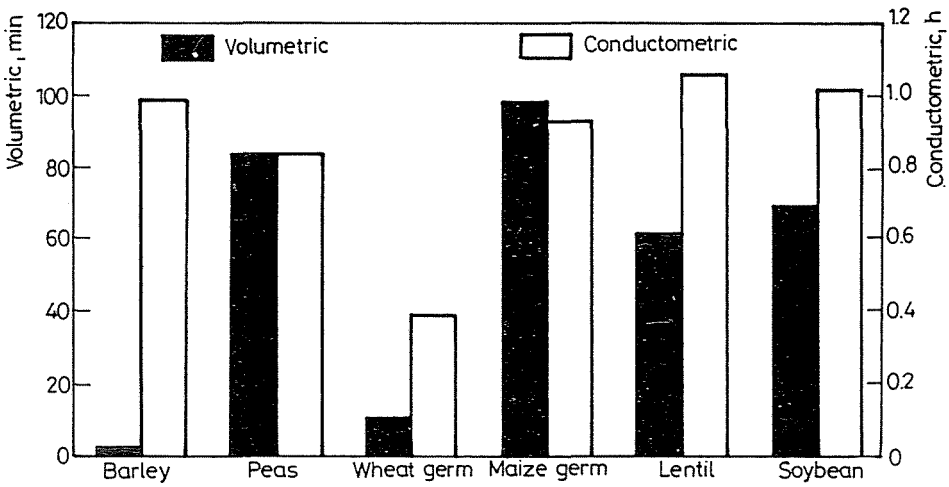

Fig. 4. Foam stability of protein solutions

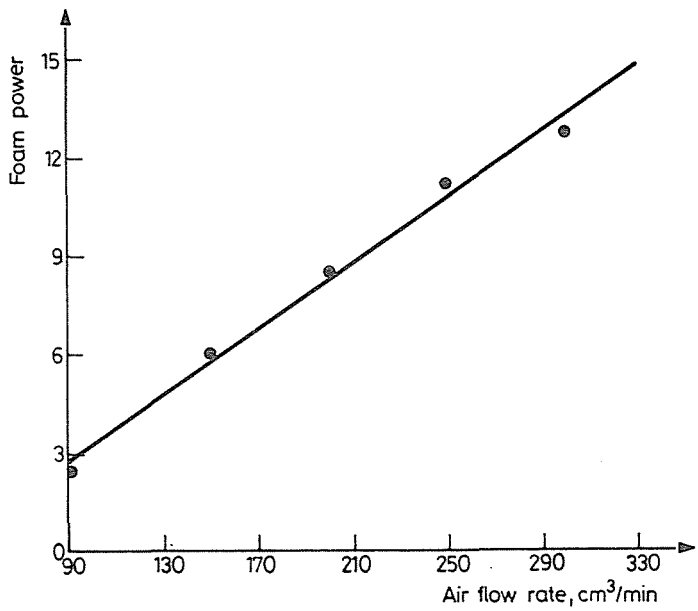

Fig. 5. Relationship between the foam power and air flow rate of BSA-protein solution

and 300 cm^3/min were used. The results of experiments are summarized in *Fig. 5* (foaming power) and *Fig. 6* (foam stability). As it can be seen

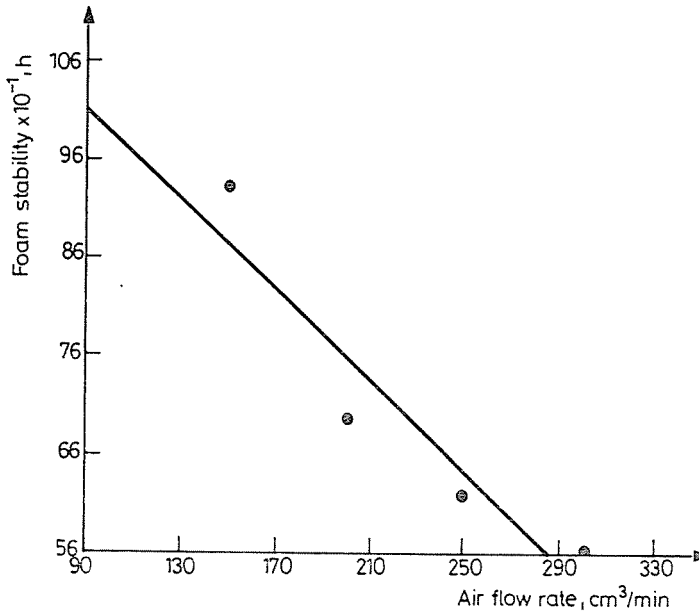

Fig. 6. The effect of air flow rate on the foam stability of BSA-protein solution

from the figures an increase in FP was observed with increasing air flow rate. The correlation is practically linear.

Finally the effect of protein concentration on the results of measurements was studied in the concentration range of 0.05 % to 0.25 %. It was found that the foaming power and the foam stability do not change in the protein concentration range investigated.

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