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Water activity and chemical composition of some food emulsions

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The water activity, pH and other compositional parameters such as the moisture, fat and NaCl contents of various food emulsions were determined: butters, margarine (W/O) and mayonnaises (O/W). Water activity was determined by a gravimetric method (PEC procedure) and an instrumental method (dew-point hygrometer). The mean a_w values obtained for the samples assayed were 0·904 ± 0·050 (butters), 0·914 ± 0·028 (margarines) and 0·947 ± 0·013 (mayonnaises). The a_w of the butter and margarine samples could be predicted with an error less than 0·02 units from the NaCl content of their aqueous phase (m) by using the following simple linear regression equation:

$$a_w = 0{\cdot}954 - 0{\cdot}036m$$

This equation could not be used to predict the a_w of the mayonnaises, which, however, were obtained by using the Chen equation for mixtures of solutes.

INTRODUCTION

Butters and margarine are among those foodstuffs whose continuous phase consists of fat (W/O emulsion). In fact, they are composed of fat from milk and of fats and oils from products other than milk, respectively. Similarly, mayonnaises are water emulsions of oil (O/W) chiefly composed of vegetable oil, egg yolk, salt, water and vinegar.

There are few reports on the water activity (a_w) of these types of product. Thus, Troller (1983) reported a_w values of 0·88 for liquid margarine, and Chirife *et al.* (1989) provided values between 0·928 and 0·955 for mayonnaises.

The aim of this work was to provide preliminary information on this parameter and determine a_w from chemical composition data in order to establish a potential correlation with the stability of these products.

MATERIAL AND METHODS

Material

The experimental material consisted of five salted butter samples (denoted by a_1–a_5); five margarine samples, of which two (b_1 and b_2) were salted, one (b_3) was mid-salted and another two (b_4 and b_5) were unsalted; and four mayonnaise samples (c_1–c_4). All samples were purchased at local markets and transferred to the authors' laboratory for subsequent analysis.

Methods

The different parameters (pH and moisture, fat and NaCl contents) were determined in the butters and margarines according to FIL–IDF norms (1960, 1969, 1981*a*,*b*). On the other hand, the pH values of the mayonnaises were determined potentiometrically with a digital pH meter, and their moisture and NaCl contents were measured according to AOAC recommendations (AOAC, 1980).

The water activity of the butters and margarines was determined by using the gravimetric methods developed by McCune *et al.* (1981) as modified by Marcos *et al.* (1985), while that of the mayonnaises was measured with a Decagon Devices CX-1 dew-point hygrometer (Pullman, WA, USA).

Mathematical determinations of a_w were done by simple linear least-squares regression from the NaCl molality of the aqueous and the Chen equation (Chen, 1990).

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RESULTS AND DISCUSSION

Table 1 lists the a_w and pH values obtained for the samples assayed. As can be seen, there are significant differences in the two parameters between samples: in fact, a_w ranged between 0·827 and 0·960 for samples a and c, respectively. The highest a_w values of the butters and margarines were yielded by samples a_4, a_5, b_4 and b_5 (0·952, 0·946, 0·936 and 0·951, respectively). Likewise, the pH values of the butter samples were generally higher than those of the margarines (5·89 versus 4·85 on average). On the other hand, the mean a_w and pH of the mayonnaise samples were 0·947 and 3·84, respectively, i.e. very similar to those reported by Chirife *et al.* (1989)—0·930 to 0·950 and 3·8, respectively.

Table 2 lists the moisture, fat and NaCl contents of the samples. Both the moisture and the fat contents are within the range considered to be normal for these types of product. In this respect, it is worth noting the low water content of sample a_3 (11·7%) and the similar fat contents of all samples. Also, the mean fat content of the butters was somewhat higher than that of the margarines (83·4% versus 80·8%). As far as NaCl is concerned, the butter and margarine samples with the lowest contents (a_4, a_5, b_4 and b_5, with 0·44, 0·66, 0·51 and 0·36%, respectively) also featured the greatest a_w values (Table 1). Taking into account that sodium chloride is the main a_w-depressing agent of these products, those samples with the lowest NaCl concentrations in their aqueous phase (3·8% for butters a_4 and a_5, and 2·50% for margarines b_4 and b_5) had the highest a_w values and vice versa (the sample with the highest NaCl concentration, a_3, had the lowest a_w). A similar trend was observed in the four mayonnaise samples.

The water activities of the samples were not only determined experimentally, but also calculated from compositional data. In fact, there was a high correlation between a_w and the NaCl molality in the aqueous phase of butters and margarines which can be expressed as:

$$a_w = 0{\cdot}954 - 0{\cdot}036m \quad (1)$$

Table 3 lists the a_w values calculated by simple linear regression from eqn (1) and the differences with respect to the experimental values ($a_w^{cal} - a_w^{exp}$). As can be seen, the calculated values did not differ significantly from their experimental counterparts: the differences never exceeded 0·02 units, thus conforming to the maximum acceptable divergence between two methods recommended by Labuza *et al.* (1976).

The water activity of the mayonnaises was determined by using the Chen equation for calculation of the a_w of aqueous solutions of simple solutes (Chen, 1990):

$$a_w = \frac{1}{1 + 0{\cdot}018(B_e + Bm^n)m} \quad (2)$$

Table 1. Water activity (a_w) and pH of the butters, margarines and mayonnaises

Sample	Parameter	
	aw	pH
Butters		
a_1	0·895	5·73
a_2	0·896	6·36
a_3	0·827	5·61
a_4	0·952	5·70
a_5	0·946	6·05
$\bar{x}$	*0·903*	*5·89*
s	*0·050*	*0·31*
Margarines		
b_1	0·885	5·17
b_2	0·897	6·15
b_3	0·901	4·88
b_4	0·936	4·03
b_5	0·951	4·04
$\bar{x}$	*0·914*	*4·85*
s	*0·028*	*0·88*
Mayonnaises		
c_1	0·930	3·87
c_2	0·960	3·69
c_3	0·952	4·06
c_4	0·947	3·74
$\bar{x}$	*0·947*	*3·84*
s	*0·013*	*0·17*

$\bar{x}$, Mean; *s*, standard deviation.

Table 2. Percent moisture, fat and NaCl contents of the samples

Sample	Moisture	Fat	NaCl
Butters			
a_1	17·0	82·5	1·63
a_2	15·8	83·0	1·44
a_3	11·7	83·5	2·45
a_4	13·3	84·0	0·44
a_5	14·9	84·0	0·66
$\bar{x}$	*14·6*	*83·4*	*1·32*
s	*2·1*	*0·7*	*0·80*
Margarines			
b_1	17·1	81·0	1·56
b_2	16·6	81·0	1·82
b_3	17·7	80·0	1·36
b_4	17·5	81·0	0·51
b_5	16·9	81·0	0·36
$\bar{x}$	*17·1*	*80·8*	*1·12*
s	*0·4*	*0·4*	*0·65*
Mayonnaises			
c_1	14·4	—	1·51
c_2	21·6	—	1·08
c_3	17·1	—	1·41
c_4	29·2	—	1·32
$\bar{x}$	*20·6*	—	*1·33*
s	*6·5*	—	*0·18*

$\bar{x}$, Mean; *s*, standard deviation.

Table 3. Calculated water activities and differences with respect to the experimental a_w

Sample	a_w^{cal}	$a_w^{cal} - a_w^{exp}$
Butters		
a_1	0·895	0·000
a_2	0·898	+0·002
a_3	0·825	−0·002
a_4	0·934	−0·018
a_5	0·927	−0·019
Margarines		
b_1	0·898	+0·013
b_2	0·886	−0·011
b_3	0·906	+0·005
b_4	0·936	0·000
b_5	0·941	−0·010
Mayonnaises		
c_1*	0·939	+0·009
c_2*	0·971	+0·011
c_3*	0·952	0·000
c_4*	0·974	+0·027

* Values calculated from the Chen equation (eqn (2)).

were m is the molality of the dissolved solute (NaCl), and B_c (1·868), B (0·0582) and n (1·618) are characteristic parameters dependent on the properties of the solute concerned. As can be seen in Table 3, the differences between the values calculated from the above equation and those experimentally obtained were minimal except for sample c_4^*, which resulted in a deviation greater than 0·020 a_w units. Taking into account that NaCl is the main a_w-depressant of this type of samples, the molality of the product in the aqueous phase can be used to obtain an acceptable estimate for this parameter.

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