Functional properties of full-fat soy flour from soybeans grown in Ghana

1. Emulsifying properties

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SUMMARY

Samples of full-fat soy flour produced from five soybean varieties grown in Ghana were examined for their emulsifying properties both in a simple system containing only the flour and in combination with wheat flour, skimmed milk or meat extract to form a complex system. Samples from all the varieties were found to enhance emulsifying activity and to stabilize the emulsion formed against heat treatment. The effect of a particular variety on a complex system had no relationship with its performance in a simple system but in all cases, the degree of thermal destruction was found to depend to some extent on the initial strength of the emulsion. The various samples analysed showed varietal difference in their emulsifying properties.

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RÉSUMÉ

PLAHAR, W. A., BEDIAKO-AMOA, B. & FEJER, D.: *Propriétés fonctionnelles de la farine non dégraissée de sojas cultivés au Ghana. 1, Propriétés émulsifiantes.*

Les auteurs ont examiné des échantillons de farine non dégraissée de 5 variétés de soja cultivées au Ghana, en vue de déterminer leur pouvoir émulsifiant à l'état pur et aussi incluses dans des systèmes complexes formés en combinaison avec de la farine de blé, du lait écrémé ou de l'extrait de viande. Les échantillons de farine de toutes les variétés de soja ont amélioré la résistance à la chaleur du pouvoir émulsifiant et de la stabilité des émulsions. Pour chaque variété de soja, l'effet émulsifiant dans un système complexe n'a pas montré de relation avec son comportement à l'état pur, mais dans tous les cas il a été observé que le degré de destruction de l'émulsion par la chaleur dépend de la force initiale de l'émulsion. Les divers échantillons de farine de soja étudiés ont montré que des différences variétales existent dans leur pouvoir émulsifiant.

Introduction

Soybean products in their various forms are known to have certain functional properties that make them useful in food systems and these properties are generally attributed to the proteins and lecithins. Among these are the emulsifying properties, whipping ability, dough forming ability with wheat flour, fat absorption (promotion and prevention) water absorption (uptake and retention), textural properties, cohesion and many other properties that contribute to their usefulness as food ingredients. The full-fat soy flour being a source of crude soy protein also possesses some of these properties.

Quite often, the need arises in many food industries for the production of a food item with uniform textural characteristics. In many instances, however, the ingredients used are immiscible under ordinary conditions. In the industries of baked goods, ice cream and meat, the two immiscible liquids frequently used are water and oil. The theory of emulsification is, therefore, employed to effect intimate mixing of these normally immiscible liquids to avoid total separation.

In such cases use is made of emulsifying agents and mechanical force to reduce the interfacial tensions. Such emulsifying agents are complex molecules which have both hydrophobic non-polar and hydrophylic polar groups and they perform the function of reducing the interfacial tension by preventing the coalescence of the droplets of the internal phase.

Certain food materials contain some natural emulsifying agents and their presence in the food formulation helps to achieve stable emulsions. Lecithin, a complex mixture of phosphatides and other lipid and non-lipid materials, is one of these natural emulsifying agents; and it is commonly found in soybeans. Cravens & Sipos (1958), stated that soybean oil lecithin is widely used in the margarine, chocolate, confectionery, ice cream, macaroni and baking industries.

It is, therefore, anticipated that the full-fat soy flour will impart these attributes of its fat content to food systems. Also, soy products as additives are said to contribute nutrition, flavour, and valuable functional properties to meat preparation (Rakosky, 1970).

In this investigation, the effect of full-fat soy flour, prepared by a simple procedure relatively easy to follow and with simple equipment which may be available even in small villages, on the emulsification of meat, ice cream and baked products was examined. Both the emulsifying activity and emulsion stability were taken as indices of emulsifying property using the soy flour alone or in combination with skimmed milk, meat or wheat flour.

Materials and methods

Full-fat soy flour preparation

Recent work by Mustakas *et al.* (1967) at the USDA Northern Regional Research Laboratory attempts to modify the large scale processing of full-fat soy flour so as to adapt it to cottage industry level. A method similar to that used by Mustakas *et al.* (1967) was employed for the preparation of soy flour samples in this study.

Selected soybeans of a particular variety were washed and soaked in cloth bags in tap water at 27°C for 7 h. They were then immersion-cooked at atmospheric pressure in a steam-jacketed kettle for 10 min in boiling water to inactivate the principal enzyme components of the beans. The cooked beans were then sun-dried and cracked in a hand operated disc attrition mill to free the hulls from the seeds. The dehulled soy bean meats were ground in a hammer mill driven by an electric motor to a particle size of about 120 microns.

Samples of full-fat soy flour were in this way prepared from five varieties of soybeans—Hill, Hardee, Improved Pelican, Davies and CES 486—grown at the University of Ghana Agricultural Irrigation Research Station, Kpong, Ghana and the Department of Crop Science, Faculty of Agriculture, University of Ghana, Legon.

Determination of emulsifying activity and emulsion stability

The procedure followed is similar to that used by Mori, Ruwayama & Ishii (1972) in their studies on the functional properties of food grade soybean products.

Exactly 7·0 g of the full-fat soy flour were suspended in 100 cm^3 water and 100 cm^3 edible groundnut oil added. The 200 cm^3 mixture was emulsified in Waring Blender at high speed for 1 min. The emulsion obtained was divided evenly into four 50 cm^3 centrifuge tubes and centrifuged at 1 300 XG for 5 min. The emulsifying activity was then measured as:

$$\frac{\text{Height of emulsified layer}}{\text{Height of whole layer}} \times 100\%$$

For complex systems containing either wheat flour or skimmed milk, the mixture of 5 g of soy flour with 5 g of wheat flour or skimmed milk powder was used instead of the simple system. Simulating the meat product, the emulsifying activity was measured with the meat extract which was prepared by extracting 75 g of ground beef (fresh) with 100 cm^3 of 3% sodium chloride solution. The volume of water (100 cm^3) in the simple system was substituted with 20 cm^3 of the extract and 80 cm^3 of water. The procedure as described for the simple system was then followed to obtain the emulsifying activity.

Emulsion stability was determined in each case by heating the emulsion prepared by the above procedure at 80°C for 30 min, cooling for 15 min under tap water and centrifuging at 1 300 G for 5 min. The emulsion stability was expressed as:

$$\frac{\text{Height of remaining layer}}{\text{Height of whole layer in tube}} \times 100\%$$

These emulsifying properties were determined for the full-fat soy flour samples from all the five varieties of soybeans. Statistical methods (Freund, 1967) were employed to determine whether there were any significant varietal differences in the properties of samples examined. The Student's t-test was applied to assess the significance of the observed differences between two sample means, and an analysis of variance was carried out to determine whether the observed differences among the mean values obtained for samples from the five different varieties of soybeans could be attributed to chance or whether they were indicative of actual varietal differences.

TABLE 1

Emulsifying Properties of Full-Fat Soy Flour in a Simple System

Soybean variety	*Mean emulsifying activity (per cent)*	*Mean emulsion stability (per cent)*
Hill	49·7±0·31	42·8±0·16
Hardee	48·2±0·40	44·7±0·60
Improved Pelican	48·7±0·79	44·2±0·20
Davies	45·9±1·00	43·6±0·41
CES 486	52·7±0·31	50·7±1·32
Variance ratio (F)	47·63	63·95

Critical value of F at $P=0\cdot05 = 3\cdot48$

Results and discussion

Values obtained for the emulsifying properties (emulsifying activity and emulsion stability) are shown in Table 1 for the simple system and in Tables 2, 3 and 4 for the complex model system. The simple systems showed emulsifying activities of between 48 and 53% and emulsion stabilities of between 42 and 51%. The lower emulsion stabilities obtained is an indication of the extent of destruction to be expected when the emulsion is subjected to further heat treatment. This degree of destruction depends, to some extent, on the initial strength of the emulsion.

The results also show varietal differences in the emulsifying properties of the different samples examined. The CES 486 had the highest values for both activity and stability. The Hardee and Improved Pelican varieties have similar emulsifying properties. The Hill variety was found to have quite a high emulsifying activity but was low in emulsion stability.

For the complex system containing wheat flour (Table 2), the wheat flour alone had relatively low emulsifying properties (20% activity and 16% stability).

Addition of the full-fat soy flour raises both the emulsifying capacity and emulsion stability quite

TABLE 2

Emulsifying Properties of a Complex System Containing Wheat Flour and Full-Fat Soy Flour

Blend	*Emulsifying activity*			*Emulsion stability*		
	Mean (per cent)	*Difference test*		*Mean (per cent*	*Difference test*	
		Student's t	*Comment*		*Student's t*	*Comment*
Wheat flour only	20·3±0·40	—	—	16·1±0·25	—	—
Wheat flour and Hill soy flour	50·3±0·85	54·81	s	44·2±0·25	137·66	s
Wheat flour and Hardee soy flour	50·7±0·85	55·54	s	46·8±0·21	162·86	s
Wheat flour and Improved Pelican soy flour	48·1±0·91	48·04	s	45·7±0·47	96·31	s
Wheat flour and Davies soy flour	48·4±0·81	53·34	s	29·3±0·82	26·67	s
Wheat flour and CES 486 soy flour	46·5±1·01	41·49	s	40·7±0·70	57·32	s

S = Significant

The critical value of 't' at $P=0\cdot05$ and 4 degrees of freedom = 2·13

TABLE 3

Emulsifying Properties of a Complex System Containing Meat and Full-Fat Soy Flour

Blend	*Emulsifying activity* Mean (per cent)	Difference test Student's t	Comment	*Emulsion stability* Mean (per cent)	Difference test Student's t	Comment
Meat only	58·7±0·50	—	—	51·2±0·20	—	—
Meat and Hill soy flour	60·8±0·80	3·86	S	53·3±0·30	10·09	S
Meat and Hardee soy flour	60·6±0·26	5·84	S	58·7±0·38	30·25	S
Meat and Improved Pelican soy flour	63·3±0·44	11·26	S	61·0±0·16	66·27	S
Meat and Davies soy flour	59·7±0·25	3·10	S	57·5±0·42	23·46	S
Meat and CES 486 soy flour	60·4±0·46	4·33	S	59·1±0·42	29·41	S

S = Significant

The critical value of '*t*' at $P = 0\cdot05$ and 4 degrees of freedom = 2·13

considerably (46–51 and 29–47% respectively). These increases effected by the addition of the soy flour are all significant. Although the system containing only skimmed milk powder had high emulsifying properties (about 54% for activity and 53% for stability), the addition of full-fat flour further raises these values (Table 4).

In some cases, the differences between the values for milk alone and milk-soy flour blend are not statistically significant.

A similar situation exists in the complex systems containing meat-soy flour blends. Here also, the addition of the full-fat soy flour further raises the emulsifying properties.

In general, all the soy flour samples exhibited considerably high emulsifying properties which

TABLE 4

Emulsifying Properties of a Complex System Containing Milk and Full-Fat Soy Flour

Blend	*Emulsifying activity* Mean (per cent)	Difference test Student's t	Comment	*Emulsion stability* Mean (per cent)	Difference test Student's t	Comment
Milk only	53·8±0·20	—	—	52·6±0·47	—	—
Milk and Hill soy flour	54·7±0·79	1·98	NS	53·5±0·50	2·77	S
Milk and Hardee soy flour	59·4±0·67	13·87	S	58·3±0·66	12·18	S
Milk and Improved Pelican soy flour	58·8±0·85	9·92	S	56·5±0·45	10·38	S
Milk and Davies soy flour	57·5±0·41	14·05	S	56·2±1·20	4·84	S
Milk and CES 486 soy flour	60·2±0·31	30·05	S	53·3±0·41	1·94	NS

S = Significant, *NS* = Not significant

The critical value of '*t*' at $P = 0\cdot05$ and 4 degrees of freedom = 2·13 make them useful in food formulations requiring some degree of emulsification. Although a relatively inexpensive method was used in the preparation of the full-fat soy flour, the samples can be used as a food ingredient for this functional property in addition to their nutritional attributes.

REFERENCES

Cravens, W. W. & **Sipos, A.** (1958) Soybean oil meal. In *Processed plant foodstuffs*. (ed. A. M. Altschul), pp. 358. London and New York: Academic Press.

Freund, J. E. (1967) *Modern elementary statistics*, 3rd ed., pp. 254.

Mori, H., Ruwayama, M. & **Ishii, K.** (1972) Studies on the functional properties of food grade soybean products. *Agric. biol. Chem.* **36** (5), 719–727.

Mustakas, G., Albrecht, W. J., Bookwalter, G. N. & **Griffin, E. L.** (1967) Full-fat soy flour by a simple process for villages. **ARS—71–34 USDA.**

Rakosky, Jr., J. (1970) Soy products for the meat industry. *J. Agric. Fd Chem.* **18** (6), 1005–1009.