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EMULSIFYING CAPACITY OF GUAR AND SOYBEAN FLOUR AND THEIR APPLICATION IN DIFFERENT FOOD SYSTEMS

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By
M. M. Khalil

Food Industries Department, Faculty of Agriculture, Mansoura University

ABSTRACT

Emulsifying capacity of guar and soybean flour were studied. Guar flour has a good emulsifying capacity compared to soybean flour under various experimental conditions such as; pH, protein concentration, rate of oil addition, source of oil, sodium chloride concentration, sucrose concentration and the rate of mixing.

Beef burger products were prepared using 5, 10 and 15% guar or soybean flour as meat replacer. Data indicated no significant differences between colours of burger samples, while significant differences concerning flavour and consistency were found. Beef burgers containing 10% guar flour were the most acceptable in all samples, where as samples containing 15% guar or soybean flour were the least.

Sponge cakes were made with the addition of 5, 10 and 15% guar or soybean flour as wheat replacer. Data revealed that the samples containing guar flour were better than the samples containing soybean flour and the addition of 10% guar flour to wheat flour for making sponge cakes showed the best properties. The use of 10% guar flour as meat or wheat flour substitute for making beef burgers or sponge cakes could be recommended.

Key words: *beef burger, emulsification, guar flour, soybean flour, sponge cake.*

1. INTRODUCTION

The functional characteristics of protein in protein containing products play an important role besides nutritional considerations in determining their acceptability as ingredients in prepared foods.

Both guar and soybean seeds contain high amounts of protein. Protein content of guar seeds was determined by Khalil (2001a), it was about 36% on a dry weight basis, while protein content of soybean seeds was 38.1% as determined by Youssef and Abdel-Gawad (1992).

The largest usage of soy flour is traditionally in bakery products, bread with high protein content and satisfactory loaf properties were formulated with 15% soybean flour (Fleming and Sosulski, 1977).

Soybeans have been the primary source of protein for the use as functional ingredients in food system (Manek *et al.*, 1980).

Many factors influencing the characteristics of emulsion and the results of emulsion test, *e.g.*, equipment type and geometry, intensity of energy input, rate of oil addition, oil phase volume, pH, temperature, ionic strength, presence of sugars, presence of low molecular weight components, exposure to oxygen, kind of oil (melting point), concentration of soluble protein and emulsifying properties of the proteins were studied (Cheftel *et al.*, 1985).

Bruinsma and Finney (1982) studied the effect of guar in place of wheat flour on gas production in dough. They found that 0.1 g of guar was highly desirable replacement for 10 g of wheat flour in the production formula. Guar was less expensive, more readily available and gave somewhat higher gas production.

Mettler and Seible (1993) reported that the addition of guar to various doughs during kneading, increases the yield, gives greater resiliency, and has resulted in a softer texture, longer shelf life and better handling properties.

Abd El-Lateef and Korshom (1994) suggested that guar can be used to improve, contributing to optimum functional properties of pan and balady bread. Guar has been added to dough to retard dry out. It is useful in cake and biscuit dough at 1.0% level.

Yaseenn and Ibrahim (1997) reported that upon incorporating 6% of guar flour to wheat flour, the resulted bread was considered quite acceptable.

Khalil (2001a) studied the functional properties of guar protein isolates and the results showed high water and oil absorption as well as good emulsifying and foaming capacity.

Khalil (2001b) found that soaking of guar seeds for 12 hours reduced the phytic acid content by about 45%.

The present work was undertaken to study:

1. The emulsification capacity of guar flour compared with soybean flour as affected by protein concentration, pH, rate of oil addition, source of oil, presence of sodium chloride, presence of sucrose and rate of mixing.
2. The effect of adding guar flour compared with soybean flour to different food products, *e.g.*, as beef burgers and cakes on the physical and organoleptic properties was also investigated.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1. Wheat flour (extraction rate of 72%) (*Triticum vulgare*) obtained from a lot of flour imported from France by the Egyptian Ministry of Supply.

2.1.2. Guar seeds (*Cyamopsis tetragonoloba*) and soybean seeds *(Glycine max)* were obtained from the Legume Research Section, Agricultural Research Center, Ministry of Agriculture, Giza, Egypt.

The seeds were cleaned by removing the foreign matters, washed and soaked in water for 12 hr, then dried at 70°C in an electric oven and finally ground to a fine powder in an electric mill to pass through a 60 mesh sieve to obtain seed flour, then packed in polyethylene bags and stored in a refrigerator until used.

2.1.3. Sucrose powder, baking powder, eggs, vanilla and oils of corn, palm, sunflower and olive were obtained from the local market of Mansoura City, Egypt.

2.2. Methods

2.2.1. Determination of emulsification capacity

The emulsification capacity of guar flour (36% protein content) and soybean (38.1% protein content) was determined according to the method described by Beuchat *et al.* (1975). A desired amount of flour containing known weight of protein as determined by AOAC (1980), was dispersed in a 25 ml of distilled water in a waring blender (Braun,

West Germany). Oil was added continuously from a burtte by the rate of 0.5 ml oil/sec at first speed (1300 rpm) and blending continues until the emulsification break point was reached when there was a separation into two layers. Emulsification capacity is expressed as ml of oil emulsified per gram of protein flour.

Emulsification capacity was determined as a function of protein concentration (1-5%). Protein was determined by micro Kjeldahl (AOAC, 1980) using a nitrogen conversion factor of 6.25. Rate of oil addition (0.1-1.0 ml/sec), pH (2-11) was controlled by addition of either 0.1 N HCl or 0.1 N NaOH. Other experimental factors were sodium chloride concentration (0.1-0.6 M), rate of mixing (1300-1500 – 1800 rpm), sucrose concentration (5-30%) and source of oil (corn, palm, olive and sunflower oils).

2.2.2. Preparation of beef burgers

Beef burgers were prepared according to El-Akary (1986). One kg of meat was mixed with 20 g spice mixture, 20 g sodium chloride and 10 g, dried onions. Spice mixture consisted of 50% black peppers, 30% coriander, 5% cubeb, 5% cloves, 5% cinnamon and 5% red pepper. Percentages of guar flour or soybean flour, which replaced meat, were 5, 10 and 15%. Ingredients were thoroughly mixed by passing twice through a grinder. Beef burgers were prepared to be of 14 cm diameter, 0.5 cm thickness and 30 gm weight. Each piece was then surrounded with two pieces of butter paper and packed in polyethylene bags. The sealed bags containing beef burger pieces were frozen and stored at – 18°C.

2.2.3. Physical properties of beef burgers

Water holding capacity (WHC) and plasticity of beef burger samples were measured according to the method described by Grau and Hamm (1957) and as modified by Volovinskaia and Merkolova (1958). Exactly 0.3 g of the ground sample was placed under ashless filter paper (Watmann, No. 41) and pressed for 10 min using 1 kg weight. Two zones were formed on the filter paper and their areas were measured using a planimeter (O-bac Planimeter, 1mm.). The WHC was calculated by the differences between the area of the two zones. Plasticity was expressed as the area of the internal zone.

Cooking loss was calculated from the following equation:

$$\% \text{ Cooking loss} = \frac{W_1 - W_2}{W_1} \times 100$$

Where:

W_1= Sample weight before frying
W_2= Sample weight after frying

Beef burger samples were fried in corn oil for 1-2 min at 240°C. Shrinkage was calculated by applying the following equation:

$$\% \text{ Shrinkage} = \frac{A_1 - A_2}{A_1} \times 100$$

Where:

A_1= Sample area before frying
A_2= Sample area after frying

2.2.4. Sensory evaluation of beef burgers

Beef burger samples were tested for their quality after frying. A group of 14 panelists were asked to score colour, flavour and consistency on a score ranging between zero to 10 according to the scheme reported in Deutsche Landwritschaftliche Geselschaft (DLG method, 1973).

2.2.5. Preparation of sponge cakes

Six recipes of sponge cakes in addition to a control were formulated using the following ingredients: wheat flour (72%), substituting with guar flour or soybean flour at 5, 10 and 15% (100 gm), eggs (180 g), sucrose powder (150 g), baking powder (3 g) and vanilla (0.5 mg).

At first eggs and sucrose powder were thoroughly mixed, then all ingredients were gradually added to the mixture. Sponge cakes were baked in an oven at 230°C for 20-30 min.

Sponge cake samples were packed in polyethylene bags after cooling. The thickness (cm), weight (g) and volume (cm^3) were determined according to the methods described by Abdel Magied (1991):

2.2.6. Sensory evaluation of sponge cake

The cake products were evaluated organoleptically for texture, colour, flavour and taste according to the AACC method (1983).

2.2.7. Statistical analysis

Organoleptic properties of beef burgers and sponge cakes were statistically analysed using a factorial design according to the method of Steel and Torrie (1980).

3. RESULTS AND DISCUSSION

3.1 Emulsification capacity under variable conditions:

The results in Table (1) show the emulsification capacity (EC) of guar and soybean flour as determined over the pH range of 2-11. (EC) values of guar flour were higher than soybean flour at pH values from 4 to 9, while soybean flour had higher values of emulsification capacity than guar flour at pH values 2-3, EC on the alkaline side was more than the acidic side. These results are in agreement with that of Narayana and Narasinga (1982). EC of guar flour was higher than soybean flour in all protein concentrations and EC of both guar and soybean flour were the highest at 1% protein concentration. On the other side, EC gradually decreased with increasing protein concentration. Similar results were reported on meat protein (Acton and Saffle, 1972) ground nut flour and protein isolate (Ramanathan *et al.*, 1978).

Sunflower oil showed the highest EC in both guar and soybean flour followed by corn, palm and olive oil, respectively (Table 1). These results are in agreement with those reported by Cheftel *et al.* (1985). The rate of oil addition was adjusted to be between 0.1 and 1.0 ml/sec. In the same Table, EC is not affected by the rate of oil addition for guar and soybean flour. Similar observations were reported by El-Adawy and Khalil (1994).

Also, EC increased with increasing NaCl concentration up to 0.3 M then decreased for both guar and soybean flour. A similar effect of salt concentration on EC of other proteins was reported by Wang and Kinsella (1976); Ramanathan *et al.* (1978) and El-Adawy (1992).

Data in Table (1) indicated that EC increased with the increase of sucrose concentration up to 20% and 15% for guar and soybean flour, respectively and then became constant. These results gave the same attitude with those reported by Rahma and Moharrm (1984) on faba bean flour.

On the other hand, EC decreased with the increase of mixing speed. Similar results were reported by Ramanathan *et al.* (1978).

Table (1): The emulsification capacity (EC) under variable conditions of guar flour compared with soybean flour.

Conditions	(EC ml oil/gm protein)	
	Guar flour	Soybean four
Range of pH		
2	122	132
3	111	124
4	103	85
5	106	97
6	157	109
7	168	141
8	162	158
9	174	165
10	173	173
11	173	176
Protein concentration %		
1	257	238
2	246	195
3	209	164
4	171	140
5	143	129
Types of oil		
Sunflower oil	134	110
Corn oil	125	108
Palm oil	122	105
Olive oil	120	100
The rate of oil addition (ml/sec.)		
0.1	125	118
0.2	125	118
0.3	125	118
0.4	125	118
0.5	125	118
0.6	125	118
0.7	125	118
0.8	125	118
0.9	125	118
1.0	125	118
The rate of oil addition (ml/sec.)		
0.1	125	118
0.2	125	118
0.3	125	118
0.4	125	118
0.5	125	118
0.6	125	118
0.7	125	118
0.8	125	118
0.9	125	118
1.0	125	118
Sodium chloride concentration (μ)		
0.1	123	112
0.2	125	121
0.3	130	126
0.4	128	119
0.5	121	110
0.6	110	99
Sucrose concentration (%)		
5	129	116
10	132	121
15	135	124
20	140	126
25	141	126
30	141	126
Blender speed (rpm)		
1300	120	115
1500	110	100
1800	90	85

They attributed the decrease in EC to the fact that high speeds produce greater shear rate which decreases the particle size of the oil droplet with an increase in the surface area of the oil to be emulsified by a limited amount of soluble protein. Cerletti and Restani (1983) reported that the ability of part of the proteins to disperse at the interface between oil and water phase stabilizing the emulsion suggests that these molecules dissociate and that part of peptide has hydrophobic character.

3.2 Physical properties of beef burgers

Five, 10 and 15% of meat used in beef burgers preparation were substituted with guar flour or soybean flour. Data in Table (2) revealed that frying of beef burgers resulted in a reduction in both cooking loss and percentage of shrinkage with the increasing the level of guar or soybean flour. The cooking loss and shrinkage of beef burgers containing soybean flour at different concentrations were lower than beef burgers containing guar flour.

Table (2): Cooking loss, shrinkage %, water holding capacity (WHC) and plasticity (P) of beef burger containing different concentrations of guar flour compared with soybean flour.

Substitution %	Guar flour				Soybean flour			
	Cooking loss	Shrink-age %	WHC %	P(cm^2)	Cooking loss %	Shrink-age %	WHC %	P(cm^2)
0.00	33.00	12.00	95.45	7.32	33.00	12.00	95.45	7.32
5.00	27.51	11.10	94.99	7.10	26.21	10.54	94.16	7.23
10.00	25.19	10.00	96.97	7.15	20.94	8.78	95.85	7.28
15.00	18.92	8.33	97.13	7.25	17.24	6.73	96.33	7.30

This reduction could be a result of binding of free water of meat with certain components in both flours. These results are in a good agreement with those found by El-Akary (1986) who found that plant meat substitutes reduced cooking loss and percentage of shrinkage of beef burger. Table (2) also showed that at 5% of guar or soybean flour replacement, little or negligible changes occurred in both water holding capacity and plasticity. The increase of replacement levels (10 and 15%) increased the water holding capacity in the samples containing guar flour more than samples containing soybean flour, with negligible decrease in plasticity for both. These results gave the same attitude with those reported by El-Akary (1986).

3.3 Organoleptic evaluation of beef burger

Data in Table (3) showed significant differences between the colours of beef burger products. However, beef burgers containing

10% guar had the highest score, whereas beef burgers containing 15% guar or soybean flour had the lowest score.

Table (3): Oraganoleptic properties of beef burger containing guar flour comparing with soybean flour.

Substit-ution %	Guar flour			Soybean flour		
	Colour	Flavour	Consistency	Colour	Flavour	Consistency
0.00	9.00 ± 1.45^{a}	8.66 ± 1.32^{a}	8.56 ± 1.35^{a}	9.00 ± 1.40^{a}	8.66 ± 1.30^{a}	8.56 ± 1.33^{a}
5.00	9.24 ± 1.17^{b}	9.19 ± 1.25^{b}	8.88 ± 1.34^{a}	8.66 ± 1.07^{ab}	8.68 ± 1.31^{a}	8.65 ± 1.32^{a}
10.00	9.57 ± 1.16^{b}	9.15 ± 1.24^{b}	9.22 ± 1.20^{b}	8.97 ± 1.09^{ab}	8.59 ± 1.21^{a}	8.93 ± 1.28^{c}
15.00	8.71 ± 0.99^{ab}	8.00 ± 1.09^{ab}	8.23 ± 1.12^{ab}	7.61 ± 0.87^{c}	7.61 ± 1.03^{c}	7.44 ± 1.41^{abc}

Means values in the same column marked with the same letter are not significantly different (P>0.05).

Significant differences concerning the flavour and consistency were found between samples containing guar flour and soybean flour. Samples containing soybean flour were less acceptable by the panelists. It was obvious that beef burgers containing 10% guar flour was better than beef burgers made from 100% meat.

3.4 Some quality parameters of sponge cakes

Data shown in Table (4) indicate that the addition of guar or soybean flour caused a slight increase in sponge cakes weight before and after baking. On the other hand, thickness and volume after baking were gradually decreased by increasing the percentage of guar or soybean flour added and the weight of all cake samples under study decreased during baking. This was due to the loss of water in the oven. The data also, showed that the baking process caused a higher increment in thickness of sponge cake samples containing guar flour than samples containing soybean flour.

3.5 Organoleptic evaluation of sponge cakes

Average sensory panel scores of colour, flavour, taste and texture such as moistness, tenderness and softness for sponge cakes made from wheat flour containing guar or soybean flour are summarized in Table (5). It could be noticed from these data the significant differences between sponge cake containing guar flour and soybean flour. The data also revealed that sponge cakes containing 5% guar flour had

Table (4): Effect of adding guar flour compared with soybean flour on some quality parameters of sponge cakes.

Substitution %	Guar flour							Soybean flour						
	Before baking		After baking					Before baking		After baking				
	Thick-ness (cm)	Weight (gm)	Thick-ness (cm)	Increase thickness %	Weight (gm)	Water loss%	Volume of cakes (cm^3)	Thick-ness (cm)	Weight (gm)	Thick-ness (cm)	Increase thickness %	Weight (gm)	Water loss%	Volume of cakes (cm^3)
0.00	2	555.0	6.50	225	510.0	7.27	1660	2	550.0	6.50	225	510.0	7.27	1660
5.00	2	553.50	6.40	220	517.5	6.50	1655	2	555.6	6.20	210	520.6	6.30	1645
10.00	2	555.30	6.40	220	519.3	6.48	1650	2	558.4	6.00	200	529.4	5.19	1630
15.00	2	559.40	5.30	165	525.4	6.08	1640	2	560.5	5.10	155	536.9	5.21	1622

Table (5): Organoleptic characteristics of sponge cakes containing guar flour comparing with soybean flour.

Substitution	Guar flour							Soybean flour						
	Texture			Colour	Flavour	Taste	Total	Texture			Colour	Flavour	Taste	Total
	Moistness 10	Tender-ness 20	Softness 10	20	20	20	100	Moistness 10	Tender-ness 20	Softness 10	20	20	20	100
0.00	7.9 ± 1.18^{a}	17.2 ± 1.22^{a}	9.0 ± 1.31^{a}	17.8 ± 1.22^{a}	18.0 ± 1.34^{a}	17.5 ± 1.20^{a}	87.4	7.9 ± 1.18^{a}	17.2 ± 1.22^{a}	9.0 ± 1.31^{a}	17.8 ± 1.22^{a}	18.0 ± 1.34^{a}	17.5 ± 1.20^{a}	87.4
5.00	8.6 ± 1.23^{b}	17.6 ± 1.30^{b}	9.2 ± 1.35^{a}	18.5 ± 1.19^{b}	18.7 ± 1.27^{b}	18.0 ± 1.33^{b}	90.6	7.5 ± 1.33^{ab}	17.2 ± 1.23^{a}	8.6 ± 1.32^{b}	17.3 ± 1.30^{a}	17.3 ± 1.40^{ab}	17.4 ± 1.26^{a}	85.3
10.00	8.5 ± 1.25^{b}	18.2 ± 1.45^{ab}	9.3 ± 1.31^{a}	19.3 ± 1.37^{ab}	19.2 ± 1.09^{abc}	18.4 ± 1.06^{abc}	92.9	7.4 ± 1.35^{ab}	17.9 ± 1.35^{b}	8.5 ± 1.30^{b}	18.6 ± 1.22^{b}	18.0 ± 1.02^{a}	17.8 ± 1.37^{b}	88.2
15.00	7.4 ± 1.02^{ab}	18.0 ± 1.40^{ab}	8.5 ± 1.05^{b}	18.1 ± 1.08^{c}	18.5 ± 1.28^{b}	17.0 ± 1.24^{ab}	87.5	6.0 ± 1.07^{abc}	17.0 ± 1.20^{a}	7.0 ± 1.29^{ab}	16.8 ± 1.57^{abc}	16.7 ± 1.15^{c}	16.0 ± 1.16^{c}	79.5

Means values in the same column marked with the same letter are not significantly different (P>0.05).

better characteristics, such as texture, colour, flavour and taste, than those containing soybean flour. Replacement of 15% guar flour or soybean flour lowered the quality of sponge cakes. From the data shown in the same Table, it could be concluded that the samples containing guar flour are better than the samples containing soybean flour and the addition of 10% guar or soybean flour to wheat flour for making sponge cakes showed the best properties.

In conclusion, the use 10% of guar flour as meat or wheat flour substitute for making beef burgers or sponge cakes is recommended.

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السعة الإستحلابية لكل من دقيق الجوار ودقيق فول الصويا وتطبيقاتها فى النظم الغذائية المختلفة

منى محمود خليل

قسم الصناعات الغذائية – كلية الزراعة - جامعة المنصورة – المنصورة

ملخص

تم دراسة السعة الإستحلابية لكل من دقيق الجوار ودقيق فول الصويا ، وقد أوضحت النتائج أن السعة الإستحلابية لدقيق الجوار كانت جيدة عند مقارنتها بدقيق فول الصويا تحت الظروف المعملية المختلفة مثل : pH ، تركيز البروتين، معدل إضافة الزيت ، نوع الزيت ، تركيز كلوريد الصوديوم ، تركيز السكروز ومعدل الخلط .

- كما تم إعداد منتج بيف برجر يحتوى على ٥% ، ١٠% ، ١٥% من دقيق الجوار أو دقيق فول الصويا بدلا من اللحم وأوضحت النتائج عدم وجود فروق معنوية فى صفة اللون بين عينات البيف برجر بينما كانت هناك فروق معنوية فى كل من نكهة وقوام العينات .
- وقد وجد أن عينة البيف برجر المحتوية على ١٠% دقيق الجوار كانت الأكثر قبولا عن العينات المحتوية على ١٥% دقيق الجوار أو دقيق فول الصويا ، أما العينة المحتوية على دقيق فول الصويا فكانت أقلها قبولا .
- كما تم إعداد عينات من الكيك الإسفنجى تحتوى على ٥%، ١٠%، ١٥% من دقيق الجوار أو دقيق فول الصويا ؛ وأظهرت النتائج أن العينات المحتوية على دقيق الجوار كانت أفضل من تلك المحتوية على دقيق فول الصويا ، وكانت أفضل العينات هى العينة المحتوية على ١٠% دقيق الجوار لإنتاج كيك أسفنجى ذى مواصفات جيدة .

وتوصى الدراسة الحالية بإستخدام دقيق الجوار بنسبة ١٠% كبديل للحم أو دقيق القمح لتصنيع بيف برجر وكيك أسفنجى ذوى مواصفات حسية ومظهرية جيدة .

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (٥٣) العدد الأول (يناير ٢٠٠٢):٥٩- ٧٢.