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Utilization of Brewers Spent Grain (BSG) in Producing Functional Processed Cheese "Block"

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ABSTRACT

In the present study, brewers spent grain (BSG) was used to supplement processed cheese "Block". The BSG was added to the formula by replacing Karish cheese with 10,20,30,40 and 50%. Proximate chemical composition of BSG was determined. The resultant processed cheese "Block" samples were evaluated chemically, microbiologically, rheologically and sensory fresh and stored at 4±1^{0}C for 1, 2 and 3 month. Significant differences in chemical, microbiological, rheological and sensory evaluation have been shown by increasing the BSG level in processed cheese "Block". The addition of 50% BSG had the highest value of total solids, pH values, meltability, rheological properties and sensory evaluation but it had the lowest in titratable acidity and oil separation.

Keywords: Brewers spent grain, processed cheese, functional foods, by products.

INTRODUCTION

Processed cheese is a dairy product which differs from natural cheese in the fact that processed cheese is not made directly from milk. However, the main ingredient of processed cheese is natural cheese. Processed cheese is produced by blending natural cheese of different ages and degrees of maturity in the presence of emulsifying agents and other dairy and nondairy ingredients followed by heating and continuous mixing to form a homogeneous product with an extended shelf life (Guinee *et al*., 2004; Kycia *et al*., 2006 and Kapoor *et al*., 2007).

Processed cheese can be formulated using different types of cheese with different degree of maturation, flavorings, emulsifying salts, several ingredients, by-product in dairy factories and nondairy components (Caric and Kalab, 1993). Nondairy ingredients have been used in processed cheese for many dietary and economic reasons (Awad *et al*., 2014).

In Egypt, most of these products are made mainly from blends containing imported cheddar and gouda cheeses as well as locally produced ras cheese. The imported cheeses are usually stored for a long period, resulting in defects in their flavor and consistency (Mansour *et al*., 2011).

Many addition have been added to processed cheese to increase its nutrition value e.g. okara (Sol *et al*., 2002), exopolysaccharids (Ahmed *et al*., 2005), vegetable oil (Azzam, 2007), carrageenan (Cernikova *et al*., 2007 and 2008), starches (Trivedi and Et, 2008) , fermented barley (Awad and Salama, 2010), marine microalgae biomass (Mohamed *et al*., 2013) and lupines (Awad *et al*., 2014).

Brewers' spent grain (BSG) is obtained from barley (*HordeumBrew vulgare* L.) as the outer pericarp-seed coat layers from the original malted barley grain which remain after hot water extraction at 65–70 ^{0}C (mashing) (Mussatto *et al*., 2006). It can represent approximately 30% (w/w) of the starting malted grain (Townsley, 1979), which makes BSG a readily available, high volume and low cost by-product within the brewing industry (Treimo *et al*., (2009). Variation in BSG composition can be expected to arise from differences in barley malting cultivars, malting practices, adjuncts added and wort production during mashing processes in brewers'. (Palmer, 2006 and James *et al*., 2010). Recently, attempts have been made to use BSG as a source of phenolic acids (Bartolome´*et al*., 2002; Mussatto *et al*., 2006 and Mallouchos *et al.,* 2007) .There is approximately 3.4 million tons of BSG produced annually in the European Union according to Eurostat Dat (Mussatto *et al*, 2006 and McCarthy *et al*, 2012). BSG is of low cost and high nutritive value. Incorporation of BSG into rat diets is beneficial to intestinal digestion, alleviating both constipation and diarrhoea. Such effects were attributed to the content of glutamine-rich protein, and to the high content of non-cellulosic polysaccharides and smaller amounts of β-glucan (Mussatto, 2006 and Tang *et al*., 2009). BSG may provide a number of benefits when incorporated into human diets such as for the prevention of certain diseases including cancer, gastrointestinal disorders, diabetics, and coronary heart disease (Aman *et al*., 1994 and Jacobs *et al*., 1998).

The main objective of this study was to evaluate the brewers spent grain as industrial waste of brewers' plant and fortify processed cheese "Block" by bioactive natural compounds that present in brewers spent grain and evaluated the chemical, rheological, microbiological and sensory evaluation of processed cheese "Block" during storage periods were carried out.

MATERIALS AND METHODS

Materials

Ripened ras cheese 3 months and fresh karish cheese were obtained from the dairy pilot plant of Nasser Agricultural Secondary School, Damanhour Behera Governorate, Egypt. Butter fat was obtained from imported butter product of New zealand. Commercial JOHA emulsifying salts (JOHA SE) were obtained from BK Ladenburg corp., GmbH, Germany. Polystyrene cups (100 gm) were obtained from local market Damanhour Behera Governorate, Egypt. All chemical used were of analytioal grade and were purchased from El-Gomhouria Company for Chemical and Medical Requisites Alexandria. Chemicals used in HPLC methods were of HPLC grade and purchased from Sigma Company.

Methods

Technological methods:

Preparation of brewers spent grain (BSG):

Brewers spent grain was dried at 50 ^{0}C for 24 h then milled in laboratory mill (National, Japan) and passed through 40 mesh sieved and kept frozen in glass jars at –18^{0}C until used (Charilaos *et al*., 2009).

Preparation of processed cheese "Block":

Processed cheese "Block" was prepared according to the formula in Table (1). Brewers spent grain (BSG) was

added to the formula by replacing karish cheese with 10, 20, 30, 40 and 50% BSG.

Table 1. Ingredients used for the preparation of processed cheese ("Block" gm/kg)

Ingredients (g)	Control	BSG (%)				
		10	20	30	40	50
Ras cheese 3months	509.65	509.65	509.65	509.65	509.65	509.65
Karish cheese	218.42	196.58	174.74	152.99	131.05	109.21
Butter fat	123.77	123.77	123.77	123.77	123.77	123.77
Emulsifying salts	21.84	21.84	21.84	21.84	21.84	21.84
Distilled water	126.32	126.32	126.32	126.32	126.32	126.32
BSG	—	21.84	43.68	65.53	87.37	109.21
Total	1000	1000	1000	1000	1000	1000

BSG: brewers spent grain

Chemical methods:

Chemical analysis of brewers spent grain (BSG):

The pH values of brewers spent grain (BSG) were determined using a digital pH meters (Metter Toledo) and Titratable acidity percentage (TA) were determined according to (AOAC, 2007). Moisture, crude protein, crude ether extract, crude fiber and ash content of brewers spent grain (BSG) were determined by official methods as found in (AOAC, 2007).

Microbiological examination of brewers spent grain:

Total bacterial counts were enumerated using plate count agar as described by (Messer *et al*., 1985). Detection of Coliform bacteria, Molds and Yeasts were detected as mentioned by (APHA, 1992).

Chemical analysis of Processed cheese "Block":

Moisture content: Drying method was applied to determine the moisture content according to (Britich Standard Institution 1951 and 1952). Fat and ash content of processed cheese "Block" samples were determined according to the method described by (AOAC, 2007). Meltability of processed cheese "Block" was measured using the meltability test apparatus as described by (Olson and Price, 1958) and modified by (Rayan *et al*., 1980). Oil separation of processed cheese was determined according to (Thomas, 1973). pH values were measured using glass electrode pH meter, type-digital (model HANNA HI9321 microprocessor) according to (The British Standard Institution 1952). Titratable acidity was determined as lactic acid % according to the method described by (AOAC, 2007).

Rheological properties of processed cheese "Block" samples:

The texture profile analysis test (TPA) such as hardness, springiness, cohesiveness, adhesiveness, gumminess and chewiness of processed cheese "Block" by LFRA-Texture analyzer (1000) using computer interface software (CNS Farnell, Bore Harwood, Hertfordshire, England WD61WG) according to (Breen, 1975 and Bourne, 1978).

Microbiological examination of processed cheese:

One gm of processed cheese "Block" sample was added to 9ml of sterile distilled water. Each sample was thoroughly mixed using vortex apparatus to make a10^{-1} dilution from which decimal serial dilutions were prepared (APHA, 1992). Total bacterial counts were enumerated on standard plate count agar (Messer *et al*., 1985). Spore forming bacterial count were enumerated on standard Nutrient agar (Difco, 1984). Coliform, yeast and molds were detected as described by (APHA, 1992).

Organoleptic properties of processed cheese "Block" samples:

Samples of processed cheese were sensory accord by 20 panelists of Food Technol. Lab., Food Technology Research Ins. Agriculture research Center of Sabahia, Alexandria, Egypt, according to (Awad *et al*., 2014) for outer color and appearance (20 points), body and texture (40 points) and aroma and flavor (40 points).

Statistical analysis

All obtained data were statistically analyzed using (SAS, 2000). Data were analyzed as factorial arrangement of % of spent grain added and storage period in complete randomized design with three replicates. Comparisons among the means of different treatments were achieved using the least significant difference procedure (LSD) at $p < 0.05$ level as illustrated by (Al – Rawi and Khalaf – Allah, 1980).

RESULTS AND DISCUSSION

1-Brewers Spent Grain (BSG)

Proximate composition

Data of chemical characteristics of BSG are shown in Table (2). Proximate chemical composition of BSG showed that the chemical composition can be arranged in descending order as follow: crude protein, crude fiber, crude ether extract and finally ash, their values were 20.86, 12.17, 4.34 and 3.90%, respectively. The crude protein (20.86%) content was similar to that found by (Ranjhan, 1998) (20.00%). Higher values of it were reported by (Crickenberger and Johnson, 1982) (30.10%), and (Senthilkumar *et al*., 2010) (24.34%). On contrary, (Mussatto and Roberto, 2006 and Farcas *et al*., 2014) found lower values of BSG protein (15.30% and 18%, respectively). The crude fat found to be 4.34%. This results was lower than that mentioned by (Dong and Ogle, 2003) (10.60%), (Senthilkumar *et al*., 2010) (5.19%) and (Farcas *et al*., 2014) (6.61%). Ash content had the value 3.90%. (Dong and Ogle, 2003),while (Senthilkumar *et al*., 2010) reported 5.76%. pH value found to be 7.01 it was similar to that found by Chaudhardy and Weber, (1990).

Table 2. Chemical composition of brewers spent grain

Samples	Moisture %	Total protein%	Total fat %	Total fiber%	Ash%	Carbohy- drate*	pH	T.A %
Dried BSG	7.40	20.86	4.34	12.17	3.90	51.33	7.01	0.32

***by difference**

Microbiological examination

Brewers Spent Grain was not detected from microorganism, Coliform bacteria, Molds and Yeasts. Our results are in agreement with (James *et al*., 2010).

2- Processed cheese:

Chemical characteristics of ras and karish cheese

Data of chemical characteristics of ras and karish cheese used in processed cheese "Block" manufacturing are shown in Table (3).

Table 3. Chemical characteristics of ras and karish cheese used in processed cheese "Block" manufacturing

Component (%)	Type of cheese	
	Ras	karish
Total solids	54.81	22.85
Moisture	45.19	77.15
Fat	24.77	3.00
Crude protein	22.26	10.75
Ash	5.76	2.05
PH	4.70	4.55

Chemical composition of processed cheese samples

Data of chemical composition of processed cheese "Block" are presented in Table (4). Generally, the chemical composition of processed cheese had a significant differences affected by adding different level of BSG. Positive correlation was observed between different levels of BSG addition and total solid in fresh processed cheese and during storage periods. The addition of BSG had a slight lower of moisture ranged between 46.01 and 49.21, fat ranged between 41.07 and 41.19, protein ranged between 42.92 and 43.84 and ash ranged between 6.57 and 6.64 in fresh processed cheese and during storage period. (Pinto *et al*., 2007) reported that the addition of whey protein concentrate (1.5, 0.3 and 4.5%) has a significant effect in fat and protein but it did not show a significant effect in moisture. (Mohamed *et al.,* 2013) found that the addition of biomass marine microalgae 3.0, 4.0 and 5.0% has a significant effect in total solid, fat on dry matter and protein and it have anon significant effect on carbohydrate, ash and fiber. (Kycia *et al*., 2006) noticed that the addition of cheese base 10, 30, 50 and 70% obtained from UF milk retentate have a significant effect on protein and protein on dry matter on the other hand it have anon significant effect on dry matter, moisture, fat and fat on dry matter.

Table 4. Chemical composition of fresh and stored processed cheese samples as affected by adding brewers spent grain

	S.P (month)	Treatments						LSD%
		C	T1	T2	T3	T4	T5	
Total Solids	Fresh	$^{e}50.97^{b}$	$^{e}50.79^{d}$	$^{d}51.55^{c}$	$^{c}52.32^{c}$	$^{b}53.03^{c}$	$^{a}53.99^{c}$	0.386
	1M	$^{e}51.11^{b}$	$^{e}50.93^{c}$	$^{d}51.69^{bc}$	$^{c}52.45^{bc}$	$^{b}53.15^{bc}$	$^{a}54.11^{bc}$	0.386
	2M	$^{c}51.37^{a}$	$^{e}51.19^{b}$	$^{d}51.93^{ab}$	$^{c}52.62^{ab}$	$^{b}53.33^{ab}$	$^{a}54.32^{ab}$	0.387
	3M	$^{e}51.66^{a}$	$^{e}51.48^{a}$	$^{d}52.13^{a}$	$^{c}52.81^{a}$	$^{b}53.52^{a}$	$^{a}54.51^{a}$	0.388
LSD %		0.211	0.134	0.346	0.236	0.203	0.211	
Moisture	Fresh	$^{ab}49.03^{a}$	$^{a}49.21^{a}$	$^{bc}48.45^{a}$	$^{cd}47.68^{a}$	$^{d}46.97^{a}$	$^{e}46.01^{a}$	0.763
	1M	$^{a}48.89^{b}$	$^{a}49.07^{a}$	$^{ab}48.31^{a}$	$^{bc}47.55^{b}$	$^{cd}46.85^{ab}$	$^{d}45.89^{a}$	0.763
	2M	$^{ab}48.63^{c}$	$^{a}48.81^{b}$	$^{a}48.07^{b}$	$^{bc}47.38^{b}$	$^{cd}46.67^{bc}$	$^{d}45.68^{b}$	0.761
	3M	$^{ab}48.34^{d}$	$^{a}48.52^{c}$	$^{ab}47.87^{b}$	$^{bc}47.19^{c}$	$^{cd}46.48^{c}$	$^{d}45.49^{b}$	1.151
LSD %		0.137	0.179	0.205	0.178	0.214	0.198	
Fat / DM	Fresh	$^{a}41.21^{d}$	$^{a}41.19^{c}$	$^{b}41.16^{c}$	$^{c}41.14^{d}$	$^{d}41.12^{d}$	$^{e}41.07^{d}$	0.028
	1M	$^{a}41.23^{c}$	$^{b}41.21^{b}$	$^{c}41.18^{b}$	$^{d}41.16^{c}$	$^{e}41.14^{c}$	$^{f}41.11^{c}$	0.012
	2M	$^{a}41.25^{b}$	$^{b}41.23^{a}$	$^{c}41.21^{a}$	$^{d}41.19^{b}$	$^{d}41.18^{b}$	$^{e}41.15^{b}$	0.015
	3M	$^{a}41.26^{a}$	$^{b}41.24^{a}$	$^{c}41.22^{a}$	$^{cd}41.21^{a}$	$^{d}41.20^{a}$	$^{e}41.18^{a}$	0.013
LSD %		0.010	0.020	0.011	0.012	0.020	0.010	
Protein / DM	Fresh	$^{a}44.13^{b}$	$^{b}43.84^{a}$	$^{c}43.65^{b}$	$^{d}43.33^{b}$	$^{e}43.03^{d}$	$^{f}42.92^{c}$	0.018
	1M	$^{a}44.13^{b}$	$^{b}43.84^{a}$	$^{c}43.65^{b}$	$^{d}43.33^{b}$	$^{e}43.05^{c}$	$^{f}42.92^{c}$	0.017
	2M	$^{a}44.14^{a}$	$^{b}43.84^{a}$	$^{c}43.65^{b}$	$^{d}43.33^{b}$	$^{e}43.06^{b}$	$^{f}42.94^{b}$	0.017
	3M	$^{a}44.14^{a}$	$^{b}43.85^{a}$	$^{c}43.66^{a}$	$^{d}43.34^{a}$	$^{e}43.07^{a}$	$^{f}42.97^{a}$	0.019
LSD %		0.010	0.012	0.009	0.008	0.009	0.013	
Ash / DM	Fresh	$^{a}6.68^{b}$	$^{b}6.64^{b}$	$^{b}6.63^{b}$	$^{c}6.60^{b}$	$^{d}6.58^{b}$	$^{e}6.57^{c}$	0.012
	1M	$^{a}6.69^{a}$	$^{b}6.65^{a}$	$^{b}6.64^{a}$	$^{c}6.61^{a}$	$^{d}6.56^{b}$	$^{e}6.57^{b}$	0.013
	2M	$^{a}6.69^{a}$	$^{b}6.65^{a}$	$^{b}6.64^{a}$	$^{c}6.61^{a}$	$^{d}6.59^{b}$	$^{d}6.58^{a}$	0.019
	3M	$^{a}6.69^{a}$	$^{b}6.65^{a}$	$^{b}6.64^{a}$	$^{c}6.61^{a}$	$^{c}6.60^{a}$	$^{d}6.58^{a}$	0.019
LSD %		0.008	0.007	0.011	0.007	0.008	0.007	

■ C:- control

T1:- 10% spent grain + 90% kareish cheese **T2:- 20% spent grain + 80% kareish cheese**

T3:- 30% spent grain + 70% kareish cheese **T4:- 40% spent grain + 60% kareish cheese**

T5:- 50% spent grain + 50% kareish cheese

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

S.P: storage period **M: month** **DM: Dry Mater**

pH values of processed cheese "Block"

The changes in pH values of processed cheese "Block" samples are shown in Table (5). The values of pH were 5.43, 5.43, 5.45, 5.46, 5.47 and 5.49 for control, T1, T2, T3, T4 and T5 respectively. In fresh processed cheese, the control and T1 had the lowest value. The pH value increased with increasing the substitution level value of BSG so that T5 was the highest one. The pH value of processed cheese decreased gradually with elongation of storage period. Generally, the pH value of processed cheese had significantly affected by adding different level of BSG. (Pinto *et al*., 2007) reported that the addition of whey protein concentrate (1.5, 3.0 and 4.5%) did not show a significant effect. (Mohamed *et al.,* 2013) found that the addition of biomass marine microalgae 3.0, 4.0 and 5.0% did not have a significant effect on pH value. (Kycia *et al*., 2006) noticed that the addition of cheese base 10, 30, 50 and 70% obtained from UF milk retentate have a significant effect on pH value.

Titratable acidity of processed cheese "Block" manufacture

Data for Titratable acidity of different fresh processed cheese "Block" samples and during storage period are shown in Table (6). Generally, there were significant decreases in titratable acidity with increasing the BSG substitution level. Moreover, it was observed that significant and gradual increases were also noticed on increasing the storage period for all treated samples. The control samples in fresh and during storage were still more than that of rest treated samples. (Pinto *et al*., 2007)

reported that the addition of whey protein concentrate (1.5, 3.0 and 4.5%) has a significant effect on acidity. (Mohamed *et al.,* 2013) found that the addition of biomass marine microalgae 3.0, 4.0 and 5.0% has a significant effect on titratable acidity. (Kycia *et al*., 2006) noticed that the addition of cheese base 10, 30, 50 and 70% obtained from UF milk retentate have a significant effect on titratable acidity.

Table 5. Effect of BSG on pH values of fresh and stored processed cheese samples

Storage period (month)	Treatments						LSD %
	C	T1	T2	T3	T4	T5	
Fresh	$^{e}5.43^{a}$	$^{e}5.43^{a}$	$^{d}5.45^{a}$	$^{c}5.46^{a}$	$^{b}5.47^{a}$	$^{a}5.49^{a}$	0.01
1 month	$^{c}5.42^{b}$	$^{bc}5.43^{a}$	$^{bc}5.44^{ab}$	$^{ab}c5.45^{b}$	$^{ab}5.46^{b}$	$^{a}5.48^{b}$	0.032
2 month	$^{c}5.41^{b}$	$^{bc}5.42^{b}$	$^{bc}5.43^{b}$	$^{b}5.44^{c}$	$^{ab}5.44^{c}$	$^{a}5.47^{c}$	0.028
3 month	$^{b}5.34^{d}$	$^{a}5.40^{c}$	$^{c}5.30^{c}$	$^{a}5.41^{d}$	$^{a}5.42^{d}$	$^{a}5.44^{d}$	0.038
LSD %	0.009	0.01	0.014	0.01	0.01	0.009	

■**samples as in Table (4)**

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

Table 6. Effect of brewers spent grain on titratable acidity of fresh and stored processed cheese samples

Storage period (month)	Treatments						LSD %
	C	T1	T2	T3	T4	T5	
Fresh	$^{a}1.05^{c}$	$^{a}1.05^{c}$	$^{b}1.04^{c}$	$^{c}1.02^{c}$	$^{d}1.01^{b}$	$^{a}0.99^{c}$	0.01
1 month	$^{a}1.06^{c}$	$^{b}1.05^{c}$	$^{b}1.04^{c}$	$^{d}1.03^{c}$	$^{e}1.02^{b}$	$^{f}1.00^{b}$	0.01
2 month	$^{a}1.09^{b}$	$^{b}1.07^{b}$	$^{c}1.06^{b}$	$^{c}d1.05^{b}$	$^{e}1.03^{a}$	$^{f}1.01^{a}$	0.012
3 month	$^{a}1.14^{a}$	$^{bc}1.07^{a}$	$^{b}1.09^{a}$	$^{b}1.08^{a}$	$^{c}1.05^{a}$	$^{d}1.03^{a}$	0.039
LSD %	0.03	0.01	0.019	0.02	0.028	0.03	

■**samples as in Table (4)**

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

Meltability of processed cheese "Block"

Melting index of processed cheese "Block" was expressed as the distance of cheese flow in millimeters (mm). Meltability values of processed cheese are shown on Table (7). The lowest meltability was in control while addition 50% of BSG was the highest one fresh and during storage periods. The analysis showed that meltability value was significantly affected by the presents of BSG.

The cheese meltability showed a tendency towards decrease along the storage in all processed cheese "Block" including control. The change in Meltability values of stored samples could be due to the changes occurred in chemical properties of processed cheese such as pH value, protein and fat. The data agree with those of (Abd El-Salam *et al*., 1996; Abd El-Hamid *et al*., 2000; Awad *et al*., 2003, 2004 and Mohamed, 2004).

Oil separation of processed cheese "Block"

Oil separation of processed cheese "Block" as affected by formulated BSG when fresh and stored is show in Table (8). The oil separation values of fresh processed cheese show addition 50% from BSG was the lowest one while control had the highest value fresh and during stored. The analysis showed that the oil separation value was significantly affected by the presents of BSG.

Oil separation values increased with increasing BSG ratio in all treatments. Oil separation index of stored samples increased with prolonging the storage period. The data agree with of those obtained by (Abd El-Hamid *et al*., 2000 and El-Shabrawy *et al*., 2002).

Table 7. Effect of brewers spent grain on meltability (mm) of fresh and stored processed cheese samples

Storage period (month)	Treatments (mm)						LSD %
	C	T1	T2	T3	T4	T5	
Fresh	$^{d}11.50^{a}$	$^{c}11.90^{a}$	$^{bc}12.30^{a}$	$^{b}12.70^{a}$	$^{b}13.10a$	$^{a}13.80^{a}$	0.421
1 month	$^{c}11.30^{b}$	$^{c}11.60^{a}$	$^{bc}12.10^{a}$	$^{b}12.40^{b}$	$^{b}12.90a$	$^{a}13.50^{a}$	0.531
2 month	$^{f}10.90^{c}$	$^{e}11.30^{ab}$	$^{d}11.80^{b}$	$^{c}12.10^{c}$	$^{b}12.60^{b}$	$^{a}13.20^{ab}$	0.342
3 month	$^{e}10.40^{d}$	$^{d}10.90^{b}$	$^{c}11.40^{c}$	$^{c}11.70^{d}$	$^{b}12.20^{c}$	$^{a}12.80^{c}$	0.391
LSD %	0.301	0.331	0.249	0.291	0.284	0.362	

■**samples as in Table (4)**

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

Table 8. Effect of brewers spent grain concentrate on oil separation of fresh and stored processed cheese samples

Storage period (month)	Treatments (cm^2)						LSD %
	C	T1	T2	T3	T4	T5	
Fresh	$^{a}10.54^{c}$	$^{a}10.32^{bc}$	$^{b}10.10b^{c}$	$^{c}9.75^{b}$	$^{d}9.42^{c}$	$^{e}8.98^{b}$	0.212
1 month	$^{a}10.98^{ab}$	$^{a}10.57^{ab}$	$^{ab}10.39^{b}$	$^{c}9.88a^{b}$	$^{c}9.74^{b}$	$^{d}9.17^{a}$	0.453
2 month	$^{a}11.40^{a}$	$^{b}10.78^{a}$	$^{b}10.44^{b}$	$^{c}10.15^{a}$	$^{c}9.98^{a}$	$^{d}9.32^{a}$	0.442
3 month	$^{a}11.62^{a}$	$^{b}10.92^{a}$	$^{b}10.69^{a}$	$^{c}10.31^{a}$	$^{c}10.12^{a}$	$^{d}9.48^{a}$	0.360
LSD %	0.430	0.223	0.297	0.293	0.284	0.276	

■**samples as in Table (4)**

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

Rheological properties of processed cheese "Block":

Data of rheological properties of different processed cheese "Block" samples fresh and during storage at 4 ± 1^{0}C are shown in Table (9). Generally, there were significant decreases observed between different treatments (different level of BSG) during storage periods (3 months).

However, data showed that T5 is the highest in hardness (ranged between 1276.00 and 1215), adhesiveness (195.34-173.28), cohesiveness (0.68-0.64), springiness (5.72-5.68), gumminess (667.00-646.00) and chewiness (6976.310-6956.56) followed by T4 hardness (1234-1204), adhesiveness (184.6-164.08), cohesiveness (0.67-0.59), springiness (5.71-5.64), gumminess (651-632) and chewiness (6421.61-6389.72). (Mohamed *et al.,* 2013) found that the addition of biomass marine microalgae 3.0, 4.0 and 5.0% has a significant effect on rheological properties. (Kycia *et al*., 2006) noticed that the addition of cheese base 50 and 70% obtained from UF milk retentive have a significant effect on all rheological properties. Our results are in agreement with those obtained by (Yacoub *et al*., 2011 and Awad *et al*., 2013-2014)

Microbiological examination of processed cheese "Block":

Processed cheese "Block" was not detected from microorganism, Coliform bacteria, Molds and Yeasts and Sporforming bacteria. Our results are agreement with (Yacoub *et al*., 2011)

Sensory evaluation of different processed cheese:

Data for sensory evaluation of different processed cheese sample fresh and during storage are shown in Table (10). It was clear that the addition of BSG up to 50% increased significantly color, flavor, texture and overall acceptability. Addition 10% till 50% of BSG resulted in a market decreased in color evaluation but still all samples in acceptable range. However storage of processed cheese samples were effected on the sensory evaluation of processed cheese samples since a gradual decrease were observed in all treatments with cold storage elongation, but still all samples in acceptable range. (Pinto *et al*., 2007) mentioned that the addition of whey protein concentrate (WPC) 1.5, 3.0 and 4.5% have a significant effect on flavor and texture and it have anon significant effect on color and overall acceptability. (Mohamed *et al*., 2013) observed that the addition of biomass marine microalgae 3.0, 4.0 and 5.0% has anon significant effect on sensory evaluation. The addition was made processed cheese more firmer and easier to handle. (Kycia *et al*., 2006) noticed that the addition of cheese base 10, 30, 50 and 70% obtained from UF milk retentate have a significant effect on taste, color and texture but the values showed anon significant effect in flavor. However all samples were in acceptable range.

Table 9. Effect of brewers spent grain on rheological properties of fresh and stored processed cheese "Block" samples

	S.P month	Treatments C	T1	T2	T3	T4	T5	LSD %
Hardiness (gm)	Fresh	$^{f}875.00^{a}$	$^{e}993.00^{a}$	$^{b}1128.00^{a}$	$^{c}1190.00^{a}$	$^{b}1234.00^{a}$	$^{a}1276.00^{a}$	13.045
	1M	$^{f}860.00^{b}$	$^{e}987.00^{b}$	$^{d}1114.00^{b}$	$^{c}1147.00^{b}$	$^{b}1212.00^{b}$	$^{a}1223.00^{b}$	8.88
	2M	$^{e}853.00^{c}$	$^{d}982.00^{c}$	$^{c}1109.00^{c}$	$^{b}1142.00^{c}$	$^{a}1208.00^{bc}$	$^{a}1218.00^{c}$	15.521
	3M	$^{e}848.00^{c}$	$^{d}977.00^{d}$	$^{c}1102.00^{d}$	$^{b}1139.00^{d}$	$^{a}1204.00^{c}$	$^{a}1215.00^{c}$	11.707
LSD %		5.084	4.756	4.398	4.541	4.266	4.311	
Adhesiveness (gm / mm)	Fresh	$^{f}129.13^{a}$	$^{e}162.59^{a}$	$^{d}170.00^{a}$	$^{c}178.97^{a}$	$^{b}184.60^{a}$	$^{a}195.34^{a}$	3.445
	1M	$^{e}121.62^{b}$	$^{d}159.42^{a}$	$^{d}161.70^{b}$	$^{c}165.22^{b}$	$^{b}172.50^{b}$	$^{a}183.34^{b}$	3.439
	2M	$^{e}115.32^{c}$	$^{d}152.57^{b}$	$^{c}157.68^{bc}$	$^{c}160.87^{c}$	$^{b}168.70^{bc}$	$^{a}176.58^{c}$	3.055
	3M	$^{e}113.75^{c}$	$^{d}150.36^{b}$	$^{c}155.67^{c}$	$^{c}158.85^{c}$	$^{b}164.08^{c}$	$^{a}173.28^{c}$	3.055
LSD %		4.145	3.987	4.395	4.068	4.125	4.274	
Cohesiveness (ratio)	Fresh	$^{b}0.49^{a}$	$^{a}0.60^{a}$	$^{a}0.61^{a}$	$^{a}0.65^{a}$	$^{a}0.67^{a}$	$^{a}0.68^{a}$	0.113
	1M	$^{d}0.45^{b}$	$^{c}0.57^{b}$	$^{c}0.59^{a}$	$^{b}0.62^{b}$	$^{b}0.65^{a}$	$^{a}0.67^{a}$	0.03
	2M	$^{e}0.41^{c}$	$^{d}0.53^{c}$	$^{c}0.56^{b}$	$^{b}0.59^{c}$	$^{b}0.61^{b}$	$^{a}0.65^{b}$	0.021
	3M	$^{f}0.39^{d}$	$^{e}0.52^{c}$	$^{d}0.54^{b}$	$^{c}0.57^{c}$	$^{b}0.59^{c}$	$^{a}0.64^{b}$	0.01
LSD %		0.023	0.021	0.024	0.022	0.021	0.02	
Springiness (mm)	Fresh	$^{c}5.61^{a}$	$^{bc}5.63^{a}$	$^{ab}5.67^{a}$	$^{ab}5.69^{a}$	$^{ab}5.71^{a}$	$^{a}5.72^{a}$	0.041
	1M	$^{d}5.58^{b}$	$^{cd}5.60^{b}$	$^{c}5.62^{b}$	$^{b}5.66^{b}$	$^{ab}5.68^{b}$	$^{a}5.70^{ab}$	0.038
	2M	$^{d}5.55^{c}$	$^{cd}5.57^{c}$	$^{c}5.59^{c}$	$^{b}5.63^{c}$	$^{a}5.67^{c}$	$^{a}5.69^{b}$	0.03
	3M	$^{e}5.52^{d}$	$^{de}5.54^{d}$	$^{d}5.56^{d}$	$^{c}5.60^{d}$	$^{b}5.64^{d}$	$^{a}5.68^{c}$	0.026
LSD %		0.03	0.025	0.013	0.024	0.016	0.0211	
Gumminess (N)	Fresh	$^{e}430.00^{a}$	$^{d}592.00^{a}$	$^{c}621.00^{a}$	$^{b}643.00^{a}$	$^{b}651.00^{a}$	$^{a}667.00^{a}$	8.112
	1M	$^{f}422.00^{b}$	$^{e}587.00^{b}$	$^{d}598.00^{b}$	$^{c}622.00^{b}$	$^{b}641.00^{b}$	$^{a}658.00^{b}$	8.283
	2M	$^{f}411.00^{c}$	$^{e}579.00^{c}$	$^{d}592.00^{c}$	$^{c}617.00^{c}$	$^{b}634.00^{c}$	$^{a}647.00^{c}$	6.573
	3M	$^{f}408.00^{c}$	$^{e}574.00^{d}$	$^{d}589.00^{c}$	$^{c}615.00^{c}$	$^{b}632.00^{c}$	$^{a}646.00^{c}$	11.900
LSD %		3.086	4.011	4.00	3.245	3.652	4.241	
Chewiness (mJ)	Fresh	$^{f}5545.16^{a}$	$^{e}5794.53^{a}$	$^{d}5967.05^{a}$	$^{c}6138.65^{a}$	$^{b}6421.61^{a}$	$^{a}6976.31^{a}$	17.202
	1M	$^{f}5537.58^{b}$	$^{e}5746.21^{b}$	$^{d}5932.67^{b}$	$^{c}5998.72^{b}$	$^{b}6400.98^{b}$	$^{a}6963.23^{b}$	17.592
	2M	$^{f}5530.10^{c}$	$^{e}5742.89^{c}$	$^{d}5928.14^{c}$	$^{c}5993.26^{c}$	$^{b}6392.59^{c}$	$^{a}6957.82^{c}$	16.404
	3M	$^{f}5528.14^{c}$	$^{e}5740.26^{c}$	$^{d}5926.43^{c}$	$^{c}5991.35^{c}$	$^{b}6389.72^{c}$	$^{a}6956.56^{c}$	10.338
LSD %		6.587	6.247	6.512	6.171	6.304	6.009	

■samples as in Table (4)

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

M: month S.P: Storage Period

Table 10. Effect of brewers spent grain on sensory evaluation of fresh and stored processed cheese samples

	S.P (month)	Treatments C	T1	T2	T3	T4	T5	LSD %
Color (20)	Fresh	$^{a}18.00^{a}$	$^{b}17.70^{a}$	$^{b}17.50^{a}$	$^{c}16.60^{a}$	$^{c}16.60^{a}$	$^{d}16.52^{a}$	0.231
	1M	$^{a}17.60^{b}$	$^{a}17.50^{b}$	$^{a}17.20^{b}$	$^{b}16.50^{a}$	$^{b}16.30^{b}$	$^{c}16.24^{b}$	0.203
	2M	$^{a}17.60^{b}$	$^{b}17.40^{b}$	$^{c}17.00^{b}$	$^{d}16.50^{a}$	$^{e}16.10^{c}$	$^{f}16.00^{c}$	0.114
	3M	$^{a}17.00^{c}$	$^{a}17.00^{c}$	$^{b}16.60^{b}$	$^{c}16.40^{b}$	$^{d}15.60^{d}$	$^{e}15.52^{d}$	0.103
LSD %		0.12	0.112	0.098	0.114	0.106	0.102	
Flavor (40)	Fresh	$^{d}33.60^{a}$	$^{c}33.92^{a}$	$^{b}34.20^{a}$	$^{b}35.60^{a}$	$^{a}35.80^{a}$	$^{a}35.80^{a}$	0.116
	1M	$^{a}32.32^{b}$	$^{a}32.40^{ab}$	$^{b}32.80^{b}$	$^{c}33.80^{ab}$	$^{b}35.00^{b}$	$^{a}35.60^{b}$	0.109
	2M	$^{f}31.40^{bc}$	$^{e}32.00^{bc}$	$^{d}32.80^{b}$	$^{c}33.40^{ab}$	$^{b}34.80^{bc}$	$^{a}35.00^{c}$	0.107
	3M	$^{f}30.80^{c}$	$^{e}31.00^{c}$	$^{d}32.60^{c}$	$^{c}32.80^{ab}$	$^{b}34.60^{cd}$	$^{a}34.80^{d}$	0.105
LSD %		0.21	0.174	0.099	0.113	0.11	0.098	
Texture (40)	Fresh	$^{e}32.80^{a}$	$^{d}33.40^{a}$	$^{c}34.20^{a}$	$^{b}35.80^{a}$	$^{b}36.80^{a}$	$^{a}37.40^{a}$	0.114
	1M	$^{f}32.40^{ab}$	$^{e}33.20^{a}$	$^{d}34.20^{a}$	$^{c}35.60^{a}$	$^{b}36.20^{b}$	$^{a}36.96^{b}$	0.112
	2M	$^{f}32.20^{bc}$	$^{e}33.20^{a}$	$^{d}34.00^{ab}$	$^{c}37.20^{b}$	$^{b}36.20^{b}$	$^{a}36.84^{c}$	0.113
	3M	$^{f}31.80^{c}$	$^{e}33.20^{a}$	$^{d}33.60^{bc}$	$^{c}35.20^{c}$	$^{b}35.60^{c}$	$^{a}36.52^{d}$	0.109
LSD %		0.115	0.107	0.109	0.105	0.110	0.102	
Overall acceptability (100)	Fresh	$^{f}84.40^{a}$	$^{e}85.02^{a}$	$^{d}85.90^{a}$	$^{c}88.00^{a}$	$^{b}89.20^{a}$	$^{a}89.72^{a}$	0.214
	1M	$^{f}82.32^{b}$	$^{e}83.10^{b}$	$^{d}84.20^{ab}$	$^{c}85.90^{b}$	$^{b}87.50^{b}$	$^{a}88.80^{b}$	0.107
	2M	$^{e}81.20^{c}$	$^{d}82.60^{c}$	$^{c}83.80^{b}$	$^{b}87.10^{b}$	$^{b}87.10^{c}$	$^{a}87.84^{c}$	0.103
	3M	$^{f}79.60^{d}$	$^{e}81.20^{d}$	$^{d}82.80^{c}$	$^{c}84.40^{c}$	$^{b}85.80^{d}$	$^{a}86.84^{d}$	0.111
LSD %		0.105	0.107	0.109	0.109	0.110	0.110	

■samples as in Table (4)

a,b,c: Means in a column (between times) not sharing the some superscript are significant different at p < 0.05%

a,b,c: Means in a raw (between treatments) not sharing the some superscript are significant different at p < 0.05%

S.P: Storage Period

CONCLUSION

Brewers spent grain (BSG) by-product is a novel ingredient that can be successfully used in a functional processed cheese production. BSG is a good source of different compounds such as protein, ash, dietary fiber, carbohydrates, phenols and flavonoids. Many of them have antioxidant activity. Significant differences in chemical, rheological and sensory evaluation properties were observed due to addition of BSG.

Sensory evaluation of all treatments confirmed the possibility of use brewers spent grain as by-product in the processed cheese manufacturing for his chemical composition and the vital importance. In addition, this product can be considered as a new product with functional properties and health benefits.

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الاستفاده من تفلة المولت في تصنيع الجبن المطبوخ الوظيفي

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في هذه الدراسه تم استخدام تفلة المولت في تدعيم الجبن المطبوخ وذلك من خلال احلاله مع الجبن القريش بنسبة ١٠, ٢٠, ٣٠, ٤٠, ٥٠ % وقد تم تقدير التركيب الكيمياني في تفلة المولت وقد تم تقييم عينات الجبنه الناتجه كيميائيا وميكروبيولوجيا وحسيا وذلك في العينات الطازجه وكذلك خلال التخزين البارد علي درجة حراره ٤ ° م لمدة ١ ، ٢ و ٣ شهور وقد اظهرت النتائج اختلافات كبيره في تقييم التركيب الكيميائي والميكروبيولوجي والحسي مع زيادة نسبة تفلة المولت المضافه في الجبن. اضافة نسبة ٥٠% من تفلة المولت اعطت اعلي قيمه للمواد الصلبه والرماد وقيمة رقم الاس الهيدروجيني والزائبيه وكذلك الخواص الريولوجيه كما انها اعطت اعلي درجات للقبول الحسي ولكنه ادي الي انخفاض الرطوبه والدهن والبروتين وكذلك انخفاض الحموضه وفصل الزيت.