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USES OF POLYSACCHARIDE IN PRODUCTION OF NORMAL AND LIGHT MAYONNASE

BY

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ABSTRACT

Normal mayonnaise (70.0g oil /100g) containing 0.1% of xanthan, *Rhizobium* polysaccharide (RPS) or guar gum showed higher dynamic viscosity and sensory properties scores than control sample (without polysaccharides). Addition of the suitable level of polysaccharide considerably reduced the oil required to form oil / water emulsion from 70g to 34.69g for xanthan and 40.0g for both of RPS and guar gum in light mayonnaise. Addition of xanthan led to high stability of normal and light mayonnaise during 180 days of storage at room temperature. Consistency coefficient (K- values) were reduced by only 35.0% after 180 days of storage of normal mayonnaise containing xanthan and by 68.8%, 56.0% and 54.0% for control, RPS and guar gum samples, respectively. Although light mayonnaise containing xanthan showed the highest initial K-values, samples containing RPS recorded the highest stability during storage. The values of flow behaviour index (n-values) of normal and light mayonnaise samples were lower than the unity indicating a pseudoplastic non-Newtonian behaviour.

INTRODUCTION

During recent years oil reduced mayonnaises and dressings have improved in product quality, both in terms of eating impression as well as stability. Traditionally, the oil content in a mayonnaise is 80%, however due to an increased health awareness efforts have been directed towards the development of low-fat or no fat containing products (Marr and Pedersen, 1999).

Hydrocolloids or gums are often used for emulsion stabilization, control of pourability, cling improvement, and suspension of solid or spice particles in mayonnaise products. The commonly used gums are xanthan gum, propylene glycol alginate, and guar gum. Mayonnaise is formulated to develop characteristics such as mouthfeel and spread ability which are considered desirable by the consumer. Any change in the product after manufacture, due to instability when stored prior to sale and consumption, may have negative effects on the consumers attitude towards the product. (Ma and Barbosa- Canovas. 1995a)

Light mayonnaise as well as light sauces continue to be emulsions of oil in water in which the decrease in the percentage of oil leads to the necessity for adding stabilizing agents, generally hydrocolloids and starches, which avoid the separation of the phase which constitute the emulsion stabilizing of the product and giving it the mechanical, rheological and textural properties and characteristic of this kind of product (Pons *et al.*, 1994).

A great number of emulsion products exist in the food industry, among which are: butter, margarine, mayonnaise, salad creams, milk, ice creams, meat emulsions, etc. Spanish legislation defines mayonnaise and light sauces as products in the form of semi- solid emulsion (Pons *et al.*, 1994).

Emulsifiers play an important role in the stability and reheology of food emulsions, but these are also strong influenced by the behavior of its hydrocolloid stabilizers (Chiralt *et al.*, 1994).

The rheology of emulsions, i.e.-mayonnaise-salad creams, is influenced by several structural parameters: inter particle interactions (more important in concentrated emulsions) particle size, shape and polydispersity. The emulsions stability also depends upon structural parameters and is related to the rheological properties of these products. Structural parameters are influenced by the processing parameters (temperature, residence time and rotational speed), in addition to the oil and /or emulsifier concentration,
(Franco *et al.*, 1995).

The main rheological characteristic of salad cream and mayonnaise is the presence of a yield stress. Another important parameter is emulsion stability, with respect to creaming and coalescence. In order to enhance the stability, various polysaccharide stabilizers such as xanthan gum, or alginates are used in the preparation of mayonnaise and salad creams (Hennock *et al.*, 1984 and Marr and Pedersen, 1999).

Consumption of low calorie sauces is increasing everyday in comparison to traditional emulsified sauces that contain around 70% oil. In a light sauce formulation it is necessary to substitute a great part of oil, mainly with water. The dispersion of this small amount of oil causes difficulties in the stability and consistency of the products obtained. This problem has to be solved by the use of stabilizing agent. Starches, extensively used, provide stability and consistency to these types of products, but simultaneously give them a sticky texture, increase the caloric content and cause a considerable lowering of their microbiological stability. The substitution of these products with non digestible hydrocolloids such as locust bean gum could be an interesting option (Ferragut *et al.*, 1993; Pons *et al.*, 1994 and Marr and Pedersen, 1999)

The present investigation was carried out to select and utilize some different sources of polysaccharides (*Rhizobium* polysaccharide, xanthan, carrageenan, gellan gum and guar gum) for improving the physicochemical and functional properties and acceptability of normal mayonnaise as well as production of low calorie mayonnaises.

MATERIALS AND METHODS

Bacterial strain:

Rhizobium meliloti (EMCC-10011), which previously selected by Madkour *et al.*, (1997) to produce exopolysaccharides, was obtained from the Egyptian Microbial Culture Collection (EMCC), Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Media:

1. **Standard Medium Broth (SMB):**
   Standard medium broth used by Footrakul *et al.* (1981) and modified by Madkour *et al.* (1997) was applied for cultivation and production of *R. meliloti* exopolysaccharide.
2. **Yeast Mannitol Agar (YMA):**
   Stock culture of *R. meliloti* was grown and maintained on slopes of YMA medium (Oxoid Manual, 1979). Yeast mannitol broth was also used to activate and prepare heavy suspension of *R. meliloti.*
3. **Nutrient agar:**
   Nutrient agar was used to enumerate total viable bacterial count of the different examined samples. The plates were incubated at 32°C for 24 hours (Oxoid Manual, 1979).
4. **Bismuth sulphite agar:**
   Bismuth sulphite agar (Oxoid Manual, 1979) was used to enumerate *Salmonella sp.* The plates were incubated at 37°C for 24 hours.
5. **Potato dextrose agar:**
   Yeast and fungi counts were estimated on potato dextrose agar (Oxoid Manual, 1979). Incubation was carried out at 25-28°C for 72 hours.

Polysaccharides:

Polysaccharides from different sources including xanthan (bacterial source), carrageenan (seaweed source), guar gum (plant source) and gellan gum (bacterial source) as well as of those produced from *R. meliloti* (RPS) are used in this study. Different polysaccharides were obtained from Sigma Chemical. Co. (st. louis, Mo), USA.

Mayonnaise ingredients:

Different spices used for mayonnaise manufacture were purchased from local market, Cairo, Egypt. Commercially available corn oil was obtained from Crystal Arma Food Industries, Egypt. Commercial white vinegar (5%) was obtained from Egyptian Sugar and Distillation Company, Cairo, Egypt. Potassium sorbat was obtained from Gomhoria Company, Cairo, Egypt.

Production and recovery of *Rhizobium* polysaccharide;

Bacterial strain of *Rhizobium meliloti* (EMCC-10011*)* was used to produce exopolysaccharides as applied by Madkour *et al.* (1997).

Mayonnaise manufacture:

1. Normal mayonnaise:

Normal mayonnaise was prepared using formula according to Kishk (1997).

2. Light mayonnaise:

Different levels of the tested polysaccharides were first dispersed in water at low speed for 60 sec with a blender. The ingredients used for mayonnaise manufacture (except oil) were then mixed for 5 sec using blender on low velocity until puree formed. 0.1, 0.5 and 1.0% (w/w) of different tested aqueous polysaccharide solution was then added to the previous ingredients and mixed for an additional 5 sec (continuous phase). The low calorie mayonnaise was prepared by mixing the suitable amount of oil to the continuous phase in electric mixer for 30 sec at low speed and for 30 sec at high speed after the mass begin to thicken. To meet standards of identified requirements of the prepared mayonnaise the initial dynamic viscosity of the continuous phase must be brought to about 3.51 to 10.38 Pa.s at shear 48.6 sec^{-1}.

Mayonnaise samples were bottled in 200 ml glass bottles and stored at room temperature for 180 days until analysis.

Microbial analysis:

For microbiological analysis of different samples of mayonnaise products, eleven gram of each sample was weighed and added to 99 ml of sterilized physiological solution and the mixture was blended for 30 sec (Rao *et al.*, 1984). Mayonnaise samples were examined for, total viable bacterial count as well as *Salmonella* and yeast and molds count

Physicochemical analysis:

Moisture, lipid, ash, carbohydrate content and total nitrogen of each sample was determined according to the A.O.A.C. (1990). Crude protein was calculated by multiplying total nitrogen percentage by 5.87 according to Paulo *et al.* (1994) and Ceirwyn (1995). Total volatile nitrogen (TVN) value was performed according to the method of the Harold *et al.* (1987). The results were calculated as mg T.V.N/ 100g. The Thiobarabituric acid value (TBA) was colorimeterically determined in mayonnaise samples as mentioned by Harold *et al.* (1987). The pH values were measured using a pH meter (HANNA-Instrument, USA) according to Defreitas *et al.* (1997). The stability rate (SR) of mayonnaise was determined according to the method described by Sheng and Cotteril (1989).

Rheological analysis:

Rheological properties of mayonnaise were measured by using the rotational viscometer (Rheotest2- Germany). The rheological properties of mayonnaise were based on measuring the shear stress developed at shear rates of 0.33, 0.6, 1.0, 1.8, 3.0, 5.4, 9.0, 16.2, 27.0, 48.6, 81and 145.8 sec^{-1} respectively. The tested mayonnaise samples were introduced into the "S3" of the cylinder viscometer. Consistency coefficient (k) and flow behaviour index (n) of different samples were calculated using the Fortran program presented by Rao (1974).

Sensory analysis:

Mayonnaise samples made from different polysaccharides were assessed for their quality attributes by ten members of semi trained preference taste panel according to Raganna (1977).

Statistical analysis:

Analysis of variance followed by multiple comparisons (LSD) was applied on data of sensory evaluation according to user's Guide of Statistical Analysis System (SAS, 1996) at the computer center of Faculty of Agricultur, Ain Shams University.

RESULTS AND DISCUSSION

Selection of best kind and concentration of polysaccharides:

Normal mayonnaise sample (contains 70% oil) was prepared using 0.1% (w/w) of different polysaccharides, but the oil concentration and other ingredients were kept constant (water, acetic acid, egg yolk, sugar, salt and spices). However, light mayonnaise samples (contains less than 70% oil) were prepared with different concentration of oil, water and polysaccharides, but the other ingredients were kept constant.

Table (1) presented the dynamic viscosity (measured at shear rate 1.8 sec^{-1} and 25°C) of normal and light mayonnaise samples prepared using different polysaccharides.

Table (1): Dynamic viscosity of normal and light mayonnaise samples containing different polysaccharides

Polysaccharides type	Normal mayonnaise**		Light mayonnaise ***	
	(g oil/ 100g sample)	Dynamic viscosity* (pa.s)	(g oil/100g sample)	Dynamic viscosity (pa.s)
Control	70.0	181.07	70.0	181.07
RPS	70.0	237.11	40.0 (42..86%)****	150.89
Xanthan	70.0	245.36	34.6 (50.57%)	366.44
Guar	70.0	237.11	40.0 (42.86%)	194.00
Gellan	70.0	155.20	55.74 (20.37%)	120.70
Carrageenan	70.0	155.20	52.50 (25.0%)	129.30

RPS : *Rhizobium* polysaccharide.

* : measured at room temperature and shear rate 1.8 sec^{-1}

** : normal mayonnaise contained different polysaccharides at constant level (0.1%w/w).

*** : light mayonnaise contained different polysaccharides at (0.5% w/w)

**** : Figures in the parentheses indicate the percent decrease in oil weight over the control sample.

Dynamic viscosity of normal mayonnaise was increased as a result of addition of 0.1% of xanthan, guar gum and RPS. On contrary, addition of carrageenan and gellan gums reduced the dynamic viscosity of the normal mayonnaise than control sample. Many trails were done to choose the suitable concentration of polysaccharide required to prepare high quality light mayonnaise samples and the final results are given in Table (1). Results showed that addition of the suitable level of different tested polysaccharides considerably reduced the oil weight required to form oil in water emulsion.

Light mayonnaise samples prepared with xanthan and guar gum showed a dynamic viscosity higher than control mayonnaise samples, which could be explained by the use of polysaccharides in order to increase the consistency lost with oil reduction. On the other hand, light mayonnaise samples prepared with other tested polysaccharides showed lower dynamic viscosity.

Analysis of variance followed by multiple comparisons of panelist scores for sensory properties of normal and light mayonnaise prepared by using 0.1% and 0.5% of different polysaccharides, respectively at constant oil weight was applied to choose the best kind of polysaccharides, which improved the consistency, appearance, color, aroma and overall acceptability of normal mayonnaise and light mayonnaise (Table 2). No significant differences ($p > 0.05$) were observed in appearance, color and aroma of normal mayonnaise as a result of addition 0.1% of different polysaccharide. However, samples contained RPS, xanthan and guar gum showed similar consistency and overall acceptability with control sample. On the other hand, samples contained carrageenan and gellan gums had significantly lower consistency and overall acceptability than control sample.

Table (2): Sensory evaluation of normal and light mayonnaise samples containing 0.1% and 0.5% of different polysaccharides, respectively.

Polysaccharides type	Means of scores of sensory properties									
	Consistency		Appearance		Color		Aroma		Overall acceptability	
	Normal	Light	Normal	Light	Normal	Light	Normal	Light	Normal	Light
Control	9.1^a	8.4^b	9.2^a	8.8^b	9.0^a	8.7^b	9.4^a	8.9^a	9.3^a	8.8^b
RPS	9.4^a	7.8^c	9.5^a	7.4^d	9.4^a	8.0^c	9.5^a	9.0^a	9.5^a	8.9^b
Xanthan	9.5^a	10.0^a	9.4^a	10.0^a	9.3^a	9.0^a	9.5^a	9.0^a	9.6^a	10.0^a
Guar	9.0^a	8.5^b	9.2^a	7.8^c	9.1^a	9.0^a	9.2^a	9.0^a	9.3^a	9.0^b
Gellan	7.9^b	5.8^d	9.1^a	5.6^e	9.3^a	6.1^d	9.4^a	7.8^b	8.5^b	5.3^c
Carrageenan	7.5^b	5.4^e	8.6^a	5.2^f	8.6^a	6.3^d	8.8^a	7.8^b	8.0^b	5.5^c
L.S.D	0.923	0.395	0.956	0.378	0.975	0.276	0.871	0.247	0.768	0.325

a, b, c, d,e : Means in a columns showing the same letter are not significantly different ($p < 0.05$)

L.S.D : Least significant difference ($\alpha = 0.05$).

RPS : *Rhizobium* polysaccharide.

For light mayonnaise samples, addition of xanthan gum significantly ($p<0.05$) improved consistency, appearance, color and overall acceptability than control sample. Although light mayonnaise contained guar and RPS recorded low scores in some sensory properties, panel members gave them similar overall acceptability score like normal sample. On the other hand, addition of carrageenan and gellan to light mayonnaise samples significantly reduced the overall acceptability than normal samples.

Therefore, xanthan, guar gum and also RPS were selected to produce both of normal and light mayonnaise.

Table (3) presents the proximate chemical analysis of the normal and light mayonnaise samples prepared using the selected polysaccharides. It can be observed that normal mayonnaise samples contained a mean oil content of 70%, while the light mayonnaise samples contained much lower oil content. On the other hand, light mayonnaise samples contained higher moisture and carbohydrate content. Similar results are obtained by Pons *et al.* (1994).

Physicochemical evaluation of mayonnaise samples during storage:

1. Moisture content:

The relationship between storage period and moisture content of mayonnaise samples could be presented by a linear relationship according to Labuza, (1982) as follows:

$$Y = a - b.X$$

Where:

Y = moisture content at any time

a = moisture content at zero time

b = is a parameter representing breakdown rate of moisture content

X = storage period (days).

Table (3): Proximate chemical analysis of normal and light mayonnaise samples containing the selected Polysaccharides .(fresh weight basis)

Constituents (%)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	guar	RPS	xanthan	Guar
Moisture	23.52	23.47	23.24	23.28	49.63	52.44	49.62
Protein	3.87	3.93	3.93	3.95	4.11	4.25	4.10
Fat	70.0	70.0	70.0	70.0	40.05	34.60	40.05
Ash	1.30	1.22	1.24	1.25	1.48	1.82	1.37
Total carbohydrate*	1.31	1.38	1.59	1.53	4.73	6.89	4.86

RPS :*Rhizobium* polysaccharide.

* : Total carbohydrate was calculated by difference.

The moisture content of the normal and light mayonnaise samples was followed up during 6 months of storage at 25+2°C and the results are given in Table (4). The loss in moisture content of the normal mayonnaise samples with 0.1% polysaccharides was very minor and did not exceed 7%, even after 180 days of storage and the breakdown value ranged from –2.56 E –3 to –9.35 E –3. However, the water loss of control sample was higher than that of other normal mayonnaise samples prepared by incorporation of the selected polysaccharides that (b) value was –2.12 E –2. The role of polysaccharide may be explained by decrease in the mobility of water molecules of the mayonnaise. Water loss in the light mayonnaise samples was high during the storage period especially in that sample prepared by using guar gum (-6.03 E –2). This could be referred to the higher water activity of the emulsion as well as to the separation of water phase during the storage period making more free water available for vaporization to surrounding.

Table (4): Change in moisture content of normal and light mayonnaise samples containing different polysaccharides during storage at room temperature.

Storage period (days)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	guar	RPS	xanthan	Guar
0	23.52	23.47	23.24	23.28	49.63	52.44	49.62
30	22.91	23.31	23.18	23.16	49.51	52.33	49.42
60	22.61	23.21	23.02	22.25	49.41	51.42	49.26
90	22.09	23.16	22.99	22.16	46.70	50.84	48.28
120	20.42	23.04	22.68	21.89	45.95	50.61	47.93
150	20.22	23.04	22.42	21.80	45.95	50.49	45.67
180	20.11	22.99	22.22	21.69	45.94	50.40	35.69
(b)	-2.12 E-2	-2.56 E-3	-5.86 E-3	-9.35 E-3	-2.58 E-2	-1.26 E-2	-6.03 E-2
(R^2)	0.934	0.931	0.945	0.877	0.835	0.897	0.616

RPS :*Rhizobium* polysaccharide.

b : Is a parameter representing breakdown rate of moisture content / day.

R^2 : Coefficient of determination.

2. Stability rate:

The stability rate of normal and light mayonnaise samples was evaluated during storage of different samples at room temperature. Data presented in Table (5) clearly indicate that high stability of mayonnaise during storage has been achieved with addition of xanthan to normal and light mayonnaise. The breakdown rate has so small values as –4.52 E –2 and –3.48 E –2 for normal and light mayonnaise, respectively. These results are in agreement with Ma and Barbosa-Canovas (1995a) who stated that xanthan assist the formation of a compact three dimensional network between the egg protein molecules and absorbed oil droplets, which is responsible for the increase in resistance to flow. However, the addition of RPS led to high stability of normal mayonnaise than light mayonnaise that breakdown rate is –5.3 E –2 and –7.31 E –2, respectively. On other side, addition of guar gum caused a rapid decrease in stability during storage of light mayonnaise (–2.66 E –1) compared with that of normal mayonnaise (–9.25 E –2). The reason for such differences in the stability behaviour of mayonnaise samples could be referred to the separation of oil during storage. The adverse effect achieved by adding guar gum to the mayonnaise samples could be explained by the statements found by Sanderson (1981) and Fillery-Travis *et al.* (1994). They stated that the presence of guar gum within the continuous phase accelerates breaking of emulsion, especially at low guar gum concentration and when lecithin is present.

Table (5): Stability rate (%) of normal and light mayonnaise samples containing different polysaccharides during storage at room temperature.

Storage Period (days)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	guar	RPS	xanthan	Guar
0	100	100	100	100	100	100	100
30	99.20	100	100	100	99.70	100	99.00
60	97.14	99.70	99.70	99.10	99.00	99.70	89.00
90	92.57	98.30	97.43	90.29	96.51	98.84	83.00
120	86.57	95.71	96.00	89.43	93.5	96.53	67.00
150	85.71	92.57	94.00	88.29	90.50	94.79	62.00
180	83.71	91.43	92.57	85.14	87.50	94.79	57.50
(b)	-1.03 E-3	-5.30 E-2	-4.52 E-2	-9.25 E-2	-7.31 E-2	-3.48 E-2	-2.66 E-1
(R^2)	0.952	0.897	0.937	0.901	0.937	0.894	0.965

RPS : *Rhizobium* polysaccharide.
b : Is a parameter representing breakdown rate of moisture content / day.
R^2 : Coefficient of determination.

3. PH:

The pH values of normal and light mayonnaise samples containing different polysaccharides were measured during storage at room temperature. The pH initially was ranged between 4.46 and 4.50 for different samples. As storage period stepped up, the pH values of all studied samples were slightly increased and reached its maximum values (4.79-4.84) at the end of storage period (Table 6).

Table (6): Change in pH values of normal and light mayonnaise samples containing different polysaccharides during storage at room temperature.

Storage period (days)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	guar	RPS	xanthan	guar
0	4.48	4.46	4.46	4.46	4.50	4.50	4.50
30	4.65	4.65	4.65	4.68	4.70	4.70	4.68
60	4.68	4.68	4.69	4.69	4.62	4.72	4.68
90	4.69	4.69	4.71	4.73	4.76	4.76	4.76
120	4.82	4.77	4.75	4.79	4.78	4.78	4.80
150	4.83	4.78	4.79	4.81	4.80	4.80	4.82
180	4.83	4.79	4.80	4.81	4.80	4.83	4.84

RPS: *Rhizobium* polysaccharide.

4. Thiobarabituric acid value (TBA):

The initial TBA value of different samples (as indicator for the deterioration of mayonnaise) was ranging from 0.090 to 0.122 OD. TBA values were increased slightly during storage of different mayonnaise samples at room temperature. Control sample (without polysaccharide) showed higher TBA value than other stored samples. After 180 days of storage at room temperature samples prepared with xanthan recorded low TBA value (0.272 and 0.32 for normal mayonnaise and light mayonnaise, respectively). Whereas, those contained guar gum recorded high TBA value (0.350 and 0.359 for normal mayonnaise and light mayonnaise, respectively) (Table 7). This means that less deterioration in oil was occurred during storage as a result of adding xanthan to mayonnaise samples.

Table (7): Thio barabituric acid (TBA) values of normal and light mayonnaise samples containing different polysaccharides during storage at room temperature.

Storage period (days)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	guar	RPS	xanthan	guar
0	0.122	0.099	0.090	0.091	0.110	0.108	0.098
30	0.124	0.110	0.107	0.100	0.117	0.120	0.120
60	0.133	0.114	0.112	0.104	0.125	0.133	0.180
90	0.222	0.151	0.118	0.197	0.204	0.134	0.242
120	0.235	0.218	0.206	0.210	0.220	0.216	0.313
150	0.356	0.322	0.215	0.340	0.322	0.256	0.328
180	0.386	0.330	0.272	0.350	0.335	0.320	0.359

RPS: *Rhizobium* polysaccharide.

Rheological properties of mayonnaise during Storage:

Samples of normal and light mayonnaise prepared by using different polysaccharides, were subjected to rheological examination. The shear stress response of the tested samples was calculated and used for the analysis of rheological behaviour of the mayonnaise samples.

1. Evaluation of dynamic viscosity:

The values of dynamic viscosity were calculated by dividing shear stress values (τ) by the corresponding shear rate values (γ) between 3.0 and 81.0 (sec^{-1}).

The results (not Showed) of calculation for normal mayonnaise and light mayonnaise depict that the relationship between dynamic viscosity and shear rate was not linear indicating that all mayonnaise samples followed non-Newtonian behavior. All mayonnaise samples of normal mayonnaise and light mayonnaise with and without polysaccharides show decrease of dynamic viscosity with the increase of shear rates. The pattern of decrease in dynamic viscosity could be categorized into two phases: The first phase was characterized by a sharp decrease in viscosity values and second phase, where the decrease in viscosity values approaches zero. Practically, these two phases are necessary when mayonnaise samples were subjected to mechanical stirring or to a forced flow. All samples of normal mayonnaise showed a decrease in dynamic viscosity values with increasing storage period up to 180 days. Mayonnaise samples, which contained either xanthan or RPS gums were more stable during storage compared with control sample or mayonnaise contained guar gum. Up to a storage period of 120 days, samples with (RPS) were more stable than those of added xanthan. However, samples containing xanthan gum showed more stability for longer storage period than sample containing other added polysaccharides (Fig. 1).

Light mayonnaise contained xanthan showed higher dynamic viscosity compared with those contained RPS or guar gum. The use of RPS or guar gum has decreased the initial viscosity values of the light mayonnaise compared with those of normal mayonnaise. However, use of either xanthan or RPS in preparation of light mayonnaise sample has maintained the dynamic viscosity of the mayonnaise samples at constant values during the first three months of storage, in spite of differences in initial viscosity of both samples. In contrary, light mayonnaise prepared by guar gum showed a rapid decrease in its dynamic viscosity during storage (Fig. 2). These results agree with Hennock *et al.* (1984) and Coia and Stauffer (1987).

2. Prediction of change in dynamic viscosity during storage:

The rate of breakdown in viscosity values of mayonnaise samples could be modeled by a linear relationship between dynamic viscosity and storage time as follows:

$$\eta = \eta_0 - b\,x$$

Where:

η = dynamic viscosity after storage time (Pa.s)
η_0 = initial dynamic viscosity at zero time (Pa.s)
b = rate constant of viscosity breakdown (pa.s /day)
x = storage time (days)

Therefore, viscosity data measured at shear rate 9, 27, 48.6 sec^{-1} were applied to obtain the prediction equations, which are given in Table 8 for normal and light mayonnaise samples. Results show that these equations proved to be suitable for the prediction of viscosity during storage of mayonnaise samples, since most of the values of the coefficient of determination (R^2) were higher than 0.9.

3. Evaluation of rheological parameters:

The dynamic viscosity of the mayonnaise samples was a function of shear rate, indicating a non – Newtonian behaviour of the mayonnaise emulsion. Therefore, shear stress data were plotted vs. shear rate values according to the power (Ostwald) equation as follows (Ma and Barbosa-Canovas, 1995 b):

$$\tau = k.\gamma^{n}$$

Where:

τ: shear stress [Pa/cm^2]
k: is consistency coefficient [$Pa.s^{n}$]
γ: shear rate [s^{-1}]
n: non – Newtonian flow behaviour index

The results of calculation were presented for normal mayonnaise and light mayonnaise in Table (9). The determined R^2 - values were over 0.977, which indicate that the Ostwald equation is a suitable model for the presentation of the rheological characteristic of mayonnaise samples. As seen in Table (9) the highest stability of consistency was achieved by addition of 0.1% xanthan, since the k-values was reduced by only 35% (from 352.54 to 226.24 Pa.s) after 180 days of storage. Also the n-value was stable during the first three month of storage at values ranging between 0.34 and 0.406 At the end of 180 days storage period, the n- values of all samples were dropped below 0.3. Such change in n-value is irrelevant, since the K- values are the important parameter for rehological evaluation. All samples of light mayonnaise showed at zero time lower K- values than those of normal mayonnaise sample except that of sample prepared with guar gum. These differences in the initial consistency values are accepted, since higher oil content contribute to higher viscosity values. Although light mayonnaise sample prepared by addition of xanthan showed the highest initial K-value compared with other samples, the stability of stored RPS- light mayonnaise sample was the best among all tested samples.

Table (8): Predicted equations of linear relationship between dynamic viscosity and storage time of normal and light mayonnaise samples as affected by type of added polysaccharides.

Treat-ments	Shear rate ($9\ s^{-1}$)		Shear rate ($27\ s^{-1}$)		Shear rate ($48.6\ s^{-1}$)	
	Prediction equation $\eta = a - b\,x$	R^2	Prediction equation $\eta = a - b\,x$	R^2	Prediction equation $\eta = a - b\,x$	R^2
(Normal mayonnaise samples)						
Control	$\eta = 53.16 - 0.132\,x$	0.964	$\eta = 23.69 - 0.071\,x$	0.945	$\eta = 15.53 - 0.048\,x$	0.919
RPS	$\eta = 82.50 - 0.251\,x$	0.935	$\eta = 36.29 - 0.121\,x$	0.948	$\eta = 23.03 - 0.077\,x$	0.924
Xanthan	$\eta = 69.03 - 0.148\,x$	0.838	$\eta = 30.55 - 0.071\,x$	0.974	$\eta = 20.43 - 0.055\,x$	0.939
Guar gum	$\eta = 71.25 - 0.211\,x$	0.905	$\eta = 29.63 - 0.087\,x$	0.949	$\eta = 19.24 - 0.058\,x$	0.937
(Light mayonnaise samples)						
RPS	$\eta = 45.11 - 0.056\,x$	0.902	$\eta = 21.19 - 0.037\,x$	0.866	$\eta = 13.58 - 0.023\,x$	0.958
Xanthan	$\eta = 90.08 - 0.138\,x$	0.944	$\eta = 35.79 - 0.061\,x$	0.891	$\eta = 22.66 - 0.039\,x$	0.913
Guar gum	$\eta = 43.64 - 0.208\,x$	0.874	$\eta = 17.66 - 0.088\,x$	0.863	$\eta = 11.03 - 0.055\,x$	0.907

RPS: *Rhizobium* polysaccharide. η = viscosity at any storage time (Pa.s).
(a): intercept. **(b)** = slope.
x = storage period (days). R^2: Coefficient of determination..

Microbiological evaluation of mayonnaise samples during storage:

Different mayonnaise samples were microbiologically evaluated immediately after processing as well as during storage at room temperature for 180 days to obtain an estimate of the over all quality of the mayonnaise samples. The microbiological criteria, which were examined included, total viable aerobic bacterial counts, *Salmonella* and yeast & molds.

Total aerobic bacterial counts found in different mayonnaise samples taken during storage are shown in Table (10). Results showed that the no total viable aerobic bacterial counts were detected in most of the mayonnaise samples immediately after preparation (zero time). However, low level (3to $4x10^1$ cfu/g) was found in RPS and guar-light mayonnaise. Upon storage, the total viable counts were increased gradually for the different samples and it was more pronounced at the latter period of storage. For example, after 90 days of storage, total viable counts were ranged between $1x10^1$ and $1.39x10^3$ cfu/g and were raised to $7.5x10^3$ and $3.25x10^3$ cfu/g at the end of storage period. These means, that total aerobic counts increased from one to two logarithmic cycle during storage of different mayonnaise samples. *Salmonella* and yeast& mold were not detected during storage of different mayonnaise samples. This could be attributed to the high acidity (low pH value) of the mayonnaise samples, which prevent the survival and growth of *Salmonella* and the addition of potassium sorbate to the samples, which prevent the growth of yeast and molds. Similar results were obtained by Smittle (2000). Microbial analysis of different samples showed that their counts are similar to those recommended by Egyptian Organization of Standardization (EOS).

Table (9): The rheological parameters of normal and light mayonnaise samples containing 0.1% and 0.5 of different polysaccharides, respectively during storage at room temperature.

Mayonnaise type	Storage period (days)	Rheological parameters of normal mayonnaise with					
		Control			0.1% RPS		
		K(Pa.s)	n	R^2	K(Pa.s)	n	R^2
Normal	Zero	281.64	0.34	0.9979	286.29	0.35	0.9992
Light	Zero	281.64	0.34	0.9979	222.83	0.27	0.9947
Normal	90	113.26	0.34	0.9968	143.46	0.36	0.9974
Light	90	113.26	0.34	0.9968	199.64	0.26	0.9991
Normal	180	87.86	0.29	0.9919	125.19	0.29	0.9992
Light	180	87.86	0.29	0.9919	188.17	0.21	0.9972
		0.1% xanthan			0.1% guar		
Normal	Zero	352.54	0.406	0.9911	259.16	0.33	0.9972
Light	Zero	325.51	0.38	0.9898	274.23	0.21	0.9958
Normal	90	225.63	0.403	0.9985	129.70	0.35	0.9993
Light	90	405.01	0.21	0.9963	114.94	0.16	0.9691
Normal	180	226.24	0.221	0.9989	119.09	0.29	0.9993
Light	180	227.88	0.22	0.9983	47.00	0.19	0.9777

RPS: *Rhizobium* polysaccharide. **K:** Consistency coefficient (pa.s).
n: Flow behavior index. **R^2:** Coefficient of determination.

Table (10): Total viable aerobic bacterial count (cfu/g) of normal and light mayonnaise samples containing different polysaccharides during storage at room temperature.

Storage period (days)	Control	Normal mayonnaise with (0.1%) of			Light mayonnaise with (0.5%) of		
		RPS	xanthan	Guar	RPS	xanthan	guar
0	N.D	N.D	N.D	N.D	$3.0X10^1$	N.D	$4X10^1$
30	$9X10^0$	$1X10^1$	N.D	$1X10^1$	$5.0X10^1$	N.D	$6X10^1$
60	$1.1X10^1$	$8X10^1$	$1X10^1$	$6.5X10^1$	$6.4X10^2$	$1X10^1$	$1.6X10^2$
90	$1.6X10^1$	$1.15X10^2$	$3X10^1$	$1.6X10^2$	$1.39X10^3$	$1X10^1$	$2.35X10^2$
120	$2.1X10^2$	$1.8X10^2$	$1.95X10^2$	$4.85X10^2$	$1.8X10^3$	$1.4X10^2$	$5.25X10^2$
150	$1.5X10^3$	$1.05X10^3$	$1.05X10^3$	$1.65X10^3$	$2.4X10^3$	$6.5X10^2$	$1.55X10^3$
180	$1.75X10^3$	$1.15X10^3$	$1.2X10^3$	$1.85X10^3$	$2.5X10^3$	$7.5X10^2$	$3.25X10^3$

RPS: *Rhizobium* polysaccharide. **N.D:** Not detected .

Sensory evaluation of mayonnaise samples during Storage:

Multiple comparison using LSD was used to evaluate the sensory properties of normal and light mayonnaise.

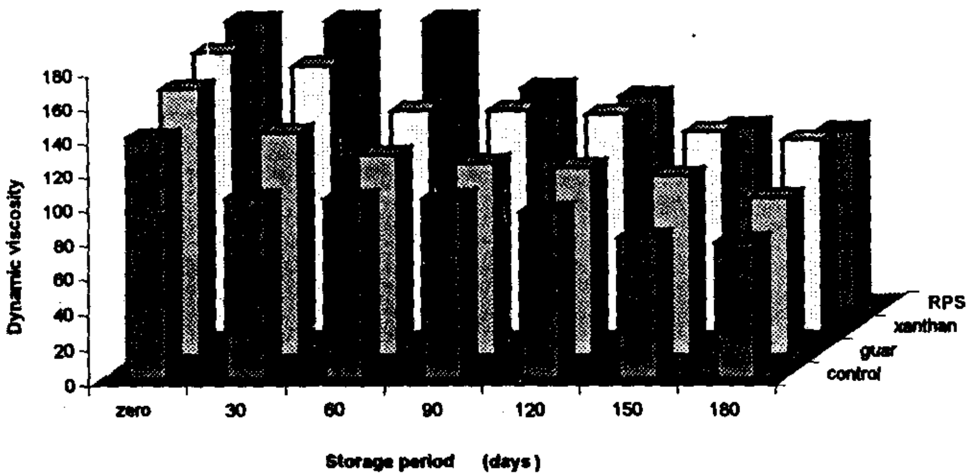

Fig (1) The effect of storage period and kind of polysaccharides on dynamic viscosity of normal mayonnaise samples at 25 °C and shear rate 3 s-1.

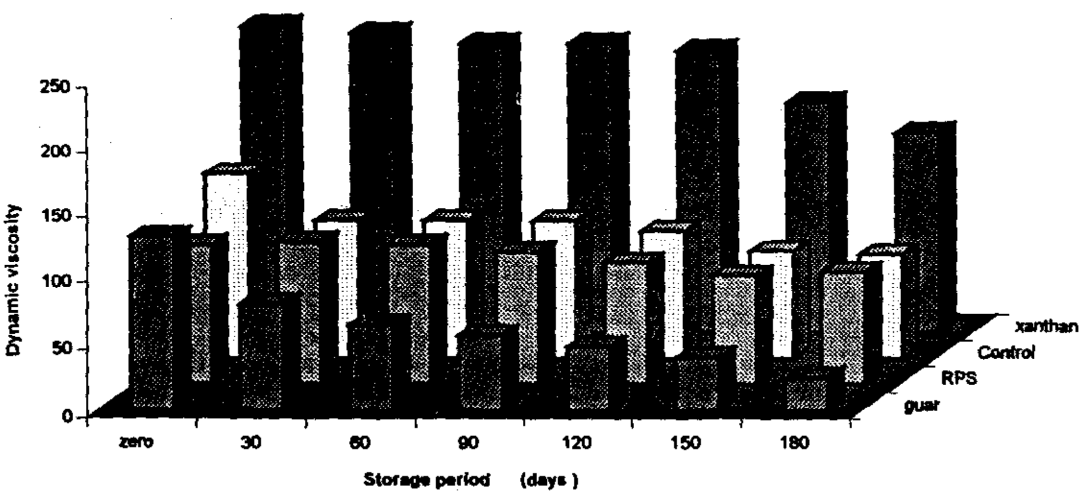

Fig (2) The effect of storage period and kind of polysaccharides on dynamic viscosity of light mayonnaise samples at 25 °C and shear rate 3 s-1.

Data of panelist scores of normal mayonnaise contained 0.1% of different polysaccharides as affected by storage at room temperature for 180 days were statistically analyzed (data not showed). No significant differences were ($p > 0.05$) observed at zero time in appearance, color, aroma and overall acceptability of normal mayonnaise prepared with or without 0.1% of different polysaccharides. However samples containing 0.1% polysaccharides showed superior consistency than control sample. Storage for 180 days at room temperature significantly ($p<0.05$) reduced sensory properties scores of normal mayonnaise samples prepared with or without polysaccharides. With respect to the effect of polysaccharide and storage period on sensory properties of normal mayonnaise, results show that the normal mayonnaise prepared with 0.1% xanthan recorded higher scores followed by RPS. At the same time, no significant differences were obtained for most sensory properties of control sample and mayonnaise prepared with 0.1% guar gum after 180 days of storage.

Multiple comparison using LSD was used to evaluate the sensory properties of light mayonnaise samples containing different polysaccharides in comparison with control normal mayonnaise (without polysaccharide) during storage for 180 days at room temperature (data not showed). Light mayonnaise containing xanthan recorded higher scores of all sensory properties similar to those of control normal mayonnaise at zero time. On the other hand, light mayonnaise contained either RPS or guar gum recorded significantly less scores of consistency, appearance and acceptability than normal mayonnaise at zero time. Statistical analysis show that no significant differences of consistency were found at zero time and 180 days of storage for light mayonnaise samples containing either RPS or xanthan. This means that addition of xanthan and RPS has achieved high stability of light mayonnaise during storage. After 180 days of storage, light mayonnaise containing either xanthan or RPS recorded superior overall acceptability scores than normal control sample (without polysaccharide). In conclusion addition of xanthan or RPS is necessary to produce high acceptable light mayonnaise.

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استخدام السكريات العديدة في إنتاج مايونيز عادي وخفيف

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سكريدات عديدة مختلفة مثل الزانثان والسكريدات العديدة للرازبيوم *Rhizobium* polysaccharide (RBS) والكرجينان والجيلان والجوار تم استخدامها لتحسين الصفات الطبيعية والفيزيائية والوظيفية وكذلك مدي القبول للمايونيز العادي والخفيف. المايونيز العادي (٧٠ جم زيت/١٠٠ جم) المحتوي علي ٠،١% زانثان أو RPS أو جوار أظهر لزوجه ديناميكيه وصفات حسيه أعلي من العينة المقارنه (بدون سكريدات عديده). اضافة المستوي المناسب من السكريد العديد للمايونيز الخفيف يقلل بدرجه ملحوظه كمية الزيت المطلوبه لتكوين معلق الزيت و الماء من ٧٠ جم ٣٤،٦٩ جم عند استخدام الزنثان والي ٤٠ جم عند استخدام كل من الـــ RPS أو الجوار. اضافة الزانثان عند تحضير المايونيز الخفيف قاد الي ثبات عالي للمايونيز العادي والخفيف أثناء التخزين لمدة ١٨٠ يوم علي درجة حرارة الغرفه. إضافة الزنثان قاد إلي ثبات عالي للمايونيز العادي والخفيف أثناء التخزين لمدة ١٨٠ يوم علي درجة حرارة الغرفة. كما حدث انخفاض في معامل القوام (K-value) بمقدار ٣٥% فقط بعد ١٨٠ يوم من تخزين للمايونيز العادي المحتوي علي زنثان وبمقدار ٦٨،٨% و٥٦% و٥٤% لكل من عينات المقارنة والـــ RPS والجوار علي التتابع. علي الرغم من كون معامل القوام الابتدائي للمايونيز الخفيف المحتوي علي الزانثان أعطت أعلي قيمه لمعامل القوام الا أن عينات المايونيز الخفيف المحتوية علي الـــ RPS سجلت أعلي ثبات أثناء التخزين. قيم مقياس الانسياب ((Flow behavior index n-values كانت أقل من الوحدة مما يدل علي سلوك غير نيوتوني.