

# Surface Properties and Emulsifying Stability of Konkoli (*Maesopsis Eminii*) Seed Gum

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**Abstract**— Konkoli (*Maesopsis eminii*) seed gum fractions, Whole gum (WKG) and Soluble gum (SKG) were evaluated for their surface and emulsifying properties. Both gum fractions were found to reduce surface tension of water to 52 mN/m at 1.0 % (w/v). It was found that surface tension of SKG was higher than that of WKG at concentrations between 0.01-1.0% (w/v). The surface tensions of the emulsions formed with both gum fractions showed that there is a remarkable surface tension in the interface between oil and water droplets at levels between 0.2-1% (w/v) of SKG solutions compared to WKG. The viscosity of emulsions prepared with WKG and SKG solutions showed that the viscosity of WKG solution is higher than that of SKG solution. All the emulsions were very stable over a period of one week indicating the formation of droplets with small droplet size. The optical density of both SKG emulsions prepared showed that the WKG is higher than that of SKG. However, both emulsions showed an increase in optical density with increase in gum concentrations.

**Keywords**— Konkoli seeds, surface properties, emulsion stability,

## 1. INTRODUCTION

Seed gums have proven to be very important agrochemicals used in many industries worldwide. Research on products made from these gums and new sources, have been intensified based on their growing applications in pharmaceutical, paper, petroleum recovery and textile industries (Kumar et al., 2010)

Gums are produced by plants as products of metabolic mechanisms. They are either viscous on adsorption of water or soluble in water. Natural gums are easily available and have been used as film-forming agents, suspensions, thickeners in food and cosmetics, tablet binders etc (Martin et al., 1991)

Konkoli seed gum (KSG) is obtained from konkoli plant (*Maesopsis eminii*), a specie located in North Eastern Nigeria. This gum is a galactomannan which is known for its binding and swelling propensity, high viscosity and hydrophilicity. KSG is widely used in Nigeria as traditional baked food product and soup thickener. (Barminas et al., 2005; Barminas and Eromosele, 2002; Osemeahon et al., 2008)

Galactomannans are produced in some plants as cell wall and storage polysaccharides with a large group of them from seeds of leguminosae family. They are an important group of polysaccharide hydrocolloids (Mathur, 2005). Galactomannans are polysaccharides made up of a  $\beta$  - (1

- 4) - D - mannan backbone with single D - galactose branches linked  $\alpha$  - (1 - 6). Their ratios of mannose/galactose (M/G) differ according to species (Kok et al., 1999). Galactomannans are used in different forms for human consumption and have many applications such as excellent stiffeners and stabilizers of emulsions. Their use in pharmaceutical, textile, biomedical, cosmetics and food industries owe to non-toxicity. (Srivastava and Kapoor, 2005; Vieira et al., 2007)

Emulsions are dispersed systems that consist of two immiscible liquids (usually oil and water) where one liquid is dispersed in the other as small droplets. They are thermodynamically unstable systems and could breakdown due to unfavourable contact between the oil and water molecules such as coalescence, sedimentation, flocculation, creaming and/or phase inversion, during storage (Mc Clements, 2005; Friberg, 1997). The extension of a long-term stability in emulsions is normally achieved by adding a variety of stabilizers. This can be sought either through control of interfacial properties or viscosity enhancement i.e. controlling the rheology of the continuous phase (Doublier and Cuvelier, 2006). An emulsifier promotes formation of emulsion and short-term stabilization by interfacial action (Dickinson, 2003). Furthermore, a stabilizer is an ingredient that can be used for enhancement of emulsion stability and may be regarded as either a texture modifier or emulsifier depending on its mode of action (Mc Clements, 2005).

Certain polysaccharides such as cellulose ethers (Ford et al., 1987), Xanthan gum (Talukdar and Plaizier-Vercammen, 1993), locust bean gum (Sujja-areevath et al., 1996) and Tragacanth gum (Dea and Madden, 1986) have been noted in showing specific surface activities and stabilization of dispersed oil droplets in aqueous system. Barminas et al. (2005) also reported that konkoli seed gum exhibits suitable swelling capacity and hydrophilicity. Moreover, a bioremediation membrane has been produced by the grafting of the gum blend with polyacrylamide and sodium alginate (Osemeahon et al., 2007, 2008)

However, bearing in mind the growing interest in new sources of gum, the present study is designed to evaluate the surface properties and emulsifying stability of konkoli seed gum

## 2. MATERIALS AND METHODS

### 2.1. Materials

Konkoli seeds (*Maesopsis eminii*) were purchased from a market in Gembu, Taraba State, Nigeria. These seeds were washed with distilled water and dried in an oven for 30 minutes at 55 °C. The seeds were broken into smaller particles using a mortar and then ground in a manually driven attrition mill to achieve 100 µm particle sizes which was stored in a polyethylene bag.

### 2.2. Preparation of soluble Konkoli gum (SKG) solutions

0.01 – 1.00g of the powdered sample was blended with water in a volumetric flask to form soluble Konkoli gum by a simple fractional method (Barminas, 2004). SKG samples were transferred into beakers and heated at 80 °C for 30 minutes in a thermostatically controlled water bath. The mixture was allowed for 24 hrs at room temperature so that the gum would separate from the mixture. After that, the soluble gum fraction was carefully decanted.

### 2.3. Preparation of whole Konkoli gum (WKG) solutions

Similar procedure used in the preparation of soluble konkoli gum solution was adopted for the preparation of the whole konkoli gum solution, except that the soluble upper layer was not separated.

### 2.4. Preparation of emulsion

Equal volume of paraffin oil (50 ml) and gum solutions (50 ml) were mixed to form emulsion. The mixtures were homogenized using an improvised homogenization process which involved repeated cycles of sucking and rapid expulsion of emulsion from a 100 ml glass syringe, to ensure proper droplet break – up which produced a creamy homogenous emulsion.

### 2.5. Preparation of Standard Sucrose solution

60g of sucrose powder was dissolved in 100ml of distilled water to obtain a standard sucrose solution of 60 % sucrose solution which was used in viscosity measurement as a standard solution.

### 2.6. Methods

#### 2.6.1. Surface Characterization

Surface tension measurements for SKG, WKG and emulsions were performed using a drop weight method (Fell, 1988)

An improvised method for this measurement was adopted as follows: - A burette was filled with distilled water using a beaker and glass funnel. The tap was opened and adjusted to give a flow in drops with a time interval of 4 seconds between each drop. A 10 ml measuring cylinder was placed below the teat of the burette where falling drops were collected up to a volume of 3 ml. The time taken to collect the 3 ml quantity of water was recorded using a stop watch and the volume was weighed on a balance. The pressure head of the liquid was kept

constant, during the measurement, by blocking the burette head. This was done to limit the influx of air, thereby controlling the rate of flow of the liquid. All measurements were taken at room temperature and the surface tension calculated. Surface tension of distilled water was taken as a standard solution.

$$\gamma_2 = \frac{\gamma_1 n_1 \rho_2}{n_2 \rho_1}$$

Where  $\gamma_2$  is the surface tension of sample,  $\gamma_1$  is the surface tension of distilled water (standard solution),  $n_1$  is the number of drops of water,  $n_2$  is the number of drops of sample,  $\rho_1$  is the density of water and  $\rho_2$  is the density of sample

#### 2.6.2. Viscosity Measurements

Viscosity of the SKG, WKG and emulsions were measured at room temperature using an improvised method with 100 ml glass syringe. The syringe was filled with the prepared 60 % sucrose solution and the time taken for the flow of 10 ml of the solution was recorded using a stop clock. The viscosity was calculated using the equation below

$$\frac{\eta_s}{\eta_{standard}} = \frac{\text{Flow time of solution}}{\text{Flow time of standard(60 % Sucrose) solution}}$$

Where  $\eta_s = \text{Viscosity of solution}$

$$\eta_{standard} = 5.9 \times 10^{-3} \text{ NSm}^{-2}$$

(Lewis, M.J., 1988)

#### 2.6.3 Optical Rotation Measurements

A DISC polarimeter type WXG – 4, which uses a 20W sodium lamp with a wavelength of 589.3 nm monochromatic light was used to determine the optical rotation of emulsions.

The SKG emulsion was diluted in a ratio of 1:150 with water and 5ml of the diluted emulsion was measured into the 100 mm polarimeter test tube, placed in the sample chamber of the polarimeter and the optical rotation was measured.

Similar procedure was repeated for WKG emulsion except that its dilution factor was 1:200 (1ml of emulsion to 200 ml distilled water). The optical rotation was calculated as thus:

$$Q = (\alpha)LC$$

Where Q = Optical rotation in degree

L = Length of solution column (test tube)

C = Concentration (quantity of solution in test tube)

$\alpha$  = Angle of rotation (degrees)

## 3. RESULTS AND DISCUSSION

### 3.1. Surface Properties

The procedure was applied to determine the surface tension of SKG and WKG at various concentrations of Konkoli Gum (KG). The results obtained are plotted on fig. 1

Table 1a: Surface Tension of Soluble Konkoli Gum (SKG)

Concentration KG	Volume SKG	No. of Drops of SKG	Weight of SKG	Density of SKG	Surface Tension of SKG
0.02	3	58	2.13	0.71	74.90
0.04	3	57	2.07	0.69	74.10
0.06	3	55	1.98	0.66	73.46
0.08	3	53	1.89	0.63	72.70
0.10	3	54	1.86	0.62	70.20
0.20	3	54	1.80	0.60	68.02
0.40	3	53	1.62	0.54	62.40
0.60	3	52	1.50	0.50	58.90
0.80	3	56	1.50	0.50	55.10
1.00	3	53	1.35	0.54	52.00

Table 1b: Surface Tension of Whole Konkoli Gum (WKG)

Concentration KG	Volume WKG	No. of Drops of WKG	Weight of WKG	Density of WKG	Surface Tension of WKG
0.02	3	86	3.01	1.00	71.19
0.04	3	85	2.86	0.95	68.42
0.06	3	89	2.79	0.93	63.97
0.08	3	88	2.64	0.88	61.22
0.10	3	89	2.61	0.87	60.52
0.20	3	88	2.52	0.84	58.38
0.40	3	89	2.55	0.85	58.47
0.60	3	90	2.49	0.83	56.46
0.80	3	88	2.34	0.87	54.26
1.00	3	87	2.22	0.74	52.07

Figure 1 shows the surface tension reduction of SKG and WKG in aqueous solutions

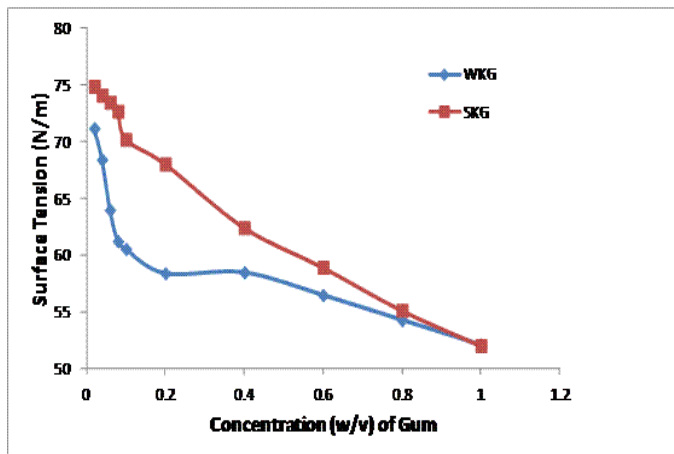


FIGURE 1: Surface Tensions of whole and Soluble Fractions of KG at 30 °C

Figure 1 shows that the surface tension of the soluble fraction (SKG) was higher than the aqueous solution of WKG. This could be attributed to protein which may be bound/associated to the native polysaccharide. (Garti et al., 1997). However, both gum solutions reduced surface tension to about 52 mN/m at 1.0 % (w/v). The surface tension reduction value obtained shows an agreement with the surface tensions of galactomannans (Munoz et al., 2007). A critical micelle concentration (CMC) was observed at approximately 0.1 % (w/v). These results are

indications of surface adsorption phenomena. Hence, the gum solutions show surface activity.

It may be concluded that WKG exhibits better surface activity and may improve interfacial tension than SKG at concentrations less than 1.0 % (w/v). Perhaps, fractionation may have eliminated the protein associated with the polysaccharides; hence, the poor surface tension reduction of SKG. However, the fraction still shows surface property indicating that it still contains some proteins.

The WKG curve in figure 1 appears to be of different forms depending on its concentration. At concentrations between 0.01 – 0.02 % w/v a drastic surface reduction is obvious which may be due to the adsorption of low molecular weight components because of their preferential migration to the surface. At concentrations between 0.2 – 0.4 % w/v which corresponds to the behaviour of the macromolecules at the surface and leads to a gradual reduction in the surface tension of the solution. Here, the surface activity is derived from the weak absorption of the homopolymer of the polysaccharide mixture on the surface. The gum undergoes rearrangement on the interface, which causes part of the homopolymer to behave like a hydrophobic anchoring polymer and a part to serve as a dangling stabilizing chain in the aqueous phase (Garti and Reichman, 1994)

### 3.2. EMULSIFYING ACTIVITY

#### 3.2.1 Viscosity of emulsions

The viscosities of the emulsions prepared with SKG are lower than those with WKG solutions. These viscosity profiles follow the individual viscosity pattern of both gum solutions obtained by Barminas, (2004). The viscosity of gums gives a guide in distinguishing between steric stabilization and depletion stabilization and the viscosity effect that gum impart on the continuous phase in o/w emulsions (Garti et al., 1999). The viscosities were measured for various concentrations of SKG and WKG and the results plotted in figure 2.

Table 2a: Viscosity of Soluble Konkoli Gum (SKG) Emulsion

Concentration of SKG Emulsion	Flow time of 60% Sucrose	Flow time of Distilled Water	Flow time of 10 ml SKG	Viscosity of SKG Emulsion	Surface Tension of WKG
0.02	11.20	11.00	12.20	$6.40 \times 10^{-3}$	71.19
0.04	11.20	11.00	12.50	$6.58 \times 10^{-3}$	68.42
0.06	11.20	11.00	13.00	$6.80 \times 10^{-3}$	63.97
0.08	11.20	11.00	13.20	$6.95 \times 10^{-3}$	61.22
0.10	11.20	11.00	14.00	$7.40 \times 10^{-3}$	60.52
0.20	11.20	11.00	14.00	$7.40 \times 10^{-3}$	58.38
0.40	11.20	11.00	15.00	$7.90 \times 10^{-3}$	58.47
0.60	11.20	11.00	15.20	$8.00 \times 10^{-3}$	56.46
0.80	11.20	11.00	16.00	$8.40 \times 10^{-3}$	54.26
1.00	11.20	11.00	18.00	$9.50 \times 10^{-3}$	52.07

Table 2b: Viscosity of Whole Konkoli Gum (WKG) Emulsion

Concentration of WKG Emulsion	Flow time of 60% Sucrose	Flow time of Distilled Water	Flow time of 10 ml WKG	Viscosity of WKG Emulsion
0.02	11.20	11.00	17.00	$8.95 \times 10^{-3}$
0.04	11.20	11.00	17.00	$8.95 \times 10^{-3}$
0.06	11.20	11.00	17.20	$9.06 \times 10^{-3}$
0.08	11.20	11.00	18.00	$9.48 \times 10^{-3}$
0.10	11.20	11.00	18.10	$9.53 \times 10^{-3}$
0.20	11.20	11.00	18.30	$9.64 \times 10^{-3}$
0.40	11.20	11.00	19.00	$10.00 \times 10^{-3}$
0.60	11.20	11.00	19.50	$10.27 \times 10^{-3}$
0.80	11.20	11.00	20.00	$10.54 \times 10^{-3}$
1.00	11.20	11.00	20.10	$10.59 \times 10^{-3}$

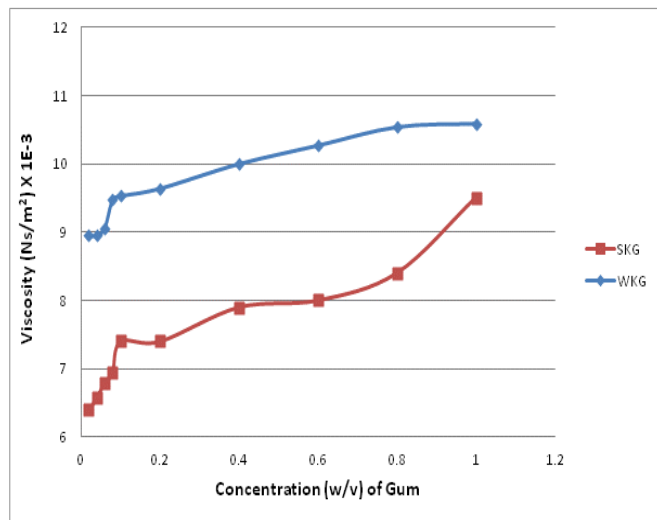


FIGURE 2: Viscosity of Emulsions Containing Different Concentration of the Two Fractions of Konkoli Solutions

The curves in figure 2 show a rapid viscosity build-up by both emulsions containing gum solutions, below 0.1 % (w/v) concentrations. Above this concentration, the emulsions become more viscous. This suggests therefore that at low concentrations (below 0.1 % w/v), weak intermolecular interactions exist between the low molecular weight gum components at the oil surface. Above 0.1 % (w/v), the gum molecules entangle and overlap, which impart higher viscosity to the solution as analysed by Perez-Mosqueda et al., (2013). One can conclude that WKG entangles more and its emulsions are more viscous than SKG emulsions.

### 3.3 EMULSIFYING ACTIVITY INDEX (EAI)

This characteristic can be determined by measuring the optical densities of SKG and WKG which is termed to be proportional to the emulsifying index and total surface area of the droplets. The results obtained from the measurement of optical densities for different concentrations of SKG and WKG emulsions are shown in figure 3.

TABLE 3A: OPTICAL ROTATION OF SOLUBLE KONKOLI GUM (SKG) EMULSION AT 500 NM

Concentration of SKG	Optical Rotation	Optical Density
0.02	74.30	0.74
0.04	75.30	0.75
0.06	77.20	0.77
0.08	78.50	0.79
0.10	80.40	0.80
0.20	82.60	0.83
0.40	84.15	0.84
0.60	83.30	0.83
0.80	86.20	0.86
1.00	89.80	0.90

Table 3b: Optical Rotation of Whole Konkoli Gum (WKG) Emulsion at 500 nm

Concentration of WKG	Optical Rotation	Optical Density
0.02	80.50	0.81
0.04	82.30	0.82
0.06	84.50	0.85
0.08	84.40	0.86
0.10	87.30	0.87
0.20	90.50	0.91
0.40	91.20	0.92
0.60	92.30	0.94
0.80	94.40	0.94
1.00	97.90	0.98

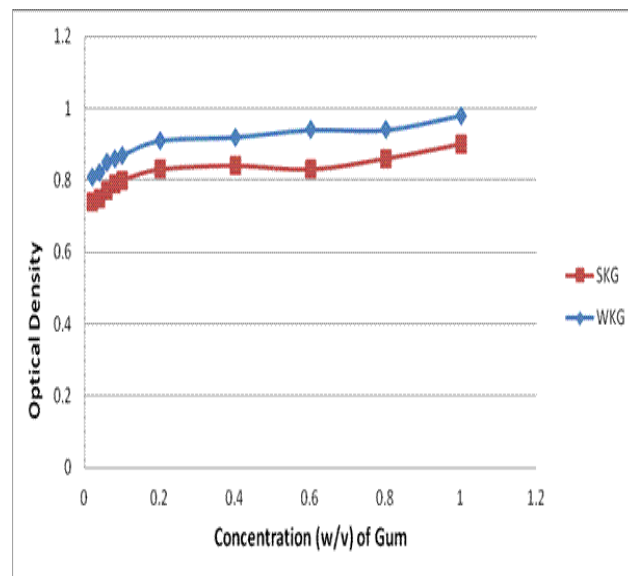


FIGURE 3: Optical Density at 500 nm Reflecting Emulsifying Activity index of Emulsions

Comparing Figures 2 and 3, the EAI may be induced by viscosity. At low gum concentrations, the viscosity is low and there may be rapid migration of the gum to the oil droplets during shear leading to an initial stabilization which reaches a maximum at 0.2 % (w/v) and 0.4 % (w/v) for WKG and SKG emulsions, respectively. Close examination of emulsions at these low concentrations (0.2-0.6 % w/v) show a greater tendency to flocculate when aged within a period of five (5) days. At higher concentrations of the gum above 0.6 % (w/v), emulsions are free from flocculation and stable to coalescence. This



could be due to restriction of migration of the oil droplets by the viscous systems.

Table 4a: Surface Tension of Soluble Konkoli Gum (SKG) Emulsion

Concentration KG	Volume SKG	No. of Drops of SKG	Weight of SKG	Density of SKG	Surface Tension of SKG
0.02	3	64	2.70	0.90	86.09
0.04	3	61	2.61	0.87	85.91
0.06	3	62	2.52	0.84	78.29
0.08	3	63	2.49	0.83	80.66
0.10	3	64	2.46	0.82	78.44
0.20	3	68	2.34	0.78	70.20
0.40	3	72	2.28	0.76	64.62
0.60	3	73	2.25	0.72	60.38
0.80	3	73	2.10	0.67	56.19
1.00	3	72	1.83	0.61	51.86

Table 4b: Surface Tension of Whole Konkoli Gum (WKG) Emulsion

Concentration KG	Volume WKG	No. Of Drops of WKG	Weight of WKG	Density of WKG	Surface Tension of WKG
0.02	3	66	2.46	0.82	76.06
0.04	3	65	2.40	0.80	75.30
0.06	3	66	2.34	0.78	72.30
0.08	3	65	2.31	0.77	71.40
0.10	3	65	2.28	0.76	71.50
0.20	3	65	2.25	0.75	70.60
0.40	3	65	2.22	0.74	69.70
0.60	3	66	1.95	0.65	60.30
0.80	3	64	1.80	0.60	57.40
1.00	3	60	1.62	0.54	55.09

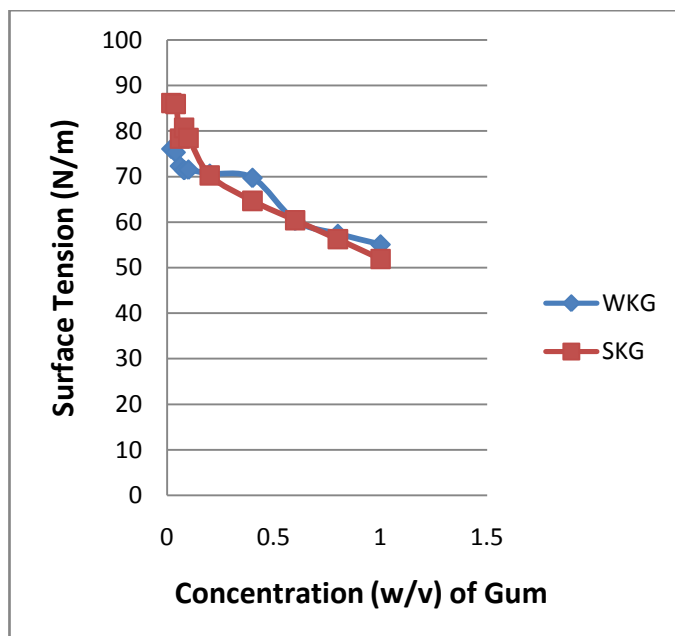


FIGURE 4: Surface Tension of Oil-in-Water Emulsions in the presence of Gum Fractions

Figure 4 shows the surface tension of the emulsions formed with both gum solutions. Surface and interfacial tensions give useful information about emulsifying properties of a component and stability of droplets against aggregation and Ostwald ripening (Mc Clements, 2005). With the exception of 0.6 % (w/v) gum solution, there is a

remarkable reduction in the interfacial tensions between 0.2 – 1.0 % of SKG solutions which may have given an improved interfacial adsorption possibly due to rapid adsorption of gum molecules and their better organization into films on the oil interface. This suggests that SKG adsorbs in a mode similar to monomeric emulsifiers, mostly perpendicular to the interface, with the only few ‘tails’ anchoring in the oil, and large dangling hydrophilic groups dissolving in the water continuous phase (Garti et al., 1999)

## CONCLUSION

The study shows that Konkoli (*maesopsis eminii*) seed gum galactomannan can be considered an emulsifier as well as a stabilizer and they can contribute to the stabilization of oil-in-water (o/w) emulsions. The gum showed limited surface activity which may facilitate precipitation of a gum film on the oil droplet that tends to reorganize itself on the surface and form a weakly oriented polymeric layer.

The adsorption of the gum on the oil droplets provides weak anchoring groups and strong stabilizing moieties, offering stabilization. Full coverage of the oil droplets was provided at relatively high gum concentrations allowing formation of stable emulsions free of coalescence and flocculation. However, when the gum concentration was not sufficient for effective droplet coverage, flocculation and creaming were detected.

This study reveals that KG solutions could be used as viscosity builders, stabilizers and may offer many food processors having interest in non-fat and low-fat applications such as salad dressings and baked foods.

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