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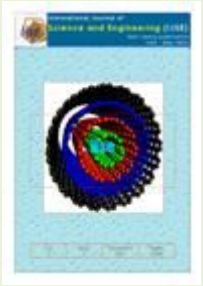

Feasibility study of Using Liquid Gel in Stabilizing Doogh by Hydrocolloids of Psyllium Husk and Guar Gum

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Abstract **-** Liquid gel technology is a method that applies in stabilizing of suspension and dispersion of solid particles in beverages. Doogh which is an Iranian traditional and functional drink has allocated a unique position among consumers. Precipitation of hydrocolloids in Doogh has been always one of the most important challenge in producing this drink. Base of this fact, this study deals with using liquid gel technology (Guar gum and Hydrocolloids of Psyllium Husk) .Different hydrocolloids concentration (0.01, 0.03, 0.05 %w/w) in Doogh heated to be hydrated at 80 ˚C resulting in producing Gel. Their flow behavior, particle distribution and microstructure analyzed, phase separation also evaluated by measuring volume of separated phases .Guar remarkably effected on Doogh flow behavior and caused to a high apparent viscosity in low shear rates, changing microstructure therefore changing particles size as well. It also subtracted the volume of separated phase .Xanthan and Psyllium increased stability of Doogh by increasing more repulsive force between particles, however larger particles precipitated. Samples containing Guar Gum indicated more yield stress.

Key words**:** Doogh, Rheological Properties, Liquid Gel, *Hydrocolloids, Phase Separation*

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I. INTRODUCTION

Acidic dairy beverages include a wide range of drinks that produce and consume and composed of a system of liquid proteins which undergoes acidifying treatment (1). Doogh is an Iranian old drink categorizing in beverages defines stirred yogurt with low viscosity (2). Doogh production categorizes in to 3 methods; traditional method in which yogurt diluted with water and its fat separated with Churn. If fat yogurt has adjusted, Doogh can be produced through direct mixing of water and yogurt (3). Other methods includes fermentation on standardized milk such as dissolving adequate dry milk in order to reach considered total dry solid then let it ferment(4).

Caseins have been stabilized by repulsion force (5). Lowering pH decreases repulsion force among micelles thus they aggregate (6). Acid Lactic Bacteria produce acid, cause to create a lower pH close to Isoelctric pH of caseins, therefore produce curd (7). Acidic dairy beverages produce phase separation where precipitated phase contains protein and colloidal particles; supernatant phase contains water, lactose and mineral. Colloidal particles of Doogh are large particles so that precipitate base on Stock law and create sediment in Doogh. Other reason involving Doogh sediment is affinity of protein particles as a result of Vanderwals and hydrophobic forces where the particles close to each other and flocculate, then create sediment at last.

Other methods of preventing precipitation are increasing viscosity such as Caseins in milk by covering

particles through charged factors like pectin, improvement of processing conditions, water absorption enhancing agent in order to create affinity of water among Doogh's proteins (8). Using hydrocollioids in improving of texture and rheological properties has been growingly studying (9). Liquid Gel technique may consider as a method of stabilizing suspension and dispersion of solid particles. Primarily the mechanism of this method refers not to create gel network and producing a structure; behave like a gel in stasis and a flowing liquid in presence of shear stress. Creating gel liquids requires special hydrocolloids and applying shear force in cooling of solution. Liquid gel shows yield stress that must remove to exhibit a flowing liquid behavior. Gel like behavior leads to fix solid particles while its fluid like behavior is an option of using it beverage industries (10).

Production of initial gel, shaking it in next step leads to a disruption of network and creating particles producing liquid gels (11). In fact , there are 3 methods of producing liquid Gel by Gellan ; 1) heating gelatin up to 70-95 ˚C , cooling it under the Tem of setting gel and finally shaking it.,2) heating solution ,adding cool water which causes to cooling Gellan and production of liquid gel.;3)dissolving of gum in cool water ,adding ions and shake(i.e. adding ions resulting in gelling of Gellan solution in which shaking create liquid gel(12).The main target of present study is focusing on producing a Doogh with no phase separation problem by using Guar Gum and Hydrocolloids of Psyllium Husk through liquid gel technique.

Material and Methods

Doogh Produced in SHIMBAR Co , Shahrekord province of Iran .At first , yogurt prepared by adding starter culture (SACCO) to pasteurized milk . To produce Doogh , yogurt diluted with water , its dry solid measured base on National Iran standard N.O. 2453. Dry solid of Doogh adjusted by adding 0.7 % table salt (99.5 % purity) on 5 % w/w. Homogenization performed at 150 bars.

pH Measurement

pH meter (Germany) used to conduct pH measurement at 25 ˚C.

Density Measurement

Picnometer equipped with capillary tube used for measuring density at 20˚C by the following formula :

Equation 1 : $\rho \frac{S}{\quad}$

In which:
S: Picnomoter weight with sample (g)
A:the weight of empty picnometer
W:The weight of Picnometer with Distilled water (g)

Adding Hydrocolloids and producing Liquid Gel

Hydrocolloids including Xanthan, Guar and Psyllium purchased from SIGMA Co , and Hydrocolloids of Psyllium Husk purchased from Rooz Daru Co.

Extraction of Hydrocolloids of Psyllium

Psyllium husk can intake water 20 times more than its volume. At first we mix pysilluim husk with water by 1:20 ratio and heat to reach complete hydration in water bath, pass through bukhner funnel then we placed extracted hydrocolloids in oven at 40 ˚C for 17 hr to dry it and powdered it by domestic mill.

Adding Hydrocolloids to Doogh

At first hydrocolloids dissolved in ionized water, then different treatments hydrated at 80 ˚C for 20 min at water bath by shaking. Heated solution of hydrocolloids (0.01, 0.03, 0.05 % w/w) added to semi diluted and homogenized Doogh , shook till Tem reached to ambient Tem and finally placed at the refrigerator.

Investigation of Phase Separation

Samples poured in lab tubes and their phase separation observed at different times and the volume of phases reported (% v).

Flow Behaviour Experiment

Vicometer Brookfiled model ((DV_{III} Brookfield engineering, Middllton, USA) equipped with spindle VL_{II} and Reocale3.2 used to investigate rheological properties at 25±0.1˚C at water bath equipped with circulation system model TC 502.The affection of Guar Gum and psyllium on flow behavior of Doogh. Plots including Flow Vs Viscosity designed for different hydrocolloids concentration, the equation of shear rate and shear stresswith power and Bingham fitted as well.

Investigation of Microstructure

Scanning Electron Microscope (SEM) MODEL EM 3200 , KYKY CO , was used to investigate microstructure of control and samples containing 0.5 % hydrocolloids, the photos prepared by 1000, 2500 and 5000 Zoom .Picture analyzed by Image Analyzer software.All results analyzed by completely randomized design , ANOVA ,and DUNCAN test using SPSS software ver 20 and exvel 2007.

RESULTS AND DISCUSSION

Physical experiments

Table 1 shows the physiochemical properties of Doogh . All the samples prepared in a day due to affection of pH on hydrocolloids.

Table.1. Doogh characteristics used

pH	Density gr/cm^3	Salt (W/W %)	Total solid (W/W %)
4.7	1.016	0.7	**5**

Properties of Flowing Behaviour of Doogh

Regular Doogh which contains 5 % dry solid behaves like a Newtonian fluid at 20 ˚C (Fig 1), so that shear rate changes constantly in shear rate between 100-250, besides apparent viscosity followed a constant rate.

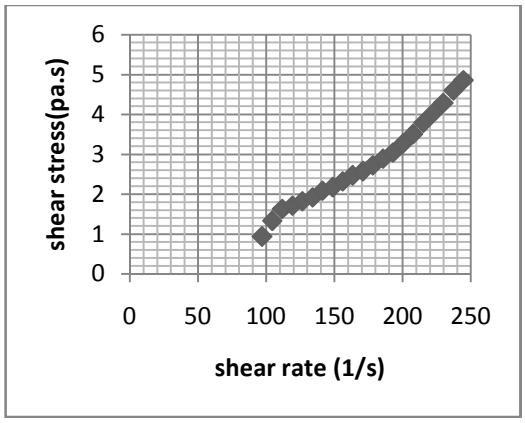

Figure.1. Flow curve of Doogh

The volume of protein particles is a critical factor in flow behaviour of Doogh in which more concentration cases to more interactions among particles, exhibits non Newtonian behaviour (13). Cross links among particles is the reason of non Newtonian behaviour .these connections disrupt in more shear rate resulting in a shear thinning behaviour in Doogh with high dry solid , thus dilution increases the gap between particles ,reduces cross links . The average of apparent viscosity was about 2 (m.pa), therefore it is thought that increasing dry solid decreases apparent viscosity ;however despite showing non Newtonian behaviour in Airan ,the same product named produced in Turkish, apparent viscosity found 10 times more Doogh(14).

Investigation of Hydrocolloids on the Fluid Behaviour of Doogh

In order to investigate hydrocolloids effect on fluid behaviour of Doogh equation related to shear rate and shear stress with power and Bingham model fitted (table 2 and 3).

Table.2. The calculated parameters of the power law model include the flow index and consistency index

Hydrocolloid	correlation coefficient	consistency index Pa.s^n	Flow index	concentration (W/W%)
_	91.2	0.85	1.18	0
Guar	87.66	4.14	0.99	0.01
	93.4	12.91	0.80	0.03
	97.7	15.53	0.77	0.05
Pysllium	95.06	0.46	1.33	0.01
	91	1.67	1.15	0.03
	90.13	3.61	1.04	0.05

Guar Affection

Guar causes to create a non Newtonian behaviour in Doogh , more apparent viscosity in low shear rate which subtracted b increasing shear rate . Regarding high apparent viscosity in lower shear rates thought that stability of 3 dimensional networks by hydrogen band in presence of this gum .This network creates a high consistency to solution and behave in way that exerting shear stress destroys it and decreases apparent viscosity (15). Increasing Guar concentration led to more apparent viscosity in lower shear rate (Figure 2).

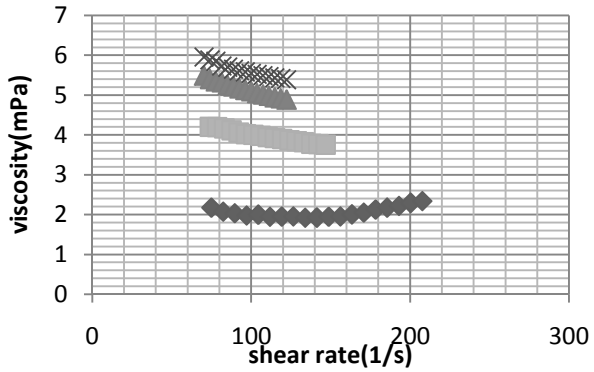

Figure. 2. The viscosity curves of samples containing different concentrations of guar (◆blank, ■0.01%, ▲0.03%, X 0.05%)

Increasing Guar Gum also changed fluid flow behaviour so that shear thinning enhanced and consistency coefficient increased (table 2).On the other side, increasing Guar gum concentration had no strong affection on more apparent viscosity or plastic viscosity of samples while large differences among samples in lower shear rate, therefore it can be concluded that Guar gum created yield stress and producing gel liquid like behaviour in more concentration of Guar. Increasing Guar concentration caused to produce more slope in plot .it indicates the intercept exhibiting the yield stress(Figure 3).

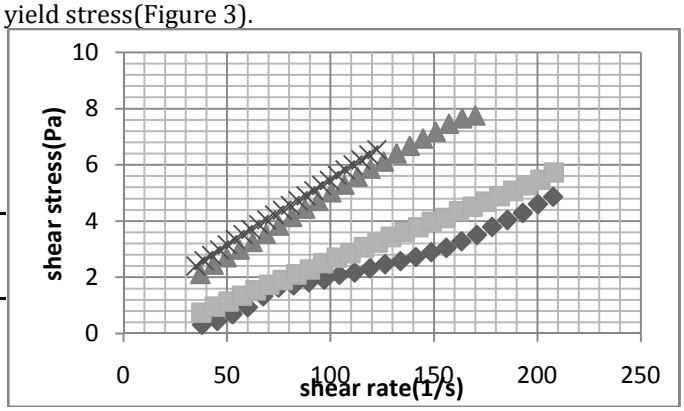

Figure. 3. The Flow curves of samples containing different concentrations of Guar (◆blank, ■0.01%, ▲0.03%, X 0.05%)

Psyllium Affection

Hydrocolloids of Psyllium create shear thinning behaviour in different way in comparison with Guar gum, no high viscosity at lower shear rates observed. It also subtracted flow index of Doogh and increasing of consistency coefficient with no plastic behaviour like Guar gum (Figure 4 and 5).

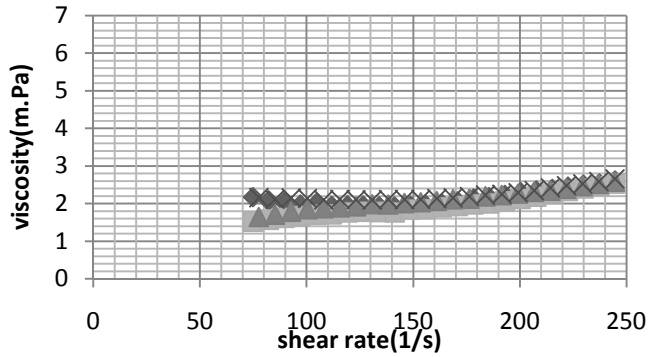

Figure.4. the viscosity curves of samples containing different concentrations of guar (◆blank, ■0.01%, ▲0.03%, X 0.05%).

These results indicated that pysllium gum has less affinity than Guar in providing 3 dimensional networks; less affection in consistency of Doogh .This hydrocolloids was not able to produce liquid gel body at 0.01 % and exhibit less yield stress than Guar in more concentration. This biopolymer has negative charge due to carboxyl group which improve the assumption of space repulsion of psyllium in stability of beverages (16).

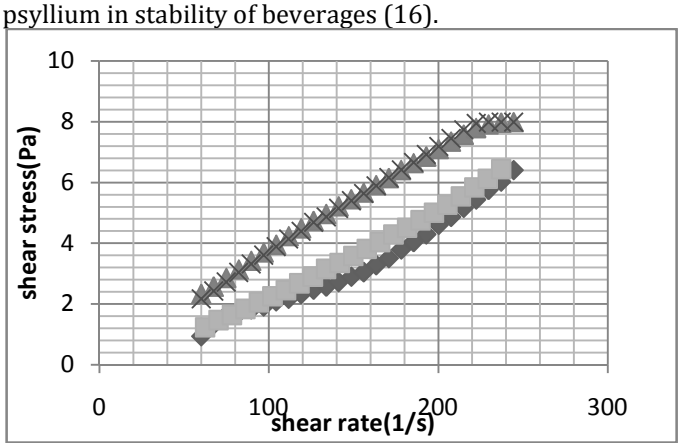

Figure.5. the Flow curves of samples containing different concentrations of guar (◆blank, ■0.01%, ▲0.03%, X 0.05%).

Investigation of Phase Separation

Phase separation can be categorized in two groups; in some cases observes as a clear supernatant and a dark phase under it, in fact no precipitation and sediment produced but a part of serum of Doogh separates from opaque part. This means that presence of hydrocolloids makes colloidal particles linked by hydrocolloids and hydrophobic connections resulting in decreasing of gap between them and occurrence of water removing, thus 3 dimensional networks from hydrocolloids and proteins is unable to keep serum and supernatant creates , no Sedimentation phase observed due to 3 dimensional networks . Increasing concentration has an important role in separated serum and reduces it. More volume of resulted supernatants in lower concentration is due to less interactions among particles of Doogh as a results of inadequate Hydrocolloids molecules (17).

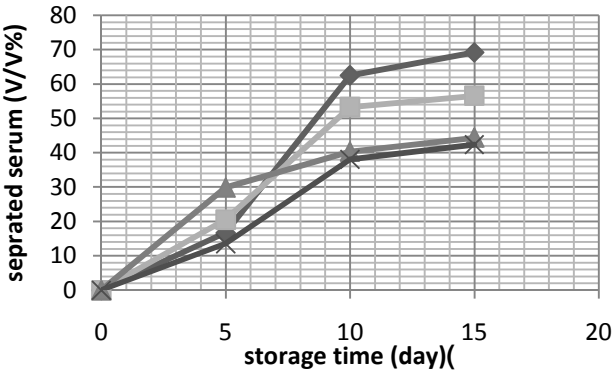

Figure.6.changes of separated serum in samples containing guar during time guar (◆blank, ■0.01%, ▲0.03%, X 0.05%)

In this study samples containing Guar gum exhibited these results which were in agreement with past researches (15). Synetic of phase separation of Doogh has been exhibited in Figure 6.

The second type, phase separation with no serum separation, in this case an opaque supernatant produced and a layer of colloids will create in the bottom due to their weight , it can be justified by Stock law. This means colloidal particles precipitate due to their high density respect to continuous phase and sedimentation occurs (15). In this study, solution containing psyllium hydrocolloids created stable sediment while in case of Guar , dark phase can flow, therefore it is thought to be inability of Psullium in creating 3 dimensional network in Doogh and no entrapment of its particle (Figure 7).

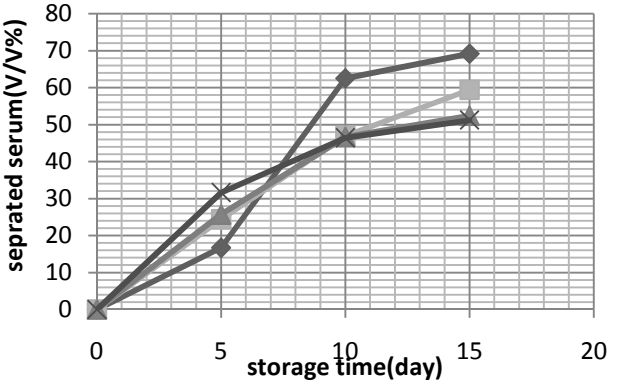

Figure.7.changes of separated serum in samples containing psyllium during time (◆blank, ■0.01%, 0.03%, X 0.05%)▲

Investigation of Structure

Doogh is produced by disruption of 3 dimensional networks of caseins in yogurt and its dilution (15). Microstructure of yogurt contains a large protein network composed of fat globule between Micelles of casein .More diluted sample, smaller Micelles create as a result less fat globules as crosslink factors of proteins (18). The size of regular particles of Doogh are 2-30 m ,however particles

between 1-100 m observed as well which is bigger in comparison with micelles of casein (D= 120 nm , L=50-600nm) , thus It is thought that why Doogh creates the same viscosity as milk with less half or 1/3 than dry solid of milk(15). Homogenization of Doogh leads to subtraction of particles size and it is important that caseins can replace on being fat globules in surrounding medium ad occurring colloids (composed of caseins) like behaviour (15). Overlap of particles of Doogh considers as reason of smooth microstructure of free hydrocolloid Doogh. Increasing Temperature of hydration denatures them and their affinity to aggregate, more hydrocolloids concentration resulting in more aggregation. Anionic hydrocolloids such as Gellan and Tetracagantin aggregate proteins through crosslink when pH of proteins is less than isoelectric (20).

Pectin slightly causes to aggregation but more homogenized texture than Gellan (15). Loucust bean gum entraps caseins; inhibit aggregation of casein micelles (19). Loucust bean gum entraps caseins; inhibit aggregation of casein micelles (19). This is the same about used hydrocolloids in present study (Figure 8), but the size of holes among particles was significantly difference (15).

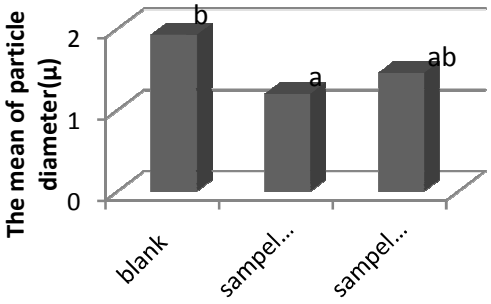

Figure 8. The mean of particle diameter in each sample

Sample containing Guar showed the less average of diameter in particles which is indicating more being homogenized than other samples. Samples containing Psyllium created larger particles as a result of colloidal particles to this hydrocolloid . There were exhibited some holes in samples which is not observed in control indicating the gap decreasing because of adding hydrocolloids (Figure 9,10,11)

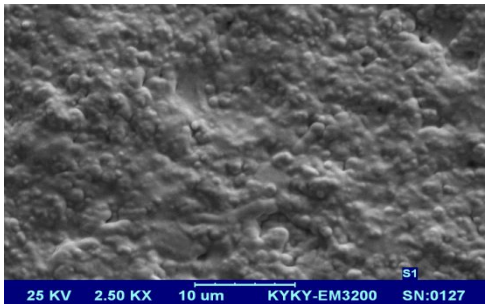

Figure.9. Blank sample.

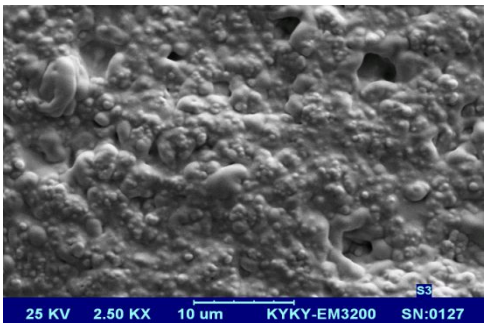

Figure.10. Samples containing guar.

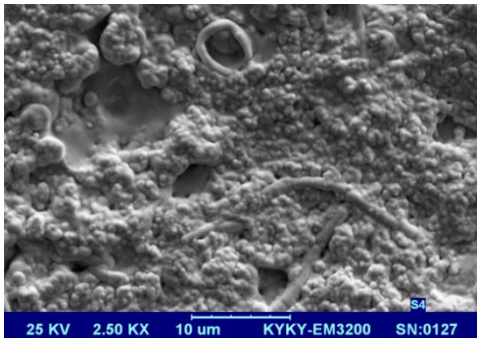

Fig.11. Samples containing psyllium

CONCLUSION

Colloidal particles in Doogh are pieces of protein which place in 3 dimensional network of gel, their interactions create non Newtonian behaviour .Regular Doogh exhibit a Newtonian behaviour because of its being dilution and complex structure ,f the composed particles. Guar which is a non absorbent molecule entrapping particles of proteins in a 3 dimensional network and increasing apparent viscosity in lower shear rates as well. Psyllium , a negative charge particle covering protein particles , leads to stability of Doogh .Unlike Guar , Psyllium showed no significant affection on viscosity.

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