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The Effects of Date Syrup and Gum Tragacanth on Physical and Rheological Properties of Date Milk Beverage

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Abstract: In the present study, the effects of adding different concentrations of date syrup (5, 10, 15, 20, 25% w/w) as a safe nutritious flavor and a replacement for sugar was scrutinized. To this end, three concentrations (0.1, 0.2, 0.3% w/w) of gum tragacanth exudates from *(AstragalusGossypinus)* as a thickening agents, increasing viscosity, giving desirable body and exceptional mouth feel and improving sensorial properties on rheological properties, particle size, color and sensory evaluation of date milk beverage were examined at 3°C. Shear stress versus shear rate data was successfully fitted into the Power Law model. It was observed that gum-free samples tend to show a Newtonian flow behavior, while all of the samples containing some percentage of gum were found to exhibit shear-thinning behavior. Sensory analysis was also performed with 50 semi-trained panelists, using a 5-point hedonic scale and, the sample with 0.2% *Astragalus Gossypinus* was selected as the most desired one by the panelists. Comparisons then were drawn between this sample, the gum-free sample which contained 10% date syrup and the commercial date milk beverage. Results suggested that the sample containing gum tragacanth from *Astragalus Gossypinus* species appears to have higher viscosity and smaller particles when compared to other samples.

Key words: Date Syrup · Date Milk Beverage · Gum Tragacanth · Rheology · Particle Size · Sensory Evaluation.

INTRODUCTION

Nowadays, in order to increase milk consumption among young and elderly people, food industries take advantage of various flavors such as chocolate, honey, strawberry and salep to modify milk taste and formulate different kinds of milk based beverages to produce more of healthy and popular products [1, 2]. Rich in calories and various vitamins and minerals, date (*Phoenix dactylifera* L.) is considered as a highly nutritious food product, which is a natural source of energy due to its high sugar content, constituting nearly 85% of its total solid. Moreover, it is rich in Potassium and extremely low in Sodium, making it a desirable food for hypertensive people who are advised to consume low sodium diets [3]. In the same line, date syrup (DS) is considered to have functional properties such as the ability to act as a sugar replacer. Most of the carbohydrates in dates are in the form of fructose and glucose, which are easily absorbed by the human body [3, 4]. Many years ago in south and southwestern of Iran DS was used by people as a natural and nutritional choice for milk flavoring and a safe alternative for added sugar. DS is used in preparation of some traditional and industrial food such as ice cream, confectionary, beverage, HalwaArdeh, yoghurt dessert [5-10].

Hydrocolloids can serve different purposes including liquid thickening, suspension of particles, increasing viscosity, giving desirable body and exceptional mouth feel, improving sensorial properties and enabling fiber

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addition for natural label beverages [11-15]. In this respect, gum tragacanth (GT) can be described as a complex, acidic, highly branched, heterogeneous polysaccharide which consists of two major fractions: tragacanthin (water-soluble) and bassorin (water-swellable) which have quite different rheological properties [16, 17]. Previous studies have provided evidence concerning the influence of gum tragacanth *(Astragalus Gossypinus)* on rheological properties of milk proteins in both model systems and real dairy beverages, stabilizing acidified dairy products and beverages like doogh, kashk and yoghurt [18-22]. In acidic dairy beverages, anionic hydrocolloids like pectin, λ-carrageenan, carboxyl methyl cellulose (CMC) and gum tragacanth interact with positively charged casein micelles and whey proteins [15, 23]. It is noteworthy that, at neutral pH, some proteins like κ-casein with positively charged regions or β-casein with hydrophobic groups bind (non- covalent) with the sulfated and hydrophobic groups of hydrocolloids [24].

Taking all the abovementioned facts into consideration, the present study intended to introduce a healthy and natural product. To this end, the influences of different concentrations (5, 10, 15, 20, 25% w/w) of date syrup as a safe, nutritious flavor and a replacement for sugar, concentrations of G.T (0.1, 0.2 and 0.3 % w/w) exudates from *Astragalus Gossypinus*(A.G), on steady shear rheological properties, particle size distribution, color and sensorial properties of date milk beverage (DMB) were studied. Rheological characterization of fluid is important for the design of unit operations, process optimization and high quality product assurance. From an engineering standpoint, the steady flow curve is the most valuable way to characterize the rheological behavior of fluids [25].

MATERIALS AND METHODS

Materials: Iranian gum tragacanthexudated by *Astragalus Gossypinus* was used in this study, collected from plants growing in different provinces of Iran. The raw gums were then grounded and sieved. Powdered gums with the mesh size between 200 and 500 microns were used in current experiment. Furthermore, standardized milk (2.5% fat) and date syrup (°Brix = 82, ρ = 1.35) were kindly provided by Pegah dairy factory (Tehran, Iran).

Sample Preparation: Primary samples were prepared by gentle mixing of the date syrup (5, 10, 15, 20 and 25% w/w), sugar (2%w/w) with milk in 100ml bottles.

The other samples were also readied by blending the date syrup (10%w/w), sugar (2%w/w) and gum tragacanth powder *(Astragalus Gossypinus* 0.1, 0.2 and 0.3% w/w) with milk in 100ml bottles. In the next stage, all of samples were preheated at 40°C, homogenized at 180 bar (APV 1000 lab homogenizer, Denmark), pasteurized in Ban Mari (75°C, min5), cooled at 10°C and stored at 3°C.

Rheological Measurements: Rheological measurements were performed by Physica MCR 301 rheometer (Anton paar GmbH, Graz, Austria) using a double concentric cylindergeometry with a radius ratio of 1.035 at 3°C. In order to ensure that the samples have identical shear histories, the solution was pre-sheared at a shear rate of 100 (1/s) for 30 seconds and left standing for 10 minutes to allow structure recovery and temperature equilibration. The temperature control was carried out by a peltier system equipped with fluid circulator. As for the experiments, the samples were covered with a solvent trap to prevent evaporation. The Power Law Model was utilized to describe the rheological properties of solutions over mid-range shear rates (1-50 s^{-1}). The flow behavior index (*n*) and consistency coefficient (*m*) values were obtained by fitting experimental data into the Ostwald model:

$$\tau = m^{\dot{\gamma}n}$$

where *m* is the consistency coefficient ($Pa.s^n$) and *n* is the flow behavior index (dimensionless) [25, 26].

Particle Size Analysis: The particle size distributions of samples were determined at room temperature with a laser diffraction particle size analyzer equipped with an accessory Hydro 2000S (A) (Malvern Mastersizer 2000 particle analyzer, Malvern Instruments Limited, UK). Size measurements were reported as the volume weighted mean diameter:

$$D_{(4,3)} = \Sigma n_i d_i^4 / \Sigma n_i d_i^3$$

Surface weighted mean diameter can be expressed as:

$$D_{(3,2)} = \Sigma n_i d_i^3 / \Sigma n_i d_i^2$$

where n_i is the number of particles with d_i diameter.

It is worth mentioning here that the distribution width, i.e. the Span is independent of the mean particle diameter, as indicated the following equation:

$$Span = \frac{d(0.9) - d(0.1)}{d(0.5)}$$

Absolute deviation from the median which is an indicative of polydispersity was also reported as uniformity. Where v_i is the volume of the number of particles existing between the two consecutive diameters:

$$U = \frac{1}{d(0.5)} \frac{\Sigma ivi \mid d(0.5) - di \mid}{\Sigma ivi} \quad [27]$$

Color Measurement: The L*, a* and b* values were determined for samples with a Color-Eye 7000A reflectance spectrophotometer. The instrument has d/8geometry with a 6 integrating sphere and a pulsed xenon lamp. Reflectance data were collected over the full wavelength range of the instruments (360–750 nm, 10-nm interval) with a specular component included through a SAV aperture size. The results were expressed in accordance with the CIELAB system with reference to illuminant D65 and a visual angle of 10°. In the CIE L* a* b* space, the symbols L*, a* and b* are used to represent three major qualities of color. In this regard, L* indicates lightness, for which a value of 100 represents a perfect white sample and 0 shows a perfect black. a* stands for the redness–greenness quality of the color, where positive values denote redness and negative values signify greenness. Similarly, b* symbolizes the yellowness and blueness quality of the colors, positive and negative values of which are representative of yellowness and blueness, respectively, as recommended by the International Commission on Illumination [28].

Sensory Evaluation: Sensory evaluation of samples was conducted by 50 panel members (n = 50; including 36 females and 14 males, aging from 22 to 37 yrs) of whom were graduate students of food science and technology, having an acceptable level of background knowledge on sensory evaluation of dairy and dairy-associated products. In addition, the laboratory, in which the experiments were carried out, was equipped with five separate tanks containing mineral drinking water, needed for the purpose of mouth rising between tests. Samples prepared with date syrup (10%w/w), sugar (2%w/w) and gum tragacanth powder *(Astragalusgossypinus* 0.1, 0.2 and 0.3% w/w) and milk were analyzed in terms of their appearance, color, odor, consistency, taste and overall acceptability. A 5-point hedonic scale was provided to the panelists, the scores of which ranged from 1=dislike to 5=like. The mean score for each attribute was calculated, so that comparisons could be made between the samples.

Statistical Analyses: The data reported in all of the tables were the means of triplicate observations. As for the statistical procedures, analysis of variance (ANOVA) was used for data analysis (SPSS, 16). When F-values were found to be significant ($P<0.05$) in ANOVA, Duncan's multiple range test was applied to compare the treatment means.

RESULTS AND DISCUSSION

Date Syrup Effects: Figure 1 illustrates the apparent viscosity of date milk beverages with different concentrations of date syrup. From the plot, it can be viewed that when DS concentration (%)increased from 5 to 25%, the viscosity also climbed in a linear manner. Accordingly, a clearly Newtonian behavior was observed with the DMB for all DS concentrations. Earlier studies had also shown that DMB shows a Newtonian flow behavior for most DS concentrations. It was indicated by the findings that augmenting the concentration of DS causes an increase of about (1.9)-fold in the apparent viscosity of the samples. In fact, the chemical composition of the date proves it as an important source of sugar (~81-88%, mainly fructose, glucose and sucrose) [4, 3]. Elsewhere, Matlouthi [29] concluded that sucrose concentrates affect their rheological properties. Likewise, Milani *et al.* [6] observed that any raise in date syrup concentration demonstrates a linear increase in viscosity of yogurt dessert.

Due to the considerable influence of the color of the products on consumer acceptance, the samples were examined in terms of their color quality. To this end, the average L*, a* and b* color data were calculated for each sample, as summarized in Table 1. As could be inferred from the data, increasing the concentration of DS in DMB resulted in a decrease in the L* values, i.e. the lightness of the products and the b* values which represent the yellowness, particularly. It was also observed that the positive a* values, indicating the degree of redness within the color space, correlate positively with the concentration of DS. Similar observations were found by Yanes [2], with regard to chocolate milk beverages with different formulates.

It could be viewed form both Figure 1 and Table 1 that the viscosity and color parameters for all of the samples of DMB are of the same range. Therefore, the sample with 10% DS can be regarded as the minimum amount with suitable quality. The L*, a* and b* values for in this sample have an optimum range in comparison with

Table 1: Color parameters for date milk beverage with different concentrations (5, 10, 15, 20, 25 %) of date syrup stored at 3°C

Date syrup conc. %	L^*	a^*	b^*
5	61.51^{a}	2.75^{e}	16.14^{c}
10	54.53^{b}	3.54^{d}	17.05^{a}
15	48.37^{c}	4.22^{c}	17.07^{a}
20	45.43^{d}	4.61^{b}	16.8^{b}
25	37.33^{e}	5.84^{a}	14.08^{d}

*a-e Means with different letters within the column differed significantly ($p<0.05$)

L*: lightness, a*: redness-greenness, b*: yellowness

Table 2: Parameters related to power law model (m: consistency coefficient, n: flow behavior index) for date milk beverage with different concentrations (0.1, 0.2, 0.3 %) of *Astragalus Gossypinus* that had been stored at 3°C

A.G conc. (%)	$m(Pa.s^n)$	n
0.1	0.012^{c}	0.92^{a}
0.2	0.036^{b}	0.83^{b}
0.3	0.095^{a}	0.76^{c}

*a-c Means with different letters within the column differed significantly ($p<0.05$)

the other samples. Yet another reason for this selection could be attributed to the fact that the date milk industries in Iran make use of 10% DS in their products.

The Effects of *Astragalus Gossypinus* Concentration: As also illustrated in Figure 2, the gum-free sample of DMB tended to show a Newtonian flow behavior. However, adding gum tragacanth to the DMB changed the flow behavior of the system to shear-thinning behavior. Similar results were reported by other authors for various dairy products. Telcioglu *et al.* [1] and Dugan *et al.* [30] investigated the rheological properties of salep drink and found out that the samples show shear-thinning behavior regardless of the sweeteners and milk type used for preparation of samples. Similarly, Koksoy *et al.* [31] observed that the viscosity of ayran samples decreases when shear rate is intensified. In fact, heightening the concentration of G.T. was found to cause an increase of about (10-19)-fold in apparent viscosity of the samples. Given the viscosity, however, the situation turned out to be different, since the value decreased about (3-4)-fold at higher shear rates. In the same line, the Power Law Model was closely applied to the flow curves of the DMB, the parameters of which were summarized in Table 2. As it can be seen, as the gum tragacanth concentration added up, the consistency coefficient value enlarged as well, while the flow behavior index showed a decreasing trend. The high capacity of A.G to increase the

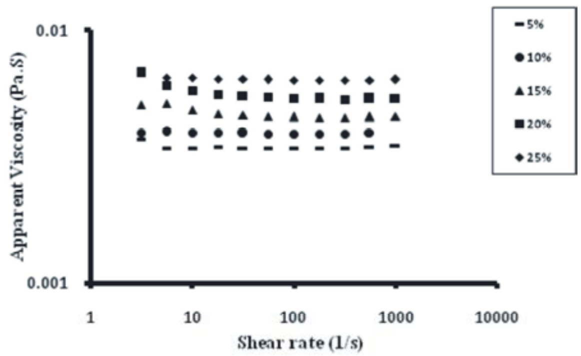

Fig. 1: Apparent viscosity of date milk beverage with (5, 10, 15, 20, 25%) date syrup stored at 3°C as a function of shear rate

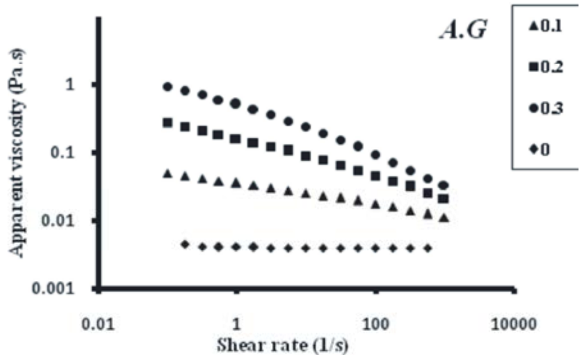

Fig. 2: Apparent viscosity of samples with different concentrations (0, 0.1, 0.2, 0.3%) of Astragalus gossypinus, stored at 3°C as a function of shear rate

consistency coefficient of the media in which it has been added might be related to the sugar composition of the A.G. It has been reported that A.G contains 1% of arabinose and 37% of galacturonic acid while A.R had arabinose and galacturonic acid contents of 51 and 9% respectively [32]. Earlier studies have shown that adding low concentrations of gum such as pectin, xanthan, guar, locust bean gum, gelatin and carrageenan to ensure the stability of acidified and non-acidified dairy drinks, increases the apparent viscosity and flow behavior of them [33-35]. In two of such studies, Ghorbani *et al.* [20] and Ghorban Shiroodi *et al.* [21] investigated the effects of different types of tragacanth on the stability of doogh and kashk and higher amounts of less found soluble part of A.G and found that these additions result in increasing the viscosity of the continuous phase and the water soluble component. They also came up with the conclusion that interaction of milk proteins and the mechanism of steric stability and preventing particles aggregation create a stable complex.

Table 3: Color parameters for date milk beverage with different concentrations (0.1, 0.2, 0.3%) of *Astragalus Gossypinus* stored at 3°C

A.G conc. (%)	L*	a*	b*
0.1	51.31[a]	3.06[a]	13.95[a]
0.2	47.54[b]	2.47[c]	11.24[b]
0.3	44.48[c]	2.99[b]	10.01[c]

*a-c Means with different letters within the column differed significantly ($p<0.05$)

L*: lightness, a*: redness-greenness, b*: yellowness

Table 4: Sensory evaluation for date milk beverage with different concentrations (0.1, 0.2, 0.3 %) of *Astragalus Gossypinus*

A.G conc. (%)	Appearance	Flavor	Odor	Consistency	Color	Overall
0.1	2.60[c]	3.72[a]	3.28[a]	3.32[c]	2.72[b]	3.12[c]
0.2	3.88[a]	3.41[b]	3.12[a]	3.92[a]	3.84[a]	3.63[a]
0.3	3.52[b]	3.45[b]	3.16[a]	3.66[b]	3.51[b]	3.46[b]

*a-c Means with different letters within the column differed significantly ($p<0.05$)

The average L*, a* and b* values of color data were summarized in Table 3. As given in the Table, addition of gum tragacanth to the DMB caused the L* values, i. e. the lightness of the product, to decrease particularly in the case of *A.G.* The same was true in the case of, the positive values of a* and b*, representing the degrees of redness and yellowness within the color space, respectively. However, the L*, a* and b* values were found to differ significantly for the DMB samples with 0.1, 0.2 and 0.3% of *A.G.* This might be attributed to the possible interactions between the polysaccharides of *A.G.* with the milk proteins of DMB, consequently resulting in the formation of complexes and greater particles. In fact, one may conclude that the size of the particles of the dispersions can affect the diffraction pattern. In other words, the smaller the diffraction object the wider the resulting diffraction pattern and vice versa. According to Fraunhofer diffraction theory [28], the intensity of the light scattered by particles is proportional to particle size. Gum concentration correlated with size parameters, consistency coefficient and color parameters. This gave way to the conclusion that gum and interaction of protein-polysaccharide can lead into the production of scattered light [2, 36].

Table 4 illustrates the average sensory evaluation results for the samples with different concentrations of *A.G.* in terms of their appearance, flavor, odor, consistency, color and overall preference. It was found that samples prepared with 0.2% *A.G.* receive the highest overall score among the samples. Hence, the comparison of viscoelastic properties of dairy beverages at low frequencies may provide a relative assessment of their sensorial characteristics. The results illustrated that the overall acceptance of samples containing *A.G.* has an inverse relationship with the particle size in case of high concentrations.

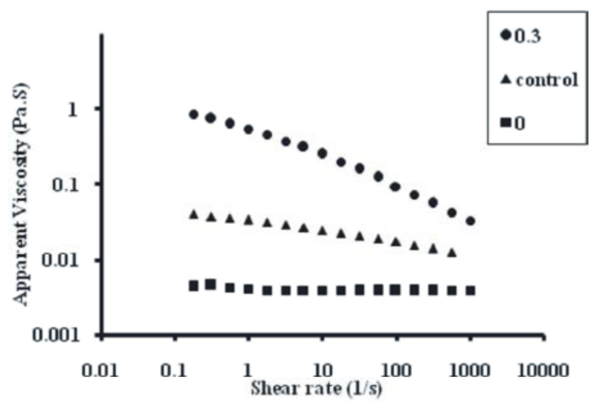

Fig. 3: Apparent viscosity of date milk beverage with 0.2% of Astragalus gossypinus, control date milk beverage (commercial date milk), and date milk beverage without gum as a function of shear rate that had been stored at 3°C

Rheological and Particle Size Measurements of Plain Milk and DMB: Comparing the results of the rheology as shown in Figure 3, one could observe that the control sample, commercial milk and date milk without tragacanth tend to show a similar flow behavior and the viscosity does not change with increasing shear rate. However, the viscosities of the control sample and the commercial milk, were greater in value when compared to that of the tragacanth-free DMB. While increasing the shear rate brought about a decrease in the viscosity of DMB with *A.G.,* the viscosity of this sample was proved to be reduced more significantly than the other samples. In addition, consistency coefficient value in the case of DMB containing *A.G* was found to be greater than the others, while the flow index is less comparatively speaking. This could be ascribed to the presence of insoluble part of the gum tragacanth, which is large and thus affected by the shear rate.

Table 5: Particle size (D[4,3]: volume weighted mean diameter, D[3,2]: Surface weighted mean diameter, Uniformity: absolute deviation from the median, Span: measure of the distribution width of particles in dispersion) for milk plain, date milk beverage without gum, date milk beverage with 0.2% of *Astragalus Gossypinus* and the controlled date milk beverage (commercial date milk) that had been stored at 3°C

Parameter	Milk plain	Date milk	Date milk 0.2AG	Date milk control
D[3,2]	2.552^{b}	1.346^{c}	2.508^{b}	15.615^{a}
D[4,3]	5.054^{d}	18.167^{c}	35.303^{b}	37.114^{a}
d[0.1]	1.35^{b}	0.0673^{c}	1.147^{b}	11.858^{a}
d[0.5]	3.442^{b}	1.460^{c}	3.118^{b}	34.461^{a}
d[0.9]	8.802^{d}	33.819^{c}	151.620^{a}	65.704^{b}
Span	2.165^{c}	22.706^{b}	48.256^{a}	1.562^{d}
Uniformity	0.859^{c}	11.8^{a}	10.7^{b}	0.477^{d}

*a-d Means with different letters within the raw differed significantly ($p<0.05$) [Unit of D = (μm)]

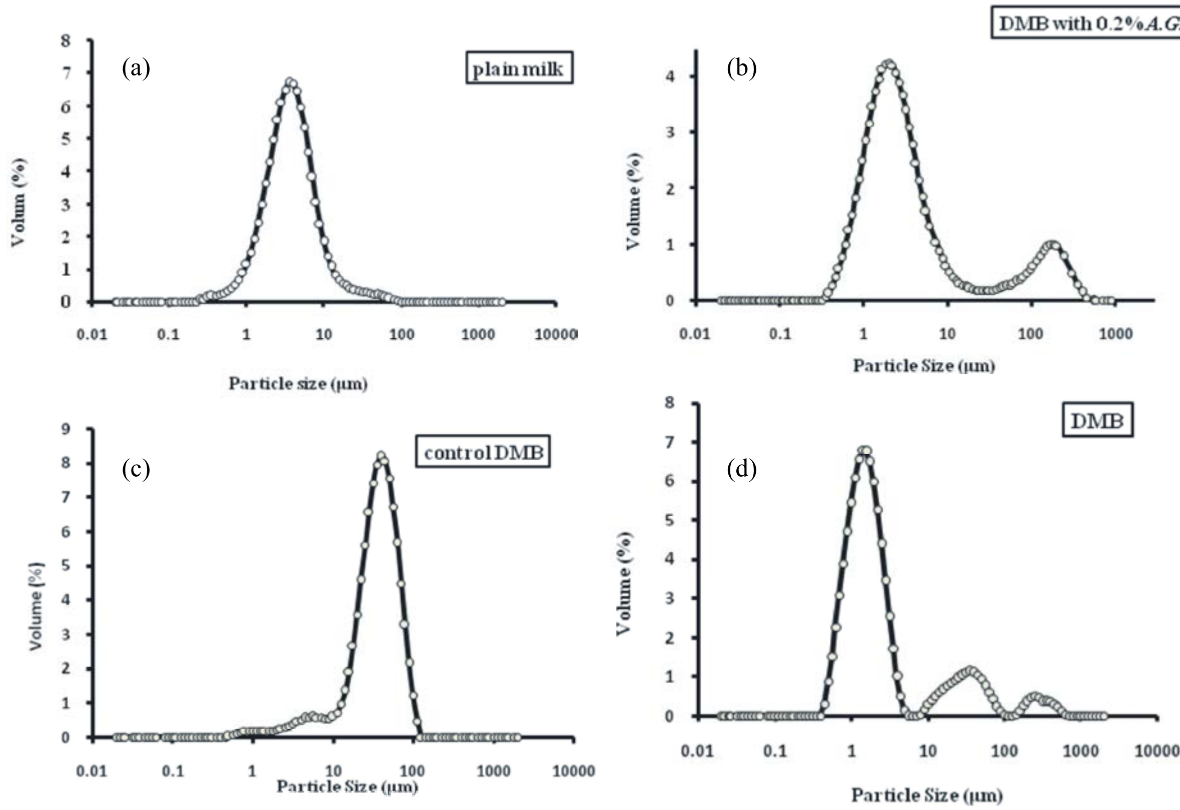

Fig. 4: Particle size for plain milk (a), date milk beverage with 0.2% of Astragalus gossypinus (b), controlled date milk beverage (commercial date milk) (c), and the date milk beverage without gum (d) that had been stored at 3°C

As represented in Figure 4 and Table 5, addition of date syrup to the plain milk is proved to change the size distribution from mono modal to multimodal. Indeed, the particle size distribution of the gum-free DMB indicated that there are three distinct particle size ranges in the sample, i.e. (0.3-10μm), (10-100μm) and (100-1000μm). It seemed that this latter range (100-1000μm) is related to pulp residues, insoluble polysaccharides and cellulosic sub stances of date syrup. In a similar vein, addition of 0.2 % *A.G.* to the DMB ledinto a drastic decrease in the volume percentage of the particles within the range of 10-100μm, a slight increase within the range of 100-1000μm, as well as a decrease in the uniformity and span values of the DMB, indicating that the polydispersity of the system has been lowered when 0.2% *A.G.* was added. It was also observable that increasing *A.G.* concentration from 0 to 0.2% heightens the values of d(0.5), d(0.9), D[3, 2] and D[4, 3]. In line with this are the findings obtained by Huang *et al*. [37] that increasing the concentration of different gums such as xanthan, Arabic gum, pectin, guar, carrageenan and fenugreek enlarges the value particle size parameters. These variations in particle size parameters could probably be accounted for by the absorption of *A.G.*polysaccharides into the casein micelles of milk. Elsewhere, Tijssen *et al.* [38] found similar results indicating that addition of carrageenan to milk drink increases the polydispersity of the system with increasing gum concentration might be a possible evidence for slight flocculation. If only absorption occurred, an increase in size polydispersity would not be observed. Although adding gum tragacanth to DMB increases polydispersity of the system, homogenization process would change the system towards monodispersity. The particle size distribution of commercial DMB indicated a mono modal plot which was formulated for guar gum, carrageenan, monostearat glycerol and distearat glycerol with the particle size of the sample being in the range of (10-100) µm with uniformity value of 0.47 and span of 1.5. These values were drastically lower than uniformity and span values of DMB containing gum tragacanth which has been homogenized in pilot plant while the commercial DMB has undergone the industrial homogenization process.

CONCLUSION

In the present study the effects of different concentrations (5, 10, 15, 20 and 25 % w/w) of date syrup on rheological properties and colorimeteric assay of date milk beverage were investigated. The viscosity and color parameters of the sample with 10% date syrup appeared to be at the optimal conditions. Three concentrations (0.1, 0.2 and 0.3 % w/w) of gum tragacanth *(Astragalus Gossypinus)* as a natural gum were used to formulate date milk beverage in order to create a desirable body, texture and mouth feel. The results indicated that viscoelastic properties, flow behavior parameters and color parameters (L*, a*, b*) are significantly affected by concentration of the gum tragacanth. According to the findings, the samples had a shear thinning behavior and Power Law Model described their flow behavior. Furthermore, sensory evaluation results suggested the sample containing 0.2% of *AstragalusGossypinus* is the most accepted sample.

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