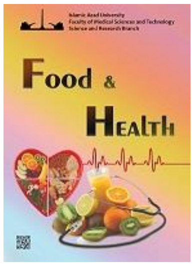
Food & Health 2021, 4(3): 24-27



Food & Health Journal
Journal homepage: fh.srbiau.ac.ir

Physicochemical, sensory, and rheological properties of beverages prepared from soy protein isolate and Persian gum enriched with jujube extract

Zahra Khoshdouni Farahani [1*]

[1] Department of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran

ARTICLE INFO

Original Article

Article history:
Received 06 April 2021
Revised 11 June 2021
Accepted 18 August 2021
Available online 20 September 2021

Keywords:
Persian gum
Soy protein isolated
Jujube extract
Beverage
Functional food

ABSTRACT

Soy beverages are widely used in the world, but due to the unpleasant taste and smell, they need to be combined with fruit juices, plant extracts, and fruits. Therefore, jujube extract which is rich in phenolic and antioxidant compounds was used in this work. On the other hand, Persian gum is considered a native gum and stabilizes the beverage. So, soy protein isolates and Persian gum-based functional beverage enriched with jujube extract was investigated in this study. The formulations were evaluated with ratios of 1% and 3% of Persian gum and with ratios of 1.5% and 3% of soy protein isolate. The evaluation included pH, Brix, turbidity, sedimentation, viscosity, and sensory properties. The outcomes showed that the highest viscosity was related to D beverage containing the highest amount of soy protein and Persian gum and also, a vice versa relation between the spindle round and viscosity was observed and so that increasing the speed to 100 rpm led to a decrease in viscosity. Moreover, the highest pH and turbidity were seen in the D beverage and this had the lowest amount of sedimentation after the C beverage. The effect of different amounts of Persian gum and soy protein on sensory evaluation was quite evident and the best features were observed in C beverage.

1. Introduction

The demand for people to enjoy a variety of foods with good nutritional value and taste that have plant and natural resources is growing in many parts of the world. One of these products is a soy protein-based beverage that can be flavored with a variety of extracts and juices (1). In 1999, the US Food and Drug Administration stated that a daily intake of at least 6.5 grams of soy protein could reduce the risk of cardiovascular disease (2). Recent studies showed that consuming soy protein isolate can protect the body against various types of cancer through different mechanisms (3). Sales of soy beverages have more than doubled since 2000, and soy beverages with extracts and juices have become an important market with annual sales of more than $100 million (4). One of the major problems in the production of some beverages is that they become biphasic over time, which is due to low viscosity, low pH, and their effect on protein sediment (5, 6, 7). Most researchers recommend the addition of stabilizers or hydrocolloid compounds as a solution to prevent beverages from becoming two-phase (8). Persian gum is found in abundance in Iran and is secreted from the trunk and branches of the almond tree (*Amygdalus scoparia Spach*). This hydrocolloid is composed of insoluble (70%) and soluble (30%) parts (9). Persian gum is a transparent gum and produces sticky solutions with high viscosity in water and has medicinal, industrial, and food applications (10). Today, fruit consumption has increased due to its health effects. These substances are rich in polyphenolic and antioxidant compounds and are anti-mutagenic, anti-carcinogenic, and anti-oxidative stress. Jujube fruit is rich in these compounds and is used as a medicinal compound and belongs to the *Rhamnaceae* family. Jujube fruit is used as an analgesic, antihypertensive, anti-diabetic, cardiotonic, antioxidant, and wound healing. The high content of total phenolic compounds in it as well as its pleasant and strong smell and taste have led to the use of its extract for various applications (11). A large share of the food products market is related to beverages. Beverages fortified with plant proteins and phenolic extracts of fruits can be introduced as new functional food products. Therefore, it is very important to

*Corresponding author: Department of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran
E-mail address: z.farahani69@yahoo.com (Zahra Khoshdouni Farahani).

produce soy beverages with good taste, and it is also important to use suitable gum to improve the texture of the beverage and the stability of the ingredients in it. There are several studies about such beverages which point to the importance of proteins and the functional ingredients within them. In one study, the characteristics of soy protein beverages containing oranges and white grapes were examined. The results showed a positive effect of fruits used in the beverages on the evaluated properties (4). In another study, the possibility of using Persian gum to stabilize the syrup in the presence of different amounts of basil seeds was investigated and the results showed the effectiveness of Persian gum for stabilization (12). However, despite increasing consumer acceptance and consumption of soy beverages, the industry is still facing challenges. Soy milk and other soy beverages are often characterized by their bean flavor and unsuitable mouth feel. Therefore, it seems necessary to change the formulation of soy beverages to improve their taste in order to increase the consumption of soy. Soy beverage with juice and extracts is a new type of soy product and a good way to get regular soy protein from your diet. The aim of this study was to investigate the physicochemical, sensory, and rheological properties of beverages containing soy protein isolate and Persian gum enriched with jujube extract, with the ability to be accepted by the consumer.

2. Materials and methods

The chemicals used to include hydroxide sodium and phenolphthalein reagent were prepared by the German (Merck company). Equipment used include mill (IKA, M20), oven (Wiseven), vacuum rotary evaporator (Heidolph, Laborota 4003, Germany), shaker (Heidolph, UNIMAX 2010), digital pH meter (Heidolph, Germany), refractometer (ATAGO, Japan), Turbidimeter (2100AN Laboratory Turbidimeter, Hach, USA), Brookfield viscometer (DV-II^{+}-RV, Brookfield Engineering Laboratories, INC., USA) and centrifuge (Sigma, 3-18k**).** Persian gum was purchased from an Esfahan company. Soy protein isolate was purchased from Shandong Yuxin Bio-Tech Co., Ltd (non-GMO), China. Jujube fruits were supplied by the local market of medicinal plants (Bojnourd, Khorasan Razavi, Iran)**.**

2.1. Aqueous extract of jujube fruit

Jujube fruits were dried at room temperature and then dried in an oven at 40 °C. Jujube powder blended with distilled water and shaken at 37 °C (180 rpm). A centrifuge device was used to separate the extract from plant remains and concentrated by a rotary evaporator (Heidolph, Laborota 4003, Germany) (11, 13, 14).

2.2. Preparation of beverages

Physicochemical properties (pH, Brix, turbidity, and sedimentation) of beverages during storage and also, sensory properties and viscosity were investigated. The functional beverage was produced by sugar (5%) (Merk, Germany), citric acid (0.1%) (Merk, Germany), water, SPI, Persian gum, and Jujube extract. This study was done on four samples which can be seen in Table 1. The formulated beverages were kept in glass bottles for two weeks at 4 °C and the evaluation was performed on the first, seventh, and fourteenth day.

Table 1. Beverage formulation.

Ingredients	Treatment names			
	A	**B**	**C**	**D**
Jujube extract (10%)	7%	7%	7%	7%
Water	89.99%	87.99%	87.49%	85.49%
SPI (3%)	1.5%	1.5%	3%	3%
Persian gum (4%)	1%	3%	1%	3%
Sugar	5%	5%	5%	5%
Citric acid	0.1%	0.1%	0.1%	0.1%

2.3. Beverage experiments

2.3.1.pH measurement

A digital pH meter (Heidolph, Germany) was used to measure the pH of samples which was calibrated with Buffer 4 and 7 (15).

2.3.2.Measurement of water-soluble solids (Brix)

Read the concentration of water-soluble solids (20 °C) based on drops of the samples on the refractometer prism (ATAGO, Japan).

2.3.3.Turbidity measurement

The turbidity of beverages was investigated by Turbidimeter (2100AN Laboratory Turbidimeter, Hach, USA) and was calculated in NTU units.

2.3.4.Viscosity measurement

The measuring of the apparent viscosity of beverages was done by a Brookfield viscometer (DV-II^{+}-RV, Brookfield Engineering Laboratories, INC., USA) by spindle No.1 (speeds 30, 60, 100 rpm) (16).

2.3.5.Stability and sedimentation

To measure the phase separation of the beverage and the stability of the product, 20 grams of each sample was poured into graduated plastic tubes with a lid and stored at constant conditions at 4 °C. The two-phase rate of the samples was determined by separating the supernatant phase by Pasteur pipette and weighing it and expressing it based on a percentage of the total weight of the sample. The samples were stored in the refrigerator for 2 weeks and tested (17).

2.4. Sensory evaluation

Sensory properties of the beverages (aroma, color, texture, taste and overall acceptance) were evaluated by using a 5-point hedonic scale (15, 18).

2.5. Statistical analysis

SPSS 26 (SPSS Inc., Chicago, IL, USA) statistics software was used for statistical analysis of the results and those are expressed as mean ± SD which were the result of three repetitions. Duncan's multiple range test was carried out for mean analysis.

3. Result and discussion

3.1. The pH changes during storage

The changing of pH during storage was seen in Table 2. The pH of all beverages has decreased over time. Almost, there was a significant difference between the treatments. The highest pH belonged to D beverage (3.21) and the lowest pH related to A beverage (3.06) on the first day of storage. Similarly, the highest and lowest pH was observed in the mentioned beverages on day 14, which were 3.18 and 2.92, respectively. Increasing the amount of hydrocolloids in beverages can lead to an increase in pH (19, 20). About changing the pH of the samples with more protein, it can be said that this is related to the effect of protein on the medium. In research, the addition of paste and puree could affect the pH content of functional beverages which was reported by Aamer and El-Kholy (21). Increasing the protein concentration leads to the accumulation of more hydrophobic bonds and disulfide bridges, which reduces the solubility of the protein and provides the basis for slight incremental changes of pH (4). On the other hand, the pH of soy protein is higher than the pH range (pH=3) in the treatments, so as the amount of protein in the treatment increases, the pH will also increase.

Table 2. The changes of pH content of beverages during storage.

Days	Treatment names			
	A	B	C	D
1	3.06 ± 0.01^{d}	3.13 ± 0.03^{c}	3.17 ± 0.03^{abc}	3.21 ± 0.04^{a*}
7	2.94 ± 0.01^{e}	3.07 ± 0.03^{d}	3.15 ± 0.05^{bc}	3.20 ± 0.02^{ab}
14	2.92 ± 0.02^{e}	3.06 ± 0.04^{d}	3.13 ± 0.02^{c}	3.18 ± 0.04^{abc}

* Different letters indicate statistically significant differences at p<0.05.

3.2. The water-soluble solids content (Brix) of beverages

According to Table 3, the Brix of the beverages was constant over time and there was no significant difference between days but there was a significant difference between treatments.

Table 3. The changes of Brix of beverages during storage.

Days	Treatment names			
	A	B	C	D
1	3.9 ± 0.08^{d}	4.2 ± 0.02^{c}	4.5 ± 0.04^{b}	4.7 ± 0.03^{a}
7	3.9 ± 0.05^{d}	4.2 ± 0.07^{c}	4.5 ± 0.08^{b}	4.7 ± 0.09^{a}
14	3.9 ± 0.04^{d}	4.2 ± 0.09^{c}	4.5 ± 0.07^{b}	4.7 ± 0.02^{a}

* Different letters indicate statistically significant differences at p<0.05.

The highest and the lowest Brix content were seen in D beverage (4.7) and in A beverage (3.9). An increasing trend of Brix was observed from A to D beverages, which can be due to the increase in SPI content in the samples. This trend was seen in a similar study, which was reported by Rostam Miri et al. (4). In other research, Lotfian et al. (22) depicted the effective performance of Brix on viscosity behavior and consistency of beverages.

3.3. Turbidity measurement

The turbidity measurement (NTU) of beverages during storage was seen in Table 4. The turbidity content decreased in all treatments during storage. The highest turbidity content was related to D beverage (339 NTU) and the lowest ones belonged to A beverage (171 NTU) in the first day. Similarly, the highest and lowest turbidity was observed in the mentioned samples on day 14, which were 282 and 121 NTU, respectively, which is because the presence of more gum and protein in the D beverage can be due to the accumulation of double helixes and trapping of particles in this structure (23, 24). An increasing trend of turbidity was observed from A to D beverages, which can be due to an increase in the amount of solids (the content of SPI and hydrocolloid) in the beverages. Persian gum was used to stabilize the beverages and its greatest impact was observed only in the first days. In the following days, the compounds in the beverages tended to settle due to instability and finally, the turbidity decreased during storage. Also, the increasing of SPI can cause seeing more turbid in beverages which could be due to increase in the number of intermolecular bonds between Persian gum, water particles, soy protein, and the entrapment of compounds in the gel network. Some studies confirmed that the existence of hydrocolloids and proteins in beverages can change turbidity (23, 24).

Table 4. The changes of turbidity of beverages during storage.

Days	Treatment names			
	A	B	C	D
1	171 ± 0.11^{k}	231 ± 0.15^{e}	256 ± 0.06^{d}	339 ± 0.05^{a}
7	150 ± 0.10^{l}	207 ± 0.09^{g}	228 ± 0.10^{f}	310 ± 0.08^{b}
14	121 ± 0.02^{m}	185 ± 0.07^{j}	202 ± 0.12^{h}	282 ± 0.14^{c}

* Different letters indicate statistically significant differences at p<0.05.

3.4. Sedimentation measurement

Sedimentation measurement (%) of beverage during storage showed in Table 5. The sedimentation increased in all samples during storage. The highest sedimentation was in A beverage (90%) and the lowest one was in C beverage (85%) on the first day. Similarly, the highest and lowest sedimentation was seen in the mentioned samples on day 14, which were 98% and 97%, respectively, which could be due to the higher amount of soluble solids in C and D treatments (the amount of gum and soy protein) and also according to the outcomes, the effect of 1% Persian gum on the stability and prevention of sedimentation was more than 3% gum, which led to less sedimentation (23, 24). Gorjian and Raftani Amiri (25) reported that the stability increased with increasing gum concentration. The interaction between proteins and polysaccharides plays an important role in the structure and further stabilization of food processes (26). Hydrocolloids are usually added to protein products because of their ability to bind to hydroxyl groups in water (27).

Table 5. The changes of sedimentation during storage.

Days	Treatment names			
	A	B	C	D
1	90.00 ± 0.05[h]	88.30 ± 0.02[j]	85.00 ± 0.11[l]	86.70 ± 0.03[k]
7	96.70 ± 0.04[d]	95.00 ± 0.08[e]	91.70 ± 0.05[g]	93.30 ± 0.04[f]
14	98.00 ± 0.07[a]	97.30 ± 0.06[b]	97.00 ± 0.12[c]	97.30 ± 0.09[b]

* Different letters indicate statistically significant differences at $p<0.05$.

3.5. The effect of different formulations on viscosity

Table 6 depicted the viscosity of different formulations of beverages. There was a significant difference between beverages ($p<0.05$). The highest and the lowest viscosity values were seen in D beverage (9.60 cp) and A beverage (9 cp) (rotation: 30 rpm). The beverages that contain higher soluble solids (Persian gum and SPI) have higher viscosity which can be seen in D and B beverages. This may be related to the interaction of these compounds with the medium and together. Hydrocolloids like Persian gum can cause stability, texture changing, texture thickening, etc. (28, 29), and proteins can make structural linkages with other compounds, so some studies explained that these characteristics can be related to the effect of hydrophobic groups (in the protein) (30).

Table 6. The effect of different formulations on viscosity (cp).

Rotational speed	Treatment names			
	A	B	C	D
1	9 ± 0.12[c]	9.30 ± 0.02[b]	9.10 ± 0.05[c]	9.60 ± 0.05[a]
7	7 ± 0.15[f]	7.25 ± 0.03[de]	7.17 ± 0.03[e]	7.33 ± 0.07[d]
14	3 ± 0.11[k]	4.33 ± 0.06[h]	4 ± 0.14[j]	4.67 ± 0.03[g]

* Different letters indicate statistically significant differences at $p<0.05$.

Opposite charges in proteins and hydrocolloids (alginate and Persian gum) can cause to form a stable network and more viscosity changing. The protein content is an important factor that affects the viscosity of beverages (31). Since SPI content is more in D and B beverages (3%), the most viscosity was seen in them. So, the addition of a higher concentration of Persian gum and SPI can change the viscosity (32, 33). Increasing the amount of gum increases the water binding capacity and reduces the flow rate, and creates a stronger network (34). Table 7 showed that there was a reverse relation between viscosity and rotation and different cycles of 30, 60, and 100 rpm caused to show a significant difference between the viscosity of the treatments (increasing speed led to the decreased viscosity). The opening of links between structural units can be one of the reasons. By increasing the shear rate, the molecular lattice bands break in the polysaccharide structure and lead to a decrease in viscosity (35). Since Persian gum is an ion-absorbing hydrocolloid, it can bind to charged protein surfaces and increase viscosity through interactions between polysaccharide and protein chains, and the higher the content of this gum leads to greater impact (36, 37). The presence of more hydrochloride in the samples can increase the viscosity because the hydrocolloid can bond with water in the samples (25). Beirami Serizkani et al. (38) was investigated the effect of Persian gum and an enzyme on the properties of kefir drink. The outcomes showed an increase in viscosity by Persian gum. Other research has shown that polysaccharides and hydrocolloids can increase the apparent viscosity of some beverages.

3.6. Sensory Evaluation

The amounts of ingredients in beverages affect the changes in the score of sensory properties (Table 7). Appearance, texture, color, aroma, and taste scores in most of the beverages were different. The highest score of appearance, color, and aroma belonged to C, B, C beverages, respectively. The highest score of texture was related to both B and C and about the taste was the same as the texture. Finally, the most overall acceptability was seen in C beverage. Aamer and El-Kholy (21) explained the addition of puree and paste to some proteins can enhance the overall acceptability of beverages. It is stated that the presence of gum (tragacanth) in beverages (doogh) can improve some sensory properties (39). Behbahani and Abbasi (12) stated that the addition of Persian gum can make the beverages more desirable by the consumer in some treatments.

Table 7. Examination of sensory characteristics of beverages.

Beverages types	Sensory characteristics					
	Appearance	Color	Texture	Aroma	Taste	Overall acceptability
A	2.8 ± 0.10[c]	2.8 ± 0.10[c]	2.8 ± 0.10[c]	2.8 ± 0.10[c]	2 ± 0.20[d]	2 ± 0.10[d]
B	3.8 ± 0.10[b]	4.8 ± 0.10[a]	3.8 ± 0.15[b]	3.8 ± 0.10[b]	3 ± 0.20[c]	3 ± 0.10[c]
C	4.8 ± 0.10[a]	4.6 ± 0.10[a]	3.8 ± 0.10[b]	4.8 ± 0.10[a]	3 ± 0.10[c]	3.8 ± 0.10[b]
D	2± 0.10[d]	2.8 ± 0.10[c]	2.8 ± 0.10[c]	2.8 ± 0.10[c]	2 ± 0.20[d]	2 ± 0.10[d]

4. Conclusion

Soy beverages are known as a favorite beverage and enriching it with a fruit extract (Jujube extract) can cover its unpleasant taste since in various sources and studies, the bean flavor and taste of this drink alone has been proven. The use of Persian gum (as a native gum) was also considered evaluating its effectiveness in stabilizing beverage compounds. The novel soy beverage showed suitable physicochemical and sensory properties. C beverage containing depicted the highest overall acceptability score. The amounts SPI and Persian gum could effect on different properties of beverages. D beverage had most viscosity, pH and turbidity. Also, the sedimentation of C beverage was lowest and Brix of all treatments was constant. In general, due to the nutraceutical value of beverages, these compounds could present suitable properties and Jujube extract improve the taste and flavor of the beverage.

References

1. Mohammadi SO, Abbasi SO, Hamidi ZO. Effects of hydrocolloids on physical stability, rheological and sensory properties of milk–orange juice mixture. *Iranian Journal of Nutrition Sciences & Food Technology*. 2011;15;5(4).
2. Food labeling: Health Claims; soy protein and coronary heart disease. *Food and Drug Administration*. 1999 Oct 26;21.
3. Badger TM, Ronis MJ, Simmen RC, Simmen FA. Soy protein isolate and protection against cancer. *Journal of the American College of Nutrition*. 2005;24(2):146S-9S.
4. Rostam Miry L, Saeidi Asl MR, Safari R. Characteristics and storability of soy drinks prepared from orange, white grape and soy protein hydrolysate by alcalase. *Journal of Innovation in Food Science and Technology*. 2019;11(1):1-9.
5. Koksoy A, Kilic M. Use of hydrocolloids in textural stabilization of a yoghurt drink, Ayran. *Food Hydrocolloids*. 2004;18(4):593-600.
6. De Kruif CG, Tuinier R. Polysaccharide protein interactions. *Food Hydrocolloids*. 2001;15(4-6):555-63.
7. Foroughinia S. Investigation of the efficiency of some mechanical factors and hydrocolloids on the stabilization of Iranian Doogh [Dissertation]. Tehran: Tarbiat Modares University, Faculty of Agriculture. 2006.
8. Sejersen MT, Salomonsen T, Ipsen R, Clark R, Rolin C, Engelsen SB. Zeta potential of pectin-stabilised casein aggregates in acidified milk drinks. *International Dairy Journal*. 2007;17(4):302-7.
9. Fadavi G, Mohammadifar MA, Zargarran A, Mortazavian AM, Komeili R. Composition and physicochemical properties of Zedo gum exudates from *Amygdalus scoparia*. Carbohydrate polymers. 2014 Jan 30;101:1074-80.
10. Abbasi S, Rahimi S. Introduction of an unknown local plant gum: Persian gum. Flour and Food Industry Magazine. 2007;4:42-51.
11. Farahani ZK, Mousavi MA. The effect of extraction conditions using ultrasonic and maceration methods on the extraction rate of phenolic compounds and the extraction efficiency of jujube fruit (Ziziphus spp.). *Applied Biology*, 2021; 11(41).
12. Behbahani M, Abbasi S. Stabilization of Flixweed (*Descurainia sophia* L.) syrup using native hydrocolloids. *Iranian Journal of Nutrition Sciences & Food Technology*. 2014;9(1):31-8.
13. Khoshdouni Farahani Z, Khoshdouni Farahani F. Chemical identification of clove (*Syzygium aromaticum*) extract and essential oil. *Applied Biology*. 2017;7(27):1-7.
14. Farahani, Z. The effect of extraction method (ultrasonic, maceration and soxhlet) and solvent type on the extraction rate of phenolic compounds and extraction efficiency of *Arctium lappa* L. roots and *Polygonum aviculare* L. grass. , 2021; 4(2): 28-34.
15. Farahani ZK, Farahani FK, Yousefi M, Nateghi L. Comparison of different commercial cheese characteristics in Iran. *European Journal of Experimental Biology*. 2013;3(3):257-60.
16. Mitschka P. Simple conversion of Brookfield RVT readings into viscosity functions. *Rheologica Acta*. 1982;21(2):207-9.
17. Arianfar A, Zohourian P. Effect of pectin on the stabilization of sorrel syrup. *Innovation in Food Science and Technology*. 2019;11(1): 109-13.
18. Khoshdouni Farahani Z. Physicochemical, textural and sensorial properties of cocoa sponge cake formulated with xanthan gum during shelf-life. Journal of Food and Bioprocess Engineering. 2021 Apr 17. https://doi.org/10.22059/jfabe.2021.319703.1087.
19. Lucey JA, Tamehana M, Singh H, Munro PA. Stability of model acid milk beverage: effect of pectin concentration, storage temperature and milk heat treatment. *Journal of Texture Studies*. 1999;30(3):305-18.
20. Tabibloghmany FS, Ehsandoost E. Investigation of Linseed (*Linum usitatissimum* L.) gum effects on rheological properties, and sensory quality of tomato ketchup during storage. *International Journal of Agriculture and Crop Sciences* (IJACS). 2013;6(2):70-66.
21. Aamer R, El-Kholy W. Production of functional beverages from whey and permeate containing kumquat fruit. *Alexandria Journal of Food Science and Technology*. 2017;14(1):41-56.
22. Lotfian F, Karami M, Moeini S. Functional protein beverage with milk and egg white: physical properties, formulation, protein contents and amino acids components. *Journal of Food and Bioprocess Engineering*. 2019;2(1):49-54.
23. Liang C, Hu X, Ni Y, Wu J, Chen F, Liao X. Effect of hydrocolloids on pulp sediment, white sediment, turbidity and viscosity of reconstituted carrot juice. *Food Hydrocolloids*. 2006;20(8):1190-7.
24. Udomsup T. Effect of xanthan gum and carboxymethyl cellulose concentration on quality of cloudy mangosteen juice. In Proceedings of the Kesetsart University Annual Conference 2011;7: 43-50.
25. Gorjian, H., Raftani Amiri, Z. Effect of cress seed mucilage on stabilization and rheological properties of non- fat doogh. *Journal of Food Research*. 2019; 29(3):145-56.
26. Hasanpour F, Hoseini E, Motalebi AA, Darvish F. Effects of Soy protein concentrate and Xanthan gum on physical properties of Silver carp (*Hypophthalmichthys molitrix*) surimi. *Iranian Journal of Fisheries Sciences*. 2012;11(3):518-30.
27. Uresti RM, López-Arias N, Ramirez JA, Vazquez M. Effect of amidated low methoxyl pectin on the mechanical properties and colour attributes of fish mince. *Food Technology and Biotechnology*. 2003;41(2):131-6.
28. Chen L, Subirade M. Alginate–whey protein granular microspheres as oral delivery vehicles for bioactive compounds. *Biomaterials*. 2006;27(26):4646-54.
29. Zhang Z, Zhang R, Zou L, McClements DJ. Protein encapsulation in alginate hydrogel beads: Effect of pH on microgel stability, protein retention and protein release. *Food Hydrocolloids*. 2016;58:308-15.
30. Van der Plancken I, Van Loey A, Hendrickx ME. Changes in sulfhydryl content of egg white proteins due to heat and pressure treatment. *Journal of Agricultural and Food Chemistry*. 2005;53(14):5726-33.
31. Katsiari MC, Voutsinas LP, Kondyli E. Manufacture of yoghurt from stored frozen sheep's milk. *Food Chemistry*. 2002;77(4):413-20.
32. Prakash S, Huppertz T, Karvchuk O, Deeth H. Ultra-high-temperature processing of chocolate flavoured milk. *Journal of Food Engineering*. 2010;96(2):179-84.
33. Vahid-Moghadam F, Fadaei V, Pourahmad R. The effect of the different concentrations of wheat fiber and gelatin on selected physicochemical, textural and sensory properties of fat-free concentrated flavored yogurt. *International Journal of Biology and Biotechnology*. 2013;10(4):637-43.
34. Abbasi S, Rahimi S. Influence of concentration, temperature, pH, and rotational speed on the flow behavior of Iranian gum (Katira) solution. *Journal of Food Science and Technology*. 2006;2(4):29-42.
35. Castellani O, Al-Assaf S, Axelos M, Phillips GO, Anton M. Hydrocolloids with emulsifying capacity. Part 2–Adsorption properties at the n-hexadecane–Water interface. *Food Hydrocolloids*. 2010;24(2-3):121-30.
36. Abbasi S, Mohammadi S. Stabilization of milk–orange juice mixture using Persian gum: Efficiency and mechanism. *Food Bioscience*. 2013;2:53-60.
37. Khanniri E, Yousefi M, Khorshidian N, Sohrabvandi S, Mortazavian AM. Development of an efficient stabiliser mixture for physical stability of nonfat unfizzy doogh. *International Journal of Dairy Technology*. 2019;72(1):8-14.
38. Beirami-Serizkani F, Hojjati M, Jooyandeh H. The effect of microbial transglutaminase enzyme and Persian gum on the characteristics of traditional kefir drink. *International Dairy Journal*. 2021;112:104843.
39. Azarikia F, Abbasi S. On the stabilization mechanism of Doogh (Iranian yoghurt drink) by gum tragacanth. *Food Hydrocolloids*. 2010;24(4):358-63.