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Processing, Standardization and Quality Evaluation of Edible Gel

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Abstract: This study deals with processing of edible gel using hydrocolloids and sucrose and/or fructose. Carrageenan, xanthan, pectin or their mixture were used to process different types of gels. Influence of hydrocolloid concentration, temperature and pH were studied and the pH ranged were 3.8 to 4.3 based on the type of hydrocolloids. Strength, texture and gelling temperature were influenced by type of hydrocolloids and other solutes. Carrageenan formed firm and brittle gel where as xanthan formed soft and flexible gel. The gels became more opaque as gelling agent concentrations increased. Gels containing 1:1 ratio of the two hydrocolloids were considered the most palatable. The breaking strength was decreased by reducing the concentration of hydrocolloids but this had an adverse effect on gel syneresis. Addition of xanthan gum made a kappa carrageenan gel softer, more cohesive and more elastic. The gelling temperatures of solutions generally increased due to the addition of sucrose, except when both cation and sucrose concentrations were high. Addition of fructose up to 35% (w/v) had no effect on the gelling temperatures. In practice it was not possible to use carrageenan or xanthan with sugar content higher than 45%. Incorporation of fructose and sucrose resulted in a marked increase in the gel clarity. At low cation concentrations, sucrose strengthened the gels; but at high cation concentrations, sucrose weakened the gels. In all cases, gels formed by rapid cooled in cold water were clearer than the corresponding gels cooled slowly in air. From microbial test it was observed that there was no formation of bacterial colony. No remarkable change in color, flavor and taste were observed at room temperature up to 7 months.

Key words: Processing · Evaluation · Edible · Gel · Standardizatio · Gelling agent

INTRODUCTION

A gel is a colloidal system in which a network of particles spans the volume of a liquid medium [1]. Although gels mainly are composed of liquids and thus exhibit densities similar to liquids, gels have the structural coherence of solids due to the network of particles that spans the liquid medium. For this reason, gels generally appear to be solid, jelly-like materials [2-3]. Gels that can be eaten are referred to herein as "edible gel compositions". The product is shelf-stable without refrigeration, i.e., it will not physically degrade, such as by syneresis, at room temperature. The popular class of edible gel comprises fruit particles such as oranges, pears, cherries, grapes, peaches and the like distributed in the gel. Edible gel generally appeals to consumers because of their sweet taste. Because edible gel products found in the marketplace typically are sweetened with sucrose. The sweetener composition may be added to the edible gel composition as a coating, as a frosting, as a glaze, or as a matrix blend i.e. added as an ingredient to the edible gel mix prior to the preparation of the edible gel composition [4]. It is common to prepare edible gels having, in addition to a gelling agent, a sweetener, a food acid, a salt of the acid, a buffering system, one or more flavor additives, one or more color additives and a bulking agent. Other components commonly used in gel formation also may be used. For example, sequestrants (e. g., EDTA) may be used to control the rate of gel formation and cross-linking agents e. g., ionic compounds such as salts of Ca^{2+}, Mg^{2+} and Na^{+} may be used to control gel strength [5]. Gelling agents that may be used in the edible gel mixes and edible gels include gelatin, algin (alginate), carrageenan, xanthan, gellan gum, pectins, konjac, agar, locust bean gum, food acids, rennet, starch and mixtures thereof [6-7]. In addition, some of the edible gels may be formed by exposure to heat. In water based gels, a preferred gelling agent is gelatin.

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Lower-calorie, fruit-gel products using gelling agents independent of sugar levels can be prepared with or without added sweeteners [8]. The sugar content of the fruit alone might be sufficient to produce an acceptably sweet product. Adding crystalline fructose, a 50/50 crystalline fructose/sucrose blend or HFCS 90 in small quantities slightly increases sweetness, as they are all sweeter than an equivalent weight of sucrose. This will raise calories according to the solids added. Fructose will soften the gel somewhat. Benzoates, sorbates (which are more active against molds at pH up to 5.0) and parabens, or methyl and propyl paramethoxybenzoates, are permitted by FDA in the fruit products at levels not to exceed 0.10%. Antioxidants also are permitted in gels to prevent oxygen-induced discoloration and off-flavors. Vitamin C can be used as an immediate reducing agent, although secondary reactions can lead to browning reactions. Gel formation dependents upon a variety of factors including, calcium ion concentration, brix concentration, protein content, temperature, pH, total acidity and time. Those skilled in the art of gel formation will readily appreciate the appropriate conditions for gel formation [9]. Generally, the pH of the edible gels may be between about 2 and about 7, depending upon the particular type of gel [4]. The flavor profile affects the acid choice. Citric acid works well for most gels. Citric or acetic acids can be selected for their individual taste impacts in tomato gels. The resulting anion as well as the acidity level affects finished-product taste [10-11].

MATERIALS AND METHODS

The experiment was conducted collaboratively in the laboratory of "Department of Food Technology and Rural Industries "Bangladesh agricultural University, Mymensingh and in the laboratory of "Department of Microbiology and hygiene" Bangladesh agricultural University, Mymensingh. Xanthan, pectin (high-methyl pectin), high fructose corn syrup (HFCS), Sodium citrate (tri-sodium citrate), potassium citrate were supplied by Pran-Rfl Group. Bangladesh. Carrageenan and food grade sucrose, Lychee flavor was supplied by Prof. Dr. M. Burhan Uddin, Department of Food Technology and Rural Industries, BAU. Phenolphthalein indicator, methylene blue indicator, 45% neutral lead acetate solution, 22% potassium oxalate solution, 0.1N NaOH, citric acid, Potassium sorbate, sodium benzoate, malic acid supplied by Department of Food Technology and Rural Industries, BAU. About 0.0.02g kg^{-1} of the strawberry flavor mix was added to all the gels.

Gel Preparation: Gels were prepared by mixing the gelling agent, citrate with cold water and then, dissolving it at 80°C in a water bath. This was combined with the sucrose/glucose syrup, which had previously been heated in a water bath until all the sucrose was dissolved. The mixture was maintained at 80°C for 15 min and constant stirring occurred throughout to ensure complete dissolution of solutes. At this stage citric acid and benzoate was added and heating continued at 80°C for a further 2 min. Finally, the flavor mixture was introduced and stirring continued for 1 min to ensure equal distribution of the volatile compounds. The mixture was then filled in the can and the fruit particle was added at this stage. The can (plastic container) was immediately sealed and allowed to cool to water at ambient temperature. Pectin gel was prepared in a similar manner, except that 5 g of the sucrose was mixed with the pectin and sodium citrate before being dissolved in water. Also, a temperature of 85°C was achieved while preparing the pectin gels and this temperature was maintained until the final stage, when the solution was cooled to ambient temperature before the flavor mixture was added.

Chemical Analysis of Gel: The physical and physico-chemical properties and chemical and biochemical composition was analyzed and the parameters assessed were moisture, pH, total soluble solids (TSS), acidity, sugar. Moisture was determined by AOAC [12], pH was determined by Covenin [13], sugar waas determined by Lane and Eynon [14] and TSS, acidity was determined by Ranganna [15].

Microbial Assessment: For microbial assessment Total Viable Count (TVC) and yeast and mold count were determined by the method described APHA [16].

Sensory Evaluation: A panel of 10 assessors participated in this study. A preliminary training session was held during which the panel developed common vocabulary to evaluate the sensory characteristics of the gels and agreed upon assessing four attributes flavor (evaluated by smelling), taste, color (all evaluated during consumption) and overall acceptability by a scoring rate on a 9 point hedonic scale. Hedonic scale used: 9=like extremely, 8=Like very much, 7=Like moderately, 6=Like slighty, 5=Neither like nor dislike, 4=Dislike slighty, 3=Dislike moderately, 2=Dislike very much and 1=Dislike extremely. The preference differences were evaluated by statistical analysis of the data for variance and consequently Duncan's Multiple Range Test (DMRT).

Table 1: Chemical composition of gels

	Parameters						
Product type	Moisture (%)	TSS (%)	pH	Acidity (%)	Reducing sugar (%)	Non- reducing sugar (%)	Total sugar (%)
S_1	62.5	37.5	3.82	0.16	10.45	24.85	35.3
S_2	63.5	36.8	3.87	0.14	9.75	26.45	36.2
S_3	60.25	39.8	3.97	0.12	10.09	27.41	37.5
S_4	64.18	35.8	4.2	0.11	11.15	22.95	34.1
S_5	61.62	38.5	4.3	0.11	10.95	25.55	36.5

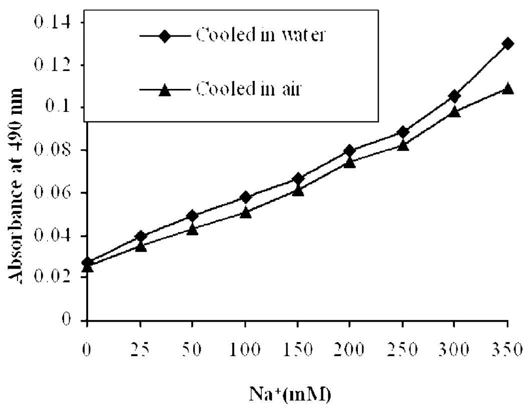

Fig. 1: Absorbance at 490 nm of 0.9% carrageenan gel containing sodium and 33% sucrose

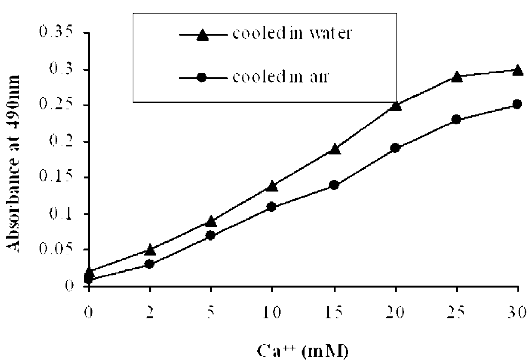

Fig. 2: Absorbance at 490 nm of gel containing 0.9% carrageenan and 33% sucrose

Storage Studies: The gel was processed, packaged and stored for 5 months. The changes of pH, TSS, moisture, acidity, reducing sugar, non-reducing sugar and total sugar were observed at an interval of 30 days under room temperature (25-30°C) during the storage period.

RESULTS AND DISSCUSSION

Composition of Edible Gels: The edible gels were prepared using different gelling agents. The gels were kept for microbiological and storage studies. The compositions of edible gels such as moisture, TSS, pH, acidity, reducing sugar, non-reducing sugar and total sugar have been shown in Table 1.

Influence of Sucrose or Fructose on Gel Clarity: Adding sucrose or fructose increased gel clarity, as indicated by lower absorbance at 490 nm. As cation concentration increased, the effect of sugar on gel clarity was more dramatic (Fig. 1 and 2). Without sugars, the gels became less clear when Ca^{2+} or Na^{+} concentration was increased. At the presence of sucrose, the gel clarity initially decreased with increasing Ca^{2+} or Na^{+} concentration, but increased with excessive cation concentrations. Light absorbance at 490 nm increased with increasing gelling agent (carrageenan or xanthan gum) concentration. That is, the gels became more opaque as gelling agent concentrations increased. In all cases, the gels cooled rapidly in cold water are clearer than the corresponding gels cooled slowly in air. The effect of fructose on gel clarity was similar to sucrose.

Influence of Sucrose on Gel Texture: Sucrose exhibits a stabilizing effect on formation and packing of carrageenan or xanthan double helices in as similar manner as cations. Excessive sucrose also hinders the aggregation of carrageenan or xanthan double helices and reduces the size of the junction zones. This was confirmed by Fiszman and Duran [17] that both resistance to rupture and firmness of 1% alginate gels were improved by the addition of sucrose up to 40%, but additional sucrose beyond 40% reduced the firmness of the gels. When the calcium concentration was smaller than stoichiometric concentration to neutralize the negative charges in the carrageenan on xanthan chains, adding sucrose should stabilize double helices. Therefore, gel strength increased with increasing sucrose concentration. On the other hand, at high calcium concentrations the amount of calcium was more than adequate to stabilize the double helices and the excess calcium hindered the aggregation of double helices. In such situations adding sucrose could only hinder the growth of junction zones. Therefore, with excess calcium concentrations, gel strength decreased with increasing sucrose concentrations.

Table 2: Mean Sensory score of gel of different samples

	Sensory attributes			
Product type	Color	Flavor	Taste	Overall acceptability
S_1	8.700[a]	8.000[a]	7.800[a]	7.700[a]
S_2	8.100[ab]	8.100[a]	7.400[a]	7.600[ab]
S_3	8.100[ab]	8.100[a]	7.400[a]	7.400[ab]
S_4	7.400[b]	6.900[ab]	6.900[a]	7.200[ab]
S_5	6.300[C]	6.600[b]	5.600[b]	6.100[b]
LSD	0.7739	1.145	1.192	1.395

Means with same letter within a column are not significantly different at $p<0.05$.

Influence of Sugars on Gelling Temperatures: Sucrose can be readily crystallized in aqueous solutions under proper conditions. In the crystal structure, the hydroxyl groups of sucrose form intramolecular and intermolecular hydrogen bonds [18]. In concentrated aqueous solutions, sucrose molecules tend to be packed in an orderly fashion. Sucrose is a disaccharide containing glucose and fructose residues. Carrageenan or xanthan molecules also contain glucose residues. The glucose units in carrageenan or xanthan chains may replace the glucose units of sucrose molecules in the ordered sucrose molecular packing. Thus orderly packed sucrose molecules may have a stabilizing effect on the orderly packed carrageenan or xanthan double helix in aqueous solutions. The stabilizing effect of sucrose on the ordered conformation of gellan gum was reported by Papageorgiou [19]. As a result, increasing sucrose content of carrageenan or xanthan gels generally resulted in a higher gelling temperature.

Sensory Evaluation of Edible Gels: It may be mentioned here that a two-way analysis of variance (ANOVA) was carried out and the results revealed that there was significant ($p<0.05$) differences in color acceptability among the samples S_1, S_2, S_3, S_4 and S_5.The analysis of variance of score points for color of the formulations showed the calculated F-value (3.507) was greater than the tabulated value (2.642). This indicates the color of the samples were not equally acceptable. Similarly, for flavor, taste and overall acceptability, the calculated F-values ($p<0.05$) were found greater than the tabulated value, i.e. the samples were not equally acceptable.

The DMRT test revealed that the color of the sample S_1 was most preferred and securing the highest mean (8.700) and significantly different than other samples. There was no significant difference in color preference of the samples S_2 and S_3. In case of flavor preference, the DMRT test revealed S_2 and S_3 were most preferred equally and securing highest mean (8.10). The sample S_5 secured lowest mean (6.60) and significantly differed from the other samples.

The result showed (Table 2) that samples S_1, S_2 and S_3 were equally acceptable. On the other hand, for taste, from the view of 10 panelists, the S_1 was the most preferred. The DMRT test revealed the highest score (secured 7.80) and significantly differed ($p<0.05$) from the other samples. The mean scores of S_1,S_2,S_3 and S_4 ranges from 7.80 to 6.90,which indicate there was no significant differences statistically but S_1 was more preferred comparing to others. The sample S5 was comparatively less acceptable and secured 5.60 score. At last, the overall acceptability, from the view of 10 panelists, the S_1 was the most preferred. The DMRT test revealed the highest score (secured 7.80) and significantly differed ($p<0.05$) from the other samples. The mean scores of S2, S_3 and S_4 ranges from 7.60 to 7.20, which indicate there were no significant differences statistically. S_1 was more preferred comparing to others. The sample S_5 was comparatively less acceptable and secured 6.10 score (Table 2).

Storage Effect on the Analysis of Gels: The gels were stored for a period of six months after packaging.the formulations were S_1, S_2, S_3, S_4 and S_5, which were examined at an interval of 30 days during the storage period. No remarkable changes were found in chemical compositions and sensory attributes.

Microbiological Studies of Processed Gels

Total Viable Count: The plates were inverted and placed in an incubator for 48 hours operated at 38°C. The total viable count was done at the interval of one month up to seven months. But there was no formation of any bacterial colony in the petridishes in any one of the intervals.

Yeast and Mold Count: The plates were inverted and placed in an incubator for 48 hours operated at 38°C. The total viable count was done at the interval of one month up to seven months. But there was no formation of any colony in the petridishes in any one of the intervals.

CONCLUSION

The increasing demand for food products with sugar content challenges the food industry to develop healthy products without affecting texture and sensory properties. Gels and gel networks play an important role in the texture of foods and as such they remain a challenge to food technologists. Adding fructose up to 35%w/v to 0.6 and 1.0% hydrocolloids solutions exhibited little effect on the gelling temperatures. The addition of 10% increment of sucrose increased the gelling temperatures by 1.5-3°C. Adding sucrose or fructose increased gel clarity by reducing the differences in refractive index between polymer and the medium, i.e. by reducing the optical contrast between gel and the surrounding environment. The potassium sorbate decreases the potential for molding. Sodium benzoate and potassium sorbate decrease the growth of yeast. Calcium ions increase the rigidity of a carrageenan gel, the effect being most pronounced when potassium ions are added as well.

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