Gels of carrageenan from different origin fall on a master curve

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ABSTRACT

Breaking and gel strength measuring of gels prepared with carrageenan from different origin revealed that the carrageenan types fall into two groups, one group has a soft and elastic texture, and the other shows a firm and brittle texture. Actually, if forming a gel, the distance to break and gel strength of carrageenan samples fall on a sort of master curve, independent of origin, molecular weight and counter ions. Gels are either firm and brittle or soft and elastic, nothing in-between.

INTRODUCTION

Carrageenan extracted from seaweed is widely used to form gels in various food products. Often kappa carrageenan is used to prepare gels that are firm and brittle, whereas iota carrageenan is used to generate softer gels.

In the food industry a texture analyzer is often used for characterizing the texture of gels. Typically a probe is penetrated into a gel cast in a container[1,2]. This set-up allows measuring gels that are not self-supporting or very brittle. This study analyses gels prepared with carrageenan from different origin, viz. Spinosum, Cottonii, Chondrus and Gigartina. Carrageenan is manufactured with different molecular weight (Mw), carrying different counter ions[3]. Gel properties in two different standardized systems were determined using texture analyzer. Water gels with 1% carrageenan in deionized water, and milk gels with 0.3% carrageenan in a dessert formulation prepared from UHT milk and sugar.

MATERIALS AND METHOD

Carrageenan from different origin, with different Mw and counter ions used in the study are listed in Table 1. Samples are experimental samples produced at CP Kelco.

1% carrageenan in deionized water:

Moisten 6.0 g carrageenan with 10 g IPA 100%, add ~600 g cold (5°C) deionized water while stirring with a whisk, heat to boiling and allow to boil for 1 min, weigh up to 600 g and pour into bloom glasses equipped with tape to allow filling to ~1 cm above the brim. Leave the gels at 5°C for 2½-3 h. Cut the top of the gel with a cheese cutter and measure gel properties on TAXT (see below).

0.3% carrageenan in milk gel system:

Dry blend 2.4 g carrageenan with 45 g sugar and add to 750 g UHT-milk (1.5% milk fat) while stirring on a magnetic stirrer. Heat to 80°C and keep stirring for 10 min, adjust to 800 g with deionized water and stir thoroughly with a rubber spatula, pour into bloom glasses equipped with tape to allow filling ~1 cm above the brim. Leave the gels at 5°C for 2½-3 h. Cut the top of the gel with a cheese cutter and measure gel properties on TAXT (see below).

Texture analyzer method:

A texture analyzer, TAXT, load cell 5 kg (Stable Micro Systems, Godalming, UK) is used for characterizing the gels, trigger force is set at 2.5 g. Gel strength (GS) is defined as the force (g) at 2 mm, breaking strength (BS) is defined as the force (g) at rupture, breaking distance (BD) is defined as the distance in mm at rupture, see Fig. 1.

Water gels: Pre-test speed 0.5 mm/s, test speed 0.5 mm/s, distance 30 mm, plunger P/1R.

Milk gels: Pre-test speed 1.0 mm/s, test speed 1.0 mm/s, distance 24 mm, plunger P/1R.

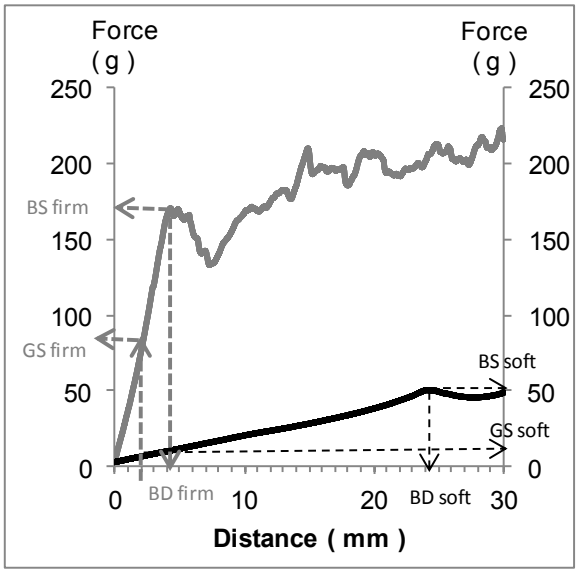

Figure 1. Typical texture analyzer curve for soft and elastic (black) or firm and brittle (grey) water gels prepared with 1% carrageenan. Force (g) vs distance (mm). GS = force at 2 mm, BS (g) and BD (mm) are read at rupture as indicated on the curves.

RESULTS

Gelation of carrageenan in deionized water is not always successful. When looking at the properties of the gels prepared from different carrageenan origin, it is seen that they fall into groups. Some carrageenan gels are soft (low GS) and elastic (high BD), others are firm (high GS) but then they are brittle (low BD).

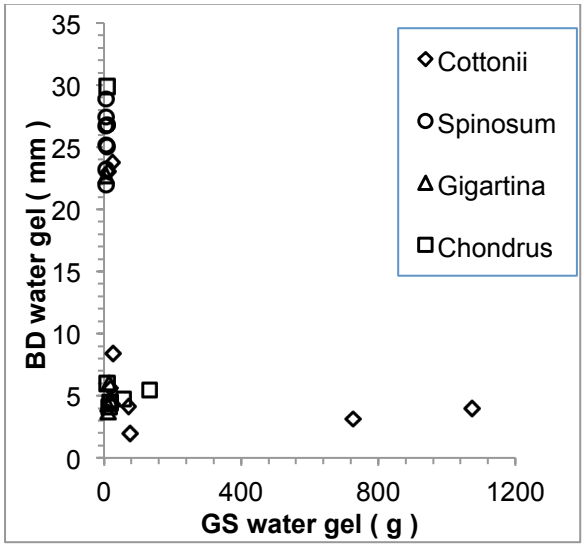

Figure 2. BD vs GS for water gels prepared with 1% carrageenan from different origin, see legend.

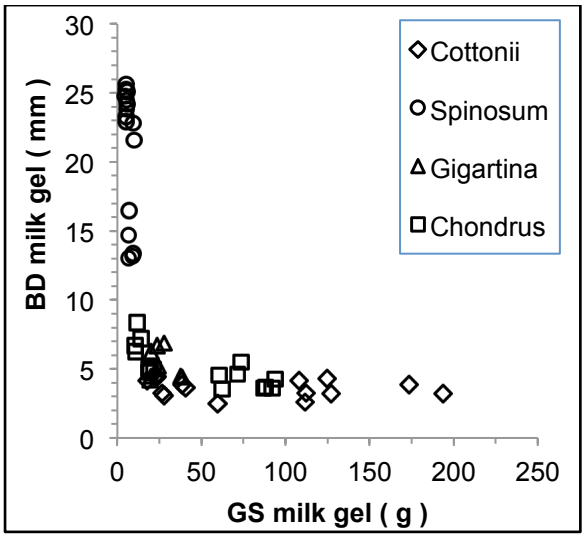

Figure 3. BD vs GS for milk gels prepared with 0.3% carrageenan from different origin, see legend.

Although only few carrageenan samples are able to generate 1% gels prepared in deionized water, the overall picture is the same no matter whether gels are prepared in deionized water or in a milk system, see Fig. 2 and 3, respectively. It is seen that

especially Cottonii generates gels that are very brittle as BD is below 5 mm before the gel ruptures, irrespective of gel strength ranging from 20-200 g for milk gels. Spinosum generates milk gels that are more elastic and their GS are typically low, below 25 g, whereas BD is in the range 10-25 mm. Gigartina and Chondrus are located in the bend of the curve, generating fairly brittle milk gels (BD below 10 mm) and soft gels in the range 10-100 g.

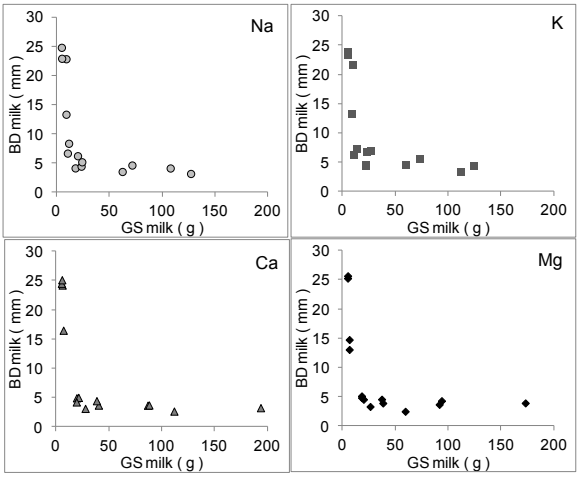

Figure 4. BD vs GS for milk gels prepared with carrageenan with different counter ions. Top left (Na), top right (K), bottom left (Ca), and bottom right (Mg).

The effect of the different counter ions (Na, K, Ca or Mg) is of minor influence, as seen in Fig. 4. There GS and BD for milk gels are shown for gels prepared with carrageenan with different counter ions. It can be seen there are gels which are firm and brittle as well as gels which are soft and elastic. And the same picture is seen when different Mw is plotted: there are gels which are firm and brittle or soft and elastic, Fig. 5.

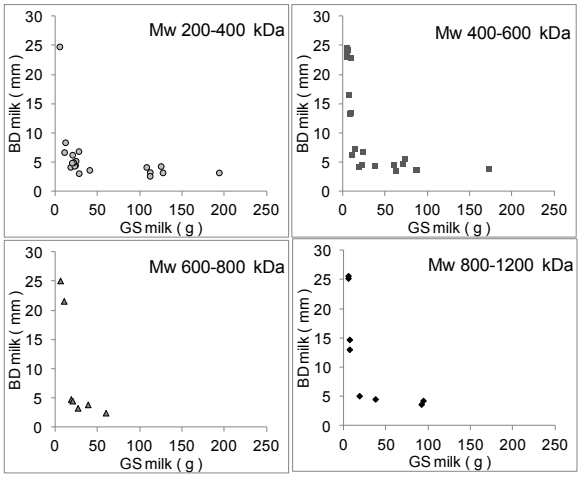

Figure 5. BD vs GS for milk gels prepared with carrageenan with different Mw.

Looking at BS as a function of GS it is seen that Spinosum is grouped separately while the other carrageenan types are grouped together, as can be seen in Fig. 6.

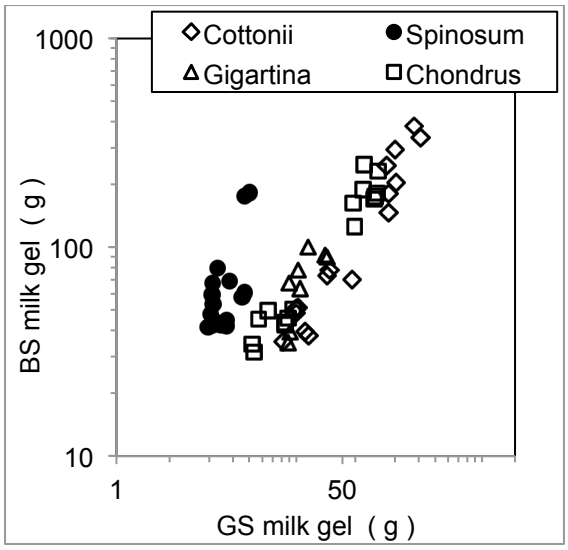

Figure 6. BS vs GS for milk gels prepared with 0.3% carrageenan from different origin, see legend.

Table 1. Carrageenan origin, Mw and predominant counter ion.

	Mw, kDa	K, mg/g	Na, mg/g	Ca, mg/g	Mg, mg/g
Cottonii	426	45	104	0	1
Cottonii	413	106	1	0	1
Cottonii	356	24	1	71	1
Cottonii	390	21	1	0	42
Cottonii	250	14	71	0	1
Cottonii	238	85	1	0	1
Cottonii	213	20	1	43	1
Cottonii	198	19	1	0	25
Cottonii	358	48	122	2	1
Cottonii	326	122	3	2	1
Cottonii	311	16	1	57	1
Cottonii	315	36	3	1	35
Cottonii	478	39	119	1	1
Cottonii	470	180	4	1	1
Cottonii	392	13	1	47	1
Cottonii	413	16	1	0	37
Spinosum	409	12	95	1	1
Spinosum	432	139	14	1	1
Spinosum	401	10	5	87	1
Spinosum	407	7	2	1	51
Spinosum	285	10	84	0	0
Spinosum	279	123	1	0	0
Spinosum	575	8	1	66	0
Spinosum	295	8	1	0	42
Spinosum	376	33	150	0	0
Spinosum	401	160	0	0	0
Spinosum	357	21	1	72	0
Spinosum	373	36	3	1	38
Spinosum	665	34	143	1	0
Spinosum	567	139	1	1	0
Spinosum	541	42	5	56	1
Spinosum	532	25	1	1	45
Gigartina	419	21	101	1	0
Gigartina	419	149	0	1	0
Gigartina	395	15	1	56	0
Gigartina	371	25	1	1	31
Gigartina	301	10	71	0	0
Gigartina	308	110	1	0	0
Gigartina	307	18	1	50	0
Gigartina	257	18	1	0	35
Gigartina	455	16	100	3	6
Gigartina	451	118	25	2	2
Gigartina	566	11	8	79	1
Gigartina	597	11	14	1	49
Gigartina	525	17	83	3	8
Gigartina	516	90	36	3	5
Gigartina	486	8	1	73	0
Gigartina	619	6	6	1	48
Chondrus	881	6	80	15	0
Chondrus	878	106	1	13	0
Chondrus	737	10	1	61	0
Chondrus	860	10	1	14	28
Chondrus	535	18	67	26	0
Chondrus	646	138	5	20	0
Chondrus	643	13	1	57	0
Chondrus	656	13	2	8	35
Chondrus	804	13	150	2	1
Chondrus	798	152	1	1	0
Chondrus	730	7	1	63	1
Chondrus	812	9	1	1	34
Chondrus	1181	24	106	4	4
Chondrus	1148	91	21	5	4
Chondrus	949	12	1	65	1
Chondrus	1121	11	1	1	39

CONCLUSION

Carrageenan from different origin can form gels in either water or milk, and the properties of these gels are either firm and brittle or soft and elastic, nothing in-between. When plotting BD vs GS the gels fall on a sort of master curve.

REFERENCES

1. Bloom, O.T. (1925). “Machine for testing jelly strength of glues, gelatins, and the like”. US patent Office 1540979

2. Nielsen, H.L., Hansen. K.M., Hansen, J.R., and Henriksen, W. (2006), ”Controlling specific rheological parameters in water jellies, using a new type of pectin”. Gums and Stabilizers for the Food Industry, 13, pp. 413-420.

3. Rudolph, B., (2000), “Seaweed Products: Red Algae of Economic Significance”. in Marine & Freshwater Products Handbook. Eds. Martin, R.E., Carter, E.P., Flick, G.J. Jr., and Davis, L.M., pp. 515-529.