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Texture/Consistency

Technical properties

Besides the specific behaviour of galactomannans in the production process, a knowledge of their effects in the final product especially in relation to texture and consistency is very important.

1

1 Hydrocolloid solutions

Technical values such as viscosity, flow curves etc. are relatively easy to determine in aqueous solutions. But these values give only partial information about consistency and texture. To establish these parameters, organoleptic testing is necessary. No absolute values can be established, but the impressions can be described verbally. The terms used when assessing aqueous foods are very wide ranging. The following are some of the words used:

slimy, short, empty, sticky, long, full-bodied, creamy etc.

In a study by F.W. Wood different hydrocolloids were assessed, which showed an identical viscosity on the Brookfield Viscometer at a rotation of 5 U/min. The following connection was established:

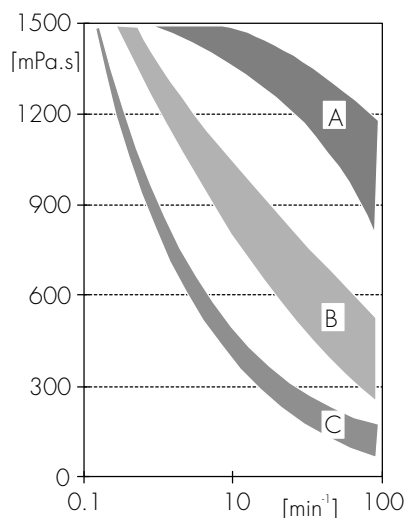


Figure 1

- A = slimy
- B = slightly slimy
- C = not slimy

"The closer the function (viscosity v shear rate) comes to the newtonian fluid, the slimier the solution becomes."

The tested hydrocolloid solutions were split into 3 groups by F.W. Wood, which differ significantly in their relationship between viscosity and shear rate (figure 1). The work of A.S. Szczensniak shows, that not only the function $hf(D)$ is decisive but also the way in which the shear rate is produced. The simplification of his conclusion is as follows:

"The sooner a solution loses viscosity in the mouth, the sooner and more easily it can be swallowed. The slower the viscosity change takes place in the mouth, the more difficult it is to swallow the solution or food."

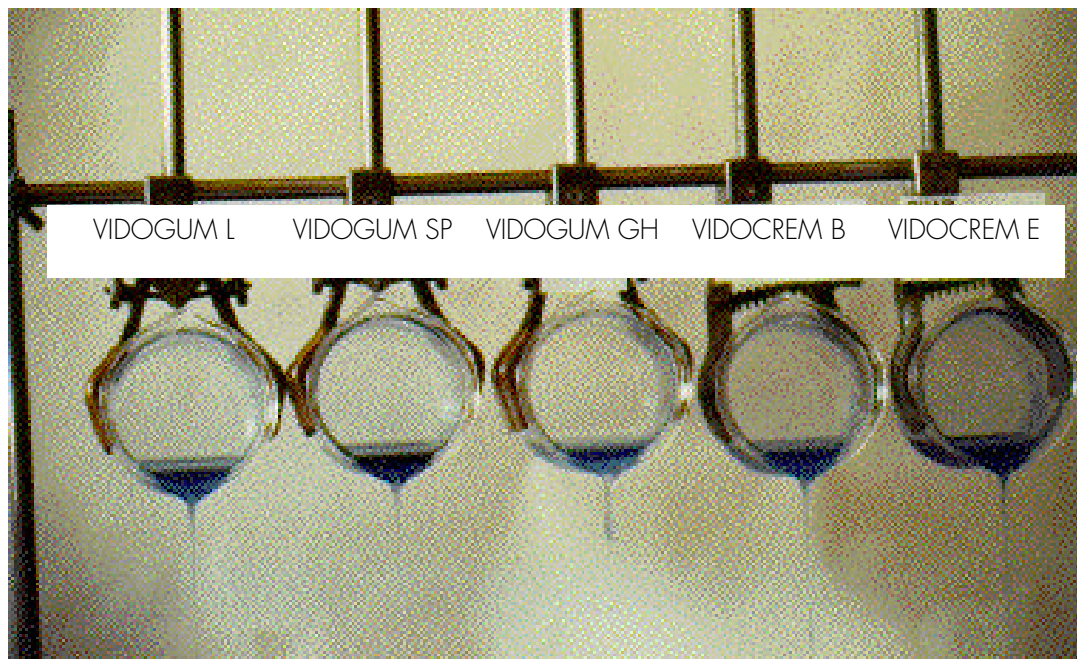
Texture/Consistency

2 Galactomannan solutions

VIDOGUM L, VIDOGUM SP and VIDOGUM GH show different flow curves (see chapter 'flow and viscosity behaviour'), therefore different textures can be expected. According to our own assessments, we describe the corresponding hydrocolloid solutions as follows:

| | |
|-------------|---|
| VIDOGUM L: | short, not slimy, consistency |
| VIDOGUM SP: | short, slightly slimy consistency, similar to LBG |
| VIDOGUM GH: | long, relatively slimy, consistency |
| VIDOCREM: | the lower the viscosity of the VIDOCREM Type, the shorter the consistency |

This assessment corresponds to the above relationship in picture 1 with VIDOCREM, i.e. VIDOGUM L shows the strongest non-Newtonian behaviour of the galactomannans used. Besides the physical properties, the texture of VIDOCREM is also significantly affected by the level of depolymerisation. As



Picture 1

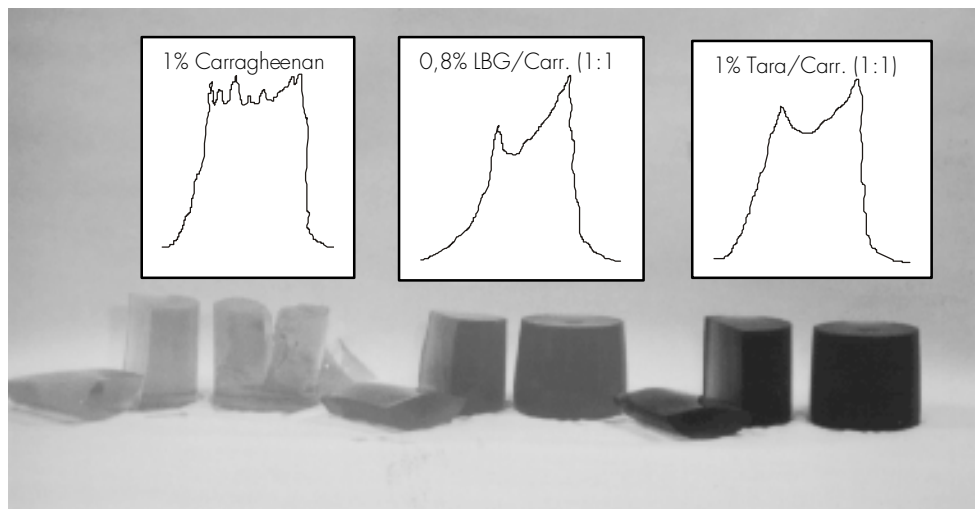
shown in picture 2 the behaviour of VIDOCREM is very similar to VIDOGUM L. Solutions were made up from the listed products so that, although the concentrations were different the measured viscosities were almost identical. As the solutions flow from the beakers, all but the VIDOGUM GH show a thin, stringy, threadlike flow. The VIDOGUM GH flow breaks up as it comes from the beaker, and it is therefore possible to say that VIDOGUM L, where it is used in applications purely as a thickening agent, can be replaced with a VIDOCREM product.

Mix-gels with galactomannans

As with solutions the characteristics of gels are often described in words. The following are some of the wide range that are used:

firm, hard, brittle, elastic, soft, rubbery, smooth, compact etc.

Some of the terms can be tested using an appropriate texture measuring device. The curves for the various gels, tested using the Stevens Texture Analyser, and shown in picture 3, can be interpreted as follows: The top of the curve gives information about the gel strength, the number of peaks an impression of the brittleness and the slope of the curve shows the elasticity.



Picture 2

But expressions such as "rubbery, smooth, cut-resistant" etc. cannot be quantified. Generally the mixed gels can be described as more elastic, and with more "body" than gels without galactomannans.

Incorporation

Technical properties

With the use of gelling and thickening agents, the first problems appear with incorporation into the aqueous phase. This mostly occurs in the formation of lumps, which can not then be broken down in spite of more vigorous agitation techniques

1

1 Introduction / Experiment

Several parameters are discussed to improve the dispersion and therefore the incorporation of the galactomannans.

2 Results / Discussion

2.1 Influence of the type of galactomannan

Field tests have shown, that the behaviour of the different galactomannan types VIDO GUM GH, VIDO GUM G, VIDOCREM (guar gums), VIDO GUM SP (tara gums) and VIDO GUM L (locust bean gum) is almost the same. However this statement is only true, if the materials compared have the same particle size distributions.

2.2 Influence of the particle size distribution

This effect shows a significant influence as already mentioned. The coarser the gum type the easier a solution in the aqueous phase is obtained. Referring to the standard types, this gives the following results:

| | |
|----------|--|
| Gum type | ≥ 150mesh: unproblematic incorporation |
| | ≥ 175mesh: slight lump formation |
| | ≤ 200mesh: strong lump formation |

Ease of obtaining a solution is ensured with coarse gum types. However there is a risk that the particle won't dissolve completely giving a disadvantage in the product and "fish eyes", if no blending or heating process takes place after the dispersion. This can be prevented by using a gum type with as narrow a particle size spectrum as possible.

2.3 Influence of a dispersing agent

If the use of a coarse gum type is not possible for texture or consistency reasons or as a result of the process technology, a dispersing agent is necessary. Most dry food additives are suitable. Sugar is the most suitable for dry mixing with gelling and thickening agents although the use of salt, spices, fruit and vegetable powders is also possible. The proportion galactomannan/dispersing agent should be 1:4 to prevent lump formation. If the food product contains oil, glucose syrup or alcohol, the galactomannan gum can be dispersed in this material and added, with stirring, to the aqueous phase. Lump formation is almost eliminated.

3 Summary

To prevent the undesirable effect of lump formation, the following proposals are usable:

- Choice of a coarser galactomannan type (≥ 150 mesh)
- Pre-mix with other dry additives, the best results are obtained with a mixture with at least 4 parts sugar
- Disperse the galactomannans in oil, glucose syrup etc.

Flow and Viscosity behaviour

Technical properties

Flow and viscosity curves of 1 % aqueous VIDO GUM and VIDOCREM solutions.

1 Introduction / Experiment

The flow curves are described by the relationship between the shear stress τ [Pa] and the shear rate D [s⁻¹]:

| | |
|-------------------|--|
| Flow curves: | Shear stress τ plotted against the shear rate D |
| Viscosity curves: | Viscosity η plotted against the shear rate D |

2

Flow behaviour is generally separated into Newtonian flow behaviour, i.e. quotient τ to D = constant and non Newtonian flow behaviour τ to D \neq constant.

Gum types / Concentration

1% VIDO GUM L 175
 1% VIDO GUM GH 175
 1% VIDO GUM G 250
 1% VIDOCREM A
 1% VIDOCREM C
 1% VIDOCREM E

Preparation of the solution

Solutions heated for 5min at 85° and cooled down to 25°C.

Material / Method

Haake Rotovisco: Type RV 12
 Measuring head: 500
 Measuring device: MV 1P
 Program: 0-128 min⁻¹
 Measuring temperature: 25°C

2 Results / Discussion

The following tables show the calculated flow (figure 1) and viscosity curves (figure 2):

Figure 1-2:

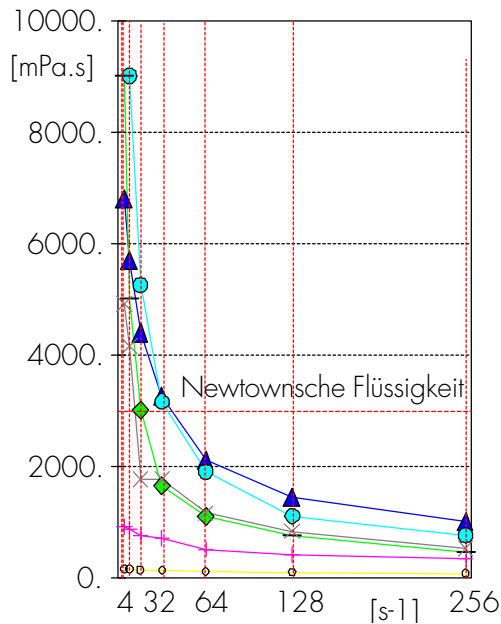


Figure 1

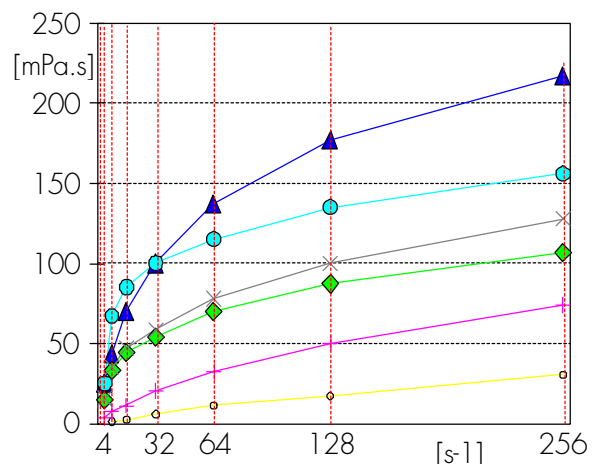
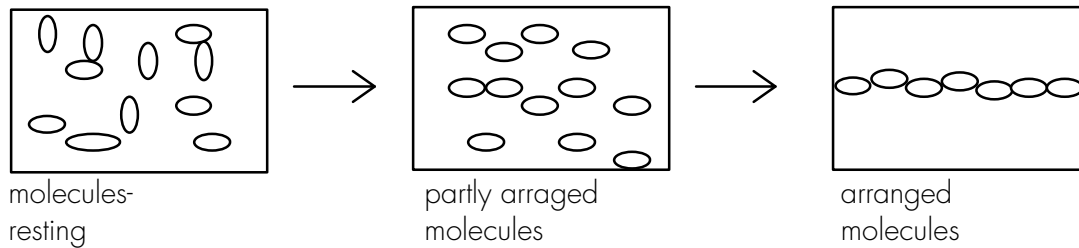


Figure 2

- ▲ = VIDO GUM L 175
- = VIDO GUM G 250
- ◆ = VIDO GUM GH 175
- = VIDO CREM A
- + = VIDO CREM C
- x = VIDO CREM E

None of the tested solutions showed Newtonian flow behaviour. This indicates that galactomannan solutions belong to the group of non-Newtonian fluids. These solutions are called intrinsically viscous due to the fact that viscosity losses occur at higher shear rates. The viscosity loss of intrinsically viscous fluids can be illustrated as follows:



3 Summary

This table shows clearly that the degree of the viscosity loss depends on the level of the viscosity. By recalculating the parameter η and D as per E. R. Morris et al (1981) over h/h_0 and D/D_0 , all solutions have an identical curve. This means that low viscosity **VIDOGUM** and **VIDOCREM** solutions also show the same intrinsically viscous behaviour.

The intrinsically viscous behaviour, i.e. viscosity decrease at increased shear rate means in practice, that with a predetermined power or pressure, higher flow rates can be obtained. In other words, the necessary energy for a required flow can be reduced.

Viscosity/Concentration

Technical properties

This section deals with the relationship between viscosity and concentration (0.2 - 1.0 %) of VIDO GUM and VIDO CREM products in aqueous solutions

1 Introduction / Experiment

The viscosities before and after a heating step were determined according to the UNIPEKTIN standard method. The measurements were carried out at 25°C.

Gum types / Concentration

VIDO GUM L 150, 175, 200
 VIDO GUM SP 175, 200
 VIDO GUM GH 150, 175, 200
 VIDO CREM A-G

3

Material/Method

Brookfield Viscosimeter: Typ RVF
 Rotation speed: 20 U/min
 Spindle: 1-6
 Measuring temperature: 25°C

2 Results / Discussion

2.1 Exponential curve characteristics

None of the gum solutions analysed showed a linear relationship between viscosity and concentration (Figure 1-4). The results showed that the viscosity increased exponentially with increased concentration.

2.2 Influence of particle size

The different particle sizes of VIDO GUM products showed negligible differences. For the same gum type, very similar curves were obtained for the 150, 175 and 200 mesh size materials.

2.3 VIDO CREM the special case

However, each VIDO CREM type (Figure 4) gives a different resultant curve. The more viscous the VIDO CREM type, the steeper the curve obtained, i.e. a relatively small viscosity increase is obtained with an increased concentration of the VIDO CREM types A - C.

2.4 VIDO GUM GH / VIDO GUM L - Viscosity after heating

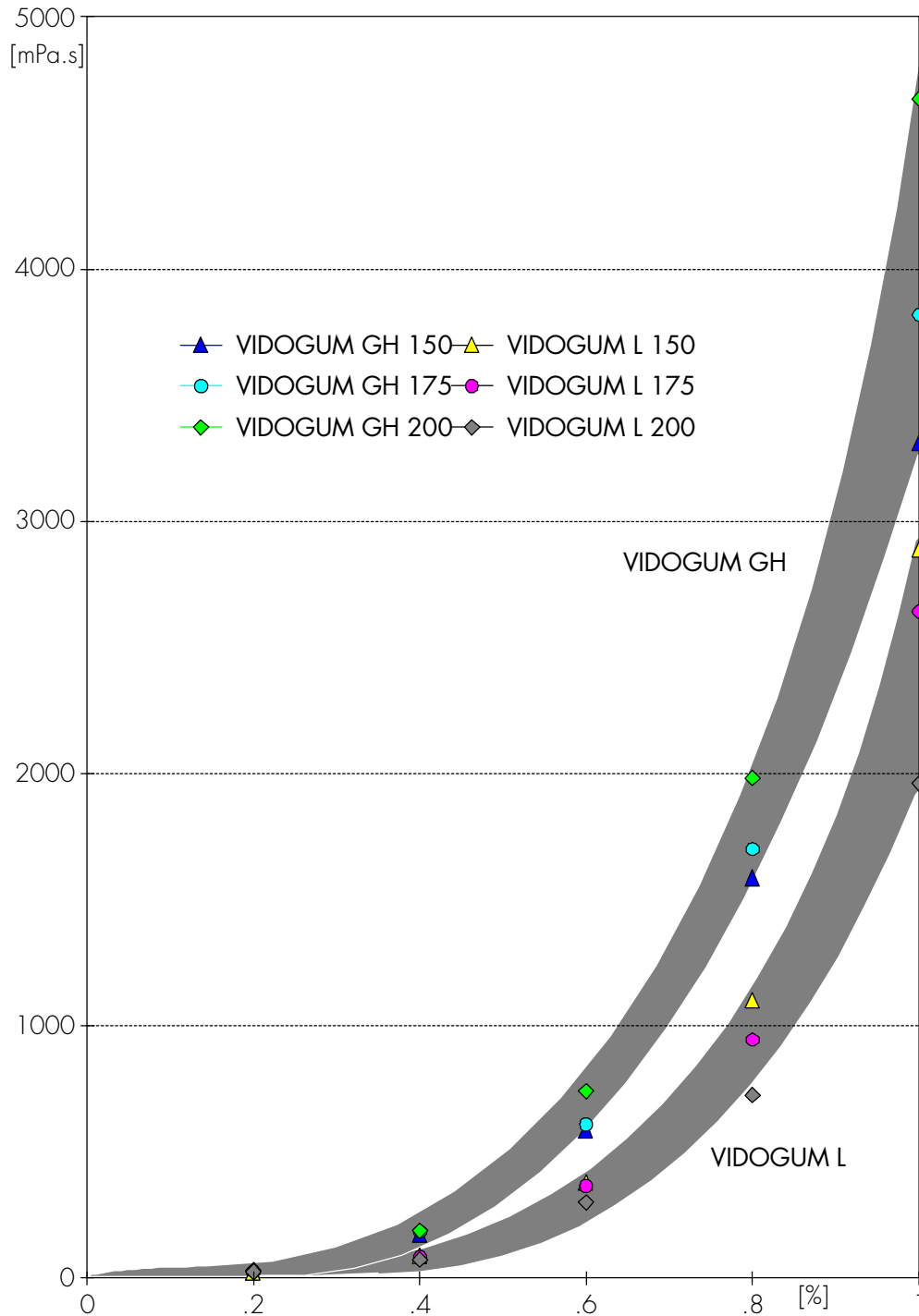


Figure 1

2.5 VIDOGLUM GH / VIDOGLUM L - viscosity before heating

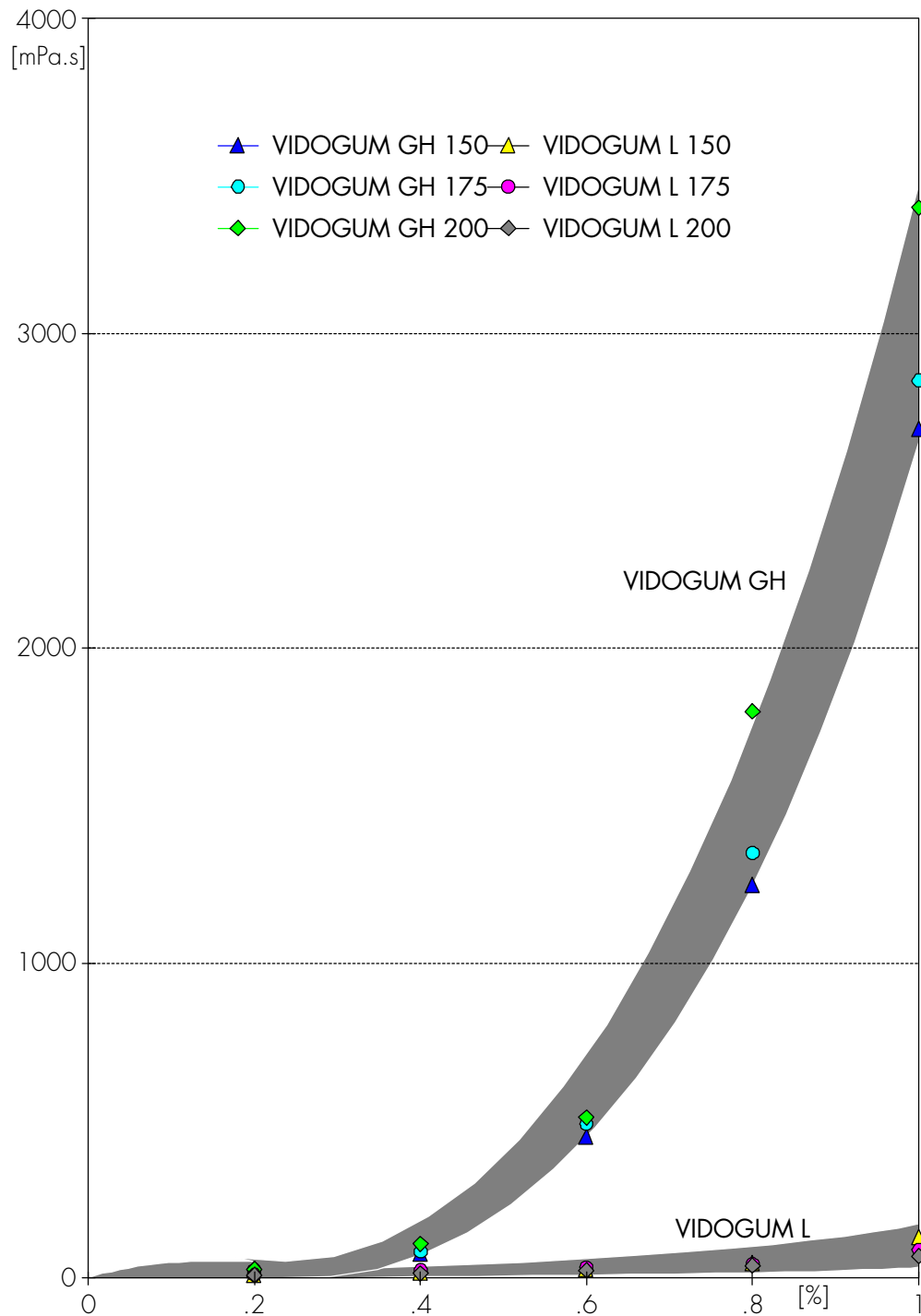


Figure 2

2.6 VIDOGUM SP - viscosity before and after heating

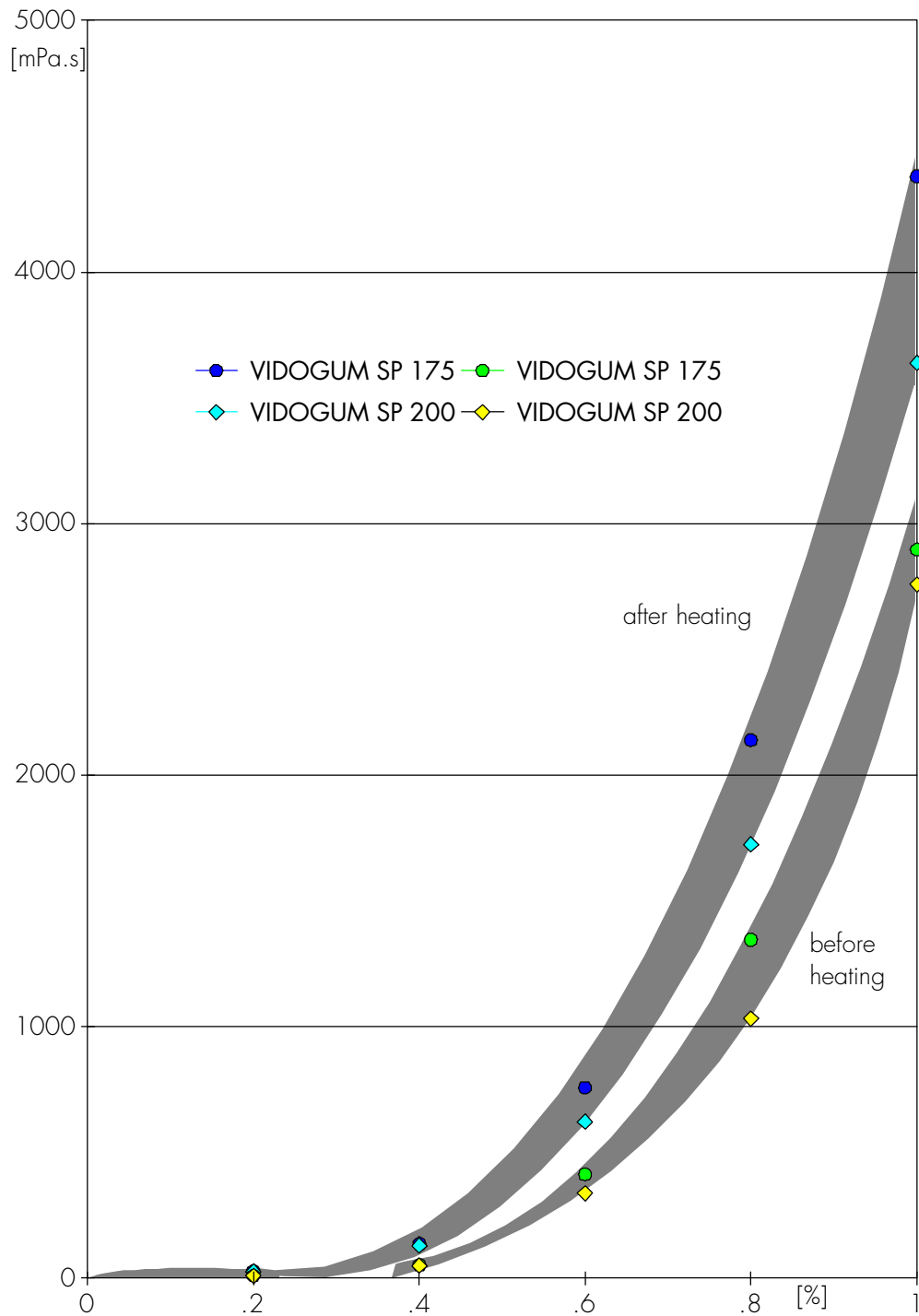


Figure 3

2.7 VIDOCREM A - G - viscosity before heating

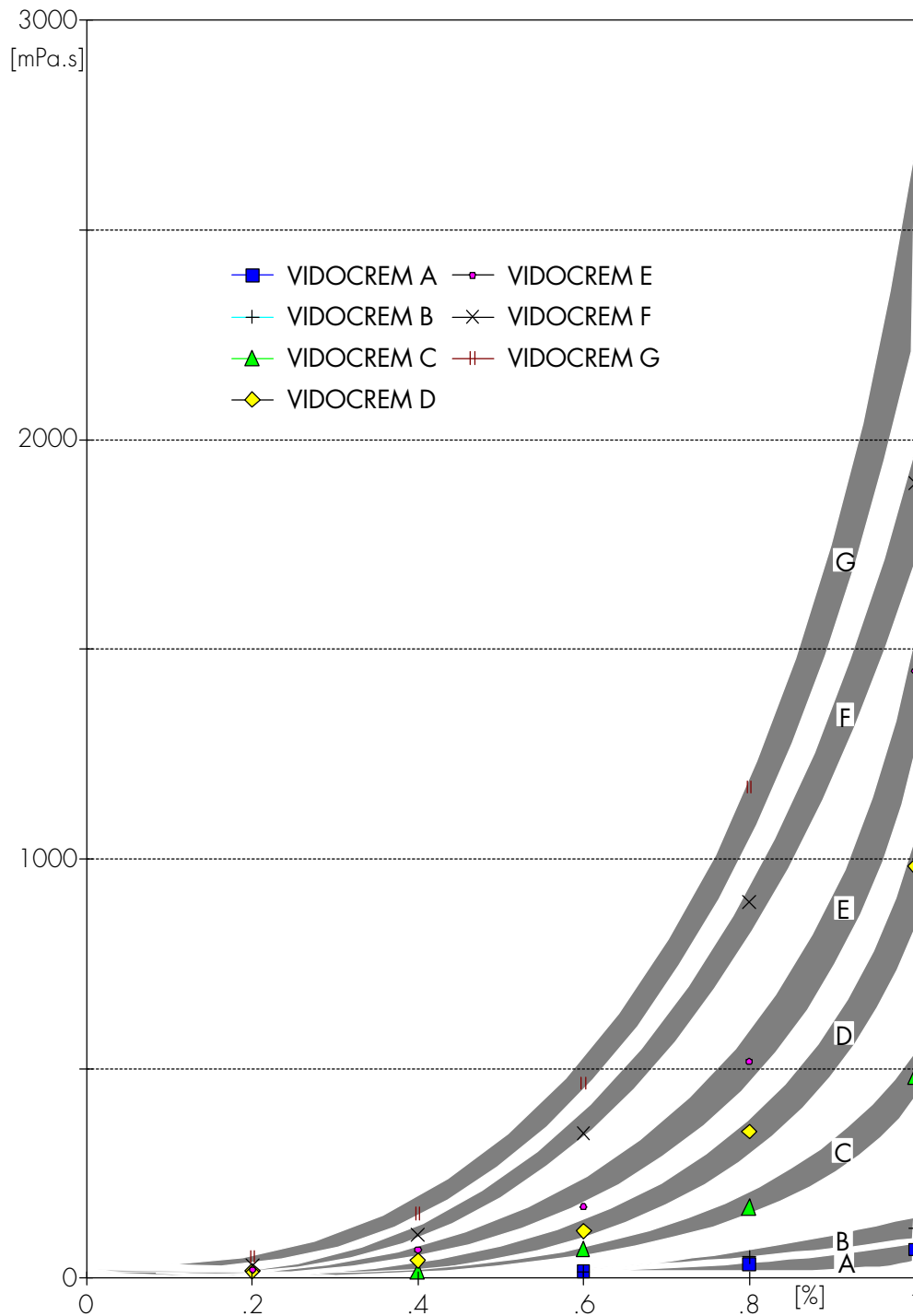


Figure 4

Viscosity/Temperature

Technical properties

The effect of different temperatures upon the viscosity of galactomannan solutions, and also the different viscosities at constant temperature difference

1 Introduction / Experiment

Galactomannan solutions undergo a reduction in viscosity when they are heated. To assess this effect, 1 % aqueous solutions of the standard **VIDOGUM** products were analysed at different temperatures. Solutions with concentrations < 1 % were also made up to cover the whole viscosity range of guar gums (**VIDOGUM GH** and **VIDOCREM**) and locust bean gum (**VIDOGUM L**).

3

| | | | | | | | | | |
|-----------------------------|---|--------------------------|---------|-----------|----------|----------|-----|------------------------|---------|
| Gum types / Concentration | 0.5-1% VIDOGUM L 150, 175, 200 0.1% VIDOGUM GH 150, 175, 200 1% VIDOGUM SP 175, 200 1% VIDOCREM C-G | | | | | | | | |
| Preparation of the solution | The solutions were heated as per UP standard method (after a heating step), cooled to 25°C, and reheated. | | | | | | | | |
| Material / Method | <table border="0"> <tr> <td>Brookfield-Viscosimeter:</td> <td>Typ RVF</td> </tr> <tr> <td>Rotation:</td> <td>20 U/min</td> </tr> <tr> <td>Spindle:</td> <td>1-3</td> </tr> <tr> <td>Measuring temperature:</td> <td>30-80°C</td> </tr> </table> | Brookfield-Viscosimeter: | Typ RVF | Rotation: | 20 U/min | Spindle: | 1-3 | Measuring temperature: | 30-80°C |
| Brookfield-Viscosimeter: | Typ RVF | | | | | | | | |
| Rotation: | 20 U/min | | | | | | | | |
| Spindle: | 1-3 | | | | | | | | |
| Measuring temperature: | 30-80°C | | | | | | | | |

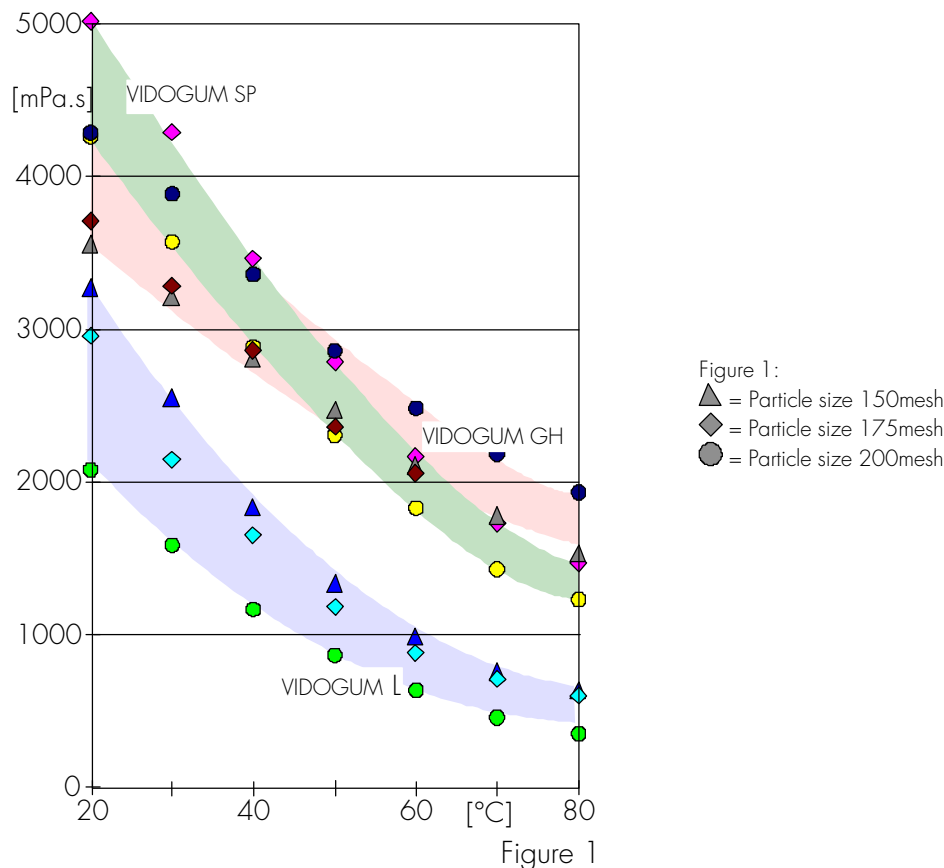
2 Results / Discussion

2.1 Influence of the galactomannan type

The viscosity curves in figure 1 show that significantly different curve gradients are obtained for the individual standard gum types. Tara gum (**VIDOGUM SP**) shows the largest viscosity reduction, and guar gum (**VIDOGUM GH**) shows the smallest viscosity reduction for a given increase in temperature.

It also shows, that the relationship between temperature (20 - 80°C) and viscosity is not linear, and this is the same for all galactomannan types.

Influence of temperature on viscosity



2.2 Influence of particle size

As expected the individual particle sizes do not significantly affect the viscosity reduction (figure 1). Within similar gum types, the curves obtained are all of the same shape.

2.3 Influence of concentration and depolymerization

There is no linear relationship between concentration and viscosity (figure 2) when solutions at varying concentrations, have their viscosities measured at two distinct temperatures ($\Delta T = \text{const.}$). This applies to both locust bean gums and guar gums. The different viscosity values of guar gum were obtained using varying concentrations of **VIDOGUM GH** and also **VIDOCREM**. The fact that curves with very high correlation factors are obtained both graphically and by calculation suggests that the depolymerized guar gums behave like the native guar gums under the influence of a temperature change.

Viscosity/Temperature

Viscosity at 30°C (f) Viscosity at 85°C

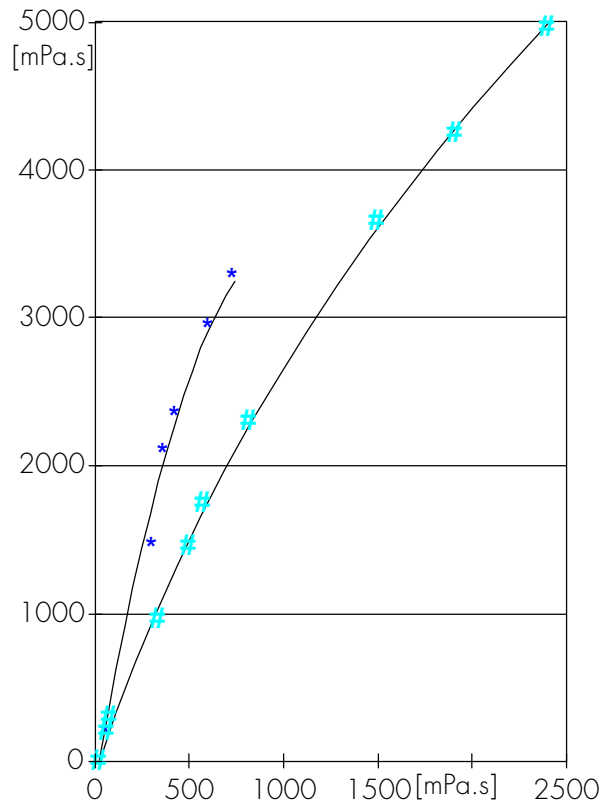


Figure 2:
 -Horizontal axes = Measurement at 85°C
 -Vertical Achse = Measurement at 30°C
 * VIDO GUM L
 # VIDO GUM GH / VIDO CREM

Figure 2

Specific Viscosity

Technical properties

The required viscosity for a product can be obtained precisely using galactomannan blends, thus simplifying the optimisation of the production process.

1 Introduction / Experiment

The following statement can be made after an examination of the solubility characteristics of guar, tara and locust bean gums:

3

All 3 galactomannan types are readily-soluble in hot water. But locust bean gum does not dissolve in cold water. Only a slight swelling of the particles occurs. Tara gum and especially guar gum are fairly readily soluble in cold water.

To demonstrate how viscosity values can be reached using different galactomannan gums, the following tests were undertaken using the UNIPEKTIN standard method.

Gum types / Concentration

1% VIDO GUM L 175 / VIDO GUM G 200I
 1% VIDO GUM L 175 / VIDO GUM GH 175
 1% VIDO GUM L 175 / VIDO GUM SP 175
 1% VIDOCREM C-G

Test condition

The cold and hot is obtained by using the UNIPEKTIN standard method

Material / Method

Brookfield Viscosimeter: Typ RVF
 Rotation: 20 U/min
 Spindle: 1-5
 Measuring temperature: 25°C

2 Results / Discussion

2.1 Viscosities of galactomannans

Galactomannans can show different viscosities before heating depending upon the production process. Expressed in relative terms, it can be established that our standard galactomannan gums behave as follows (table 1). The relative values are given on the basis of the viscosity after a heating step being 100 %.

| Product | Ratio of viscosities before & after heating |
|-------------|---|
| VIDOGUM GH | 80 - 90 %* |
| VIDOGUM G/I | 35 - 60 % |
| VIDOGUM SP | 55 - 75 % |
| VIDOGUM L | 2 - 10 % |

Table 1

* A particular quality feature of our **VIDOGUM GH** types is the significant cold solubility.

The ratio of viscosities before and after heating, as well as the absolute viscosity can be influenced by the production process. This is shown clearly in table 2 for **VIDOGUM GH** and **VIDOGUM G**.

| Product | Viscosity after heating [mPa.s] | Viscosity before heating [mPa.s] |
|--------------------------|------------------------------------|-------------------------------------|
| VIDOGUM GH | 3200 - 5000 | 2000 - 4300 |
| VIDOGUM G/ VIDOGUM SP | 2000 - 3600 | 700 - 2100 |
| VIDOGUM L | 3600 - 5200 | 2500 - 3400 |
| | 2000 - 3000 | 50 - 200 |

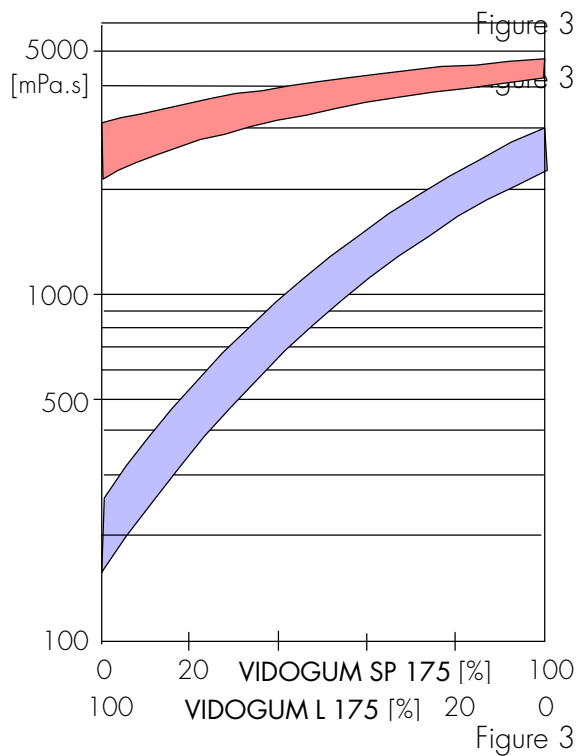
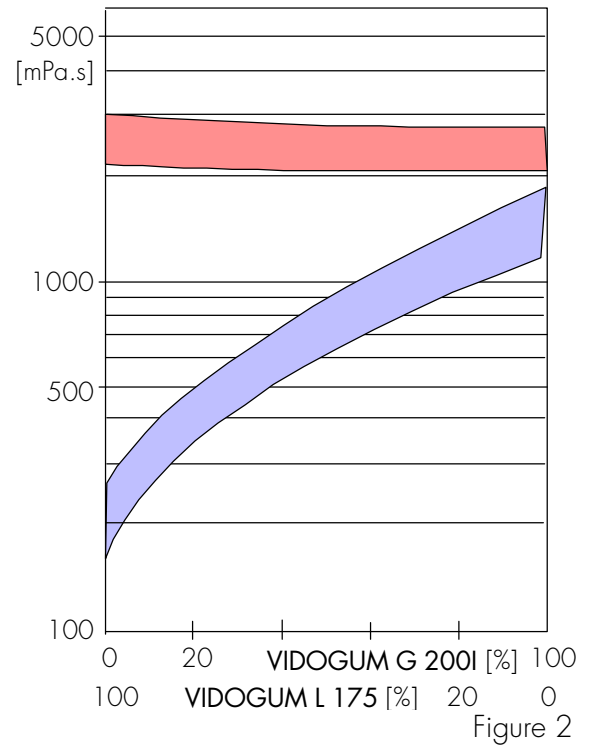
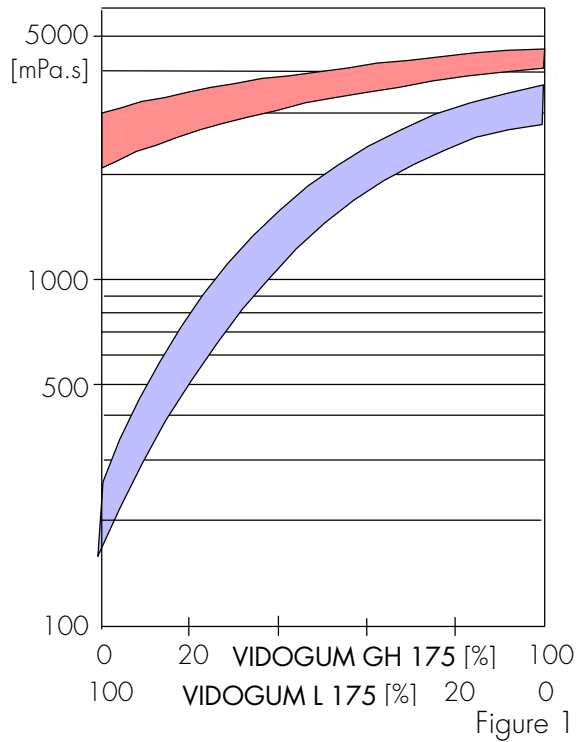
Table 2



2.2 Chance of viscosity prior to heating

As shown in the following graph, a mixture of **VIDOGUM L** with **VIDOGUM GH**, **VIDOGUM G** or **VIDOGUM SP** gives a much higher viscosity before heating. The amount of this increase can be controlled using either the mixture ratio or using a different galactomannan type. A blend of **VIDOGUM L** with a low level of **VIDOGUM GH** (figure 1) gives a significant increase in the viscosity prior to heating. However, the less soluble **VIDOGUM SP** (figure 3) or even the "poorly-soluble" **VIDOGUM G**, (figure 2) instead of **VIDOGUM GH**, allows the level of the increase to be precisely controlled.

Specific Viscosity

Viscosity values of different VIDO GUM - blends



 = viscosity after heating
 = viscosity before heating

3 Conclusion

It is possible to determine the viscosity properties for the prevailing purpose through the mixture of clearly defined and standardized galactomannan gums. **VIDOGUM L** is mostly used in processes, which run through a heating step, i.e. the full thickening is only reached after the heating step. In some cases a basic viscosity formation is required before the heating step (e.g. for the filling procedure). This can be set by adding cold soluble galactomannans as **VIDOGUM GH, G/I or SP**. In these particular cases we recommend the following products:

VIDOGUM LS Customer specific blends consisting either native or degraded guar gums in combination with locust bean gum.

VIDOGUM FS Special blend of standardized galactomannans for the application in sterilized foods e.g. fish and meat tin food, fruit soups, canned soups etc..

Solubility at room temperature

Technical properties

The cold solubility of the galactomannans, which is examined using the viscosity development, is affected by several factors. The galactomannan type, production processing and particle size distribution have an important influence

1 Introduction / Experiment

With a 1 % aqueous galactomannan solution the solubility was tested using the viscosity development at 25°C. The shear rate (=stirring conditions) was held constant for all tests. To avoid lump formation the gums were dispersed in a constant quantity of Ethanol and were afterwards mixed with water (=stirring time : 0 min.)

4

Gum types / Concentration

1% VIDO GUM L 175
 1% VIDO GUM GH 150 -200
 1% VIDO GUM G 120. - 200
 1% VIDO GUM SP 175

Test condition

Stirrer: propeller mixer
 Stiring speed: 300 U/min
 Stiring duration: 0 - 300 min.

Material / Method

Brookfield-Viscosimeter: Typ RVF
 Rotaion: 20 U/min
 Spindle: 1 - 5
 Measuring temperature: 25°C

To compare the observed viscosity values of the different galactomannans, these were converted into relative viscosities. The viscosity after a heating step (η_H) as per UNIPEKTIN standard method was used for all tests and set at 100%.

$$\text{relative viscosity in [\%]} \eta_{\text{rel.}} = \frac{\eta_x \times 100}{\eta_H}$$

2 Results / Discussion

2.1 Difference between the galactomannan types

Between the galactomannan there are differences in structure and composition, whose effect upon the binding and thickening ability, as well as on the cold water solubility, is not unimportant.

The recorded curves show the difference in cold solubility or cold viscosity against time between VIDO GUM GH 175 (guar gum), VIDO GUM SP 175 (tara gum) and VIDO GUM L 175 (locust bean gum). These different solubilities may be attributed to the galactose-/mannose ratio of each gum. (table 1)
The particle size influence can be neglected since all three gum types tested had the same particle size distribution.

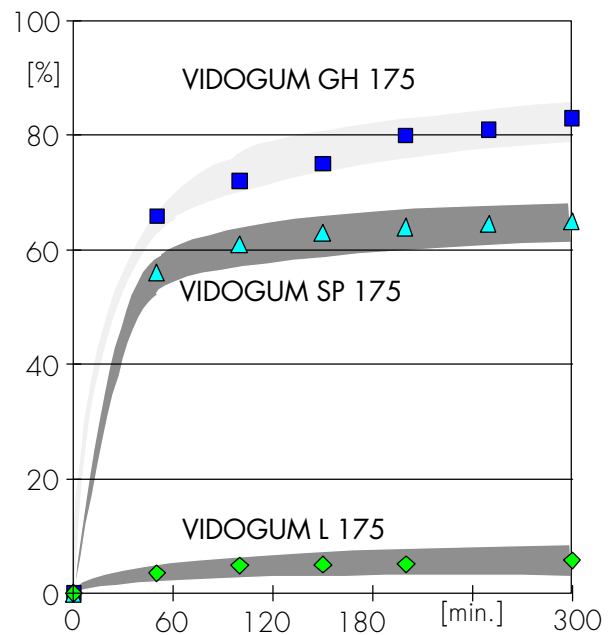


Figure 1

| Product | Ratio galactose/mannose |
|-----------------|-------------------------|
| Guar Gum | 1 : 2 |
| Tara Gum | 1 : 3 |
| Locust Bean Gum | 1 : 4 |

Table 1

2.2 Influence of the production process

VIDOGUM GH and **VIDOGUM G** are pure guar gums (produced from the same raw material). They differ, however, from each other in their solubility and thickening ability because they are produced in different ways.

The solubility tests of **VIDOGUM GH** and **G** are shown in figure 2 with the same particle size distribution.

The curves of **VIDOGUM G 200** show a distinctly flatter viscosity development against time compared to the **VIDOGUM GH 200**. Besides the significantly quicker viscosity build-up of **VIDOGUM GH 200**, the maximum final viscosity is higher after 60min at 25°C. These two differences are attributed to the different production processes.

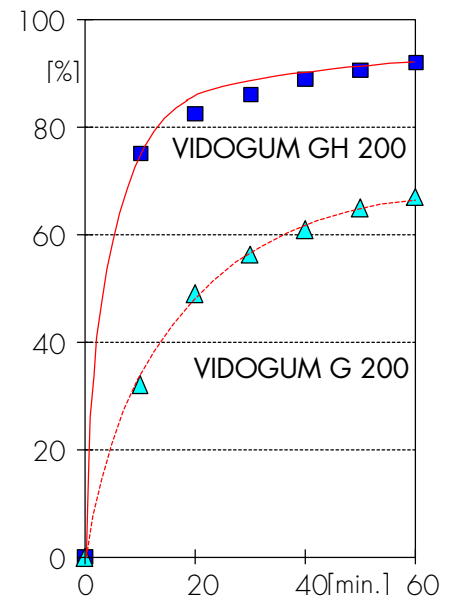


Figure 2

2.3 Solubility of different particle size

The particle size has an important influence on the solubility of galactomannans. Coarser gums are more readily soluble with respect to swelling and avoiding lump formation without dispersing agents, but need much more time for the full thickening power to develop. This characteristic can be used to advantage during long agitation periods or high temperature processing. For this reason we divide our **VIDOGUM** standard products into different sieve qualities. Standard particle size focal points are 150, 175 and 200 mesh.

Solubility at room temperature

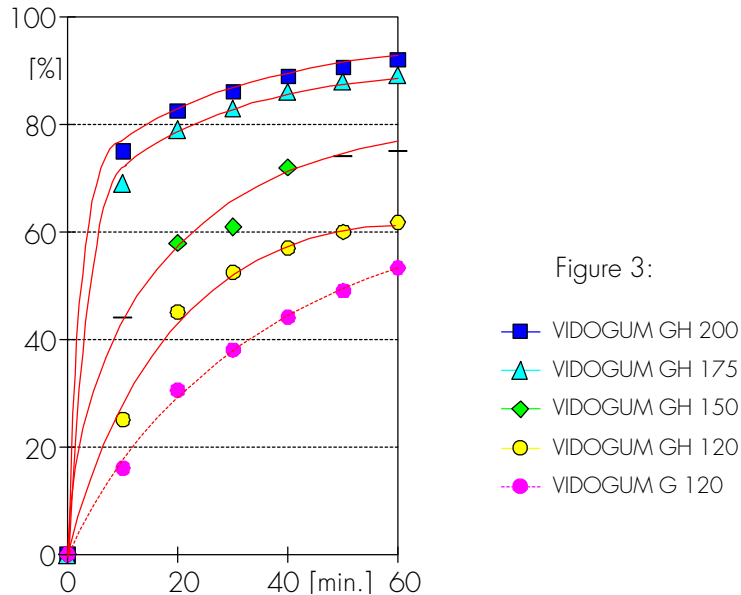


Figure 3:

- VIDO GUM GH 200
- ▲ VIDO GUM GH 175
- ◆ VIDO GUM GH 150
- VIDO GUM GH 120
- VIDO GUM G 120

Figure 3

The solubilities of the different guar gums (VIDOGUM GH and VIDO GUM G) with differing particle size focal points are shown in figure 3.

The curves show a distinctive difference with VIDO GUM GH 120 - 200 . The coarser the product, i.e. the smaller the mesh number, the slower the viscosity develops and the lower is the obtainable end viscosity after a defined time. As an additional comparison a coarse VIDO GUM G 120 quality is shown as in figure 3. As with the 200 mesh significant differences are obtained using the 120 mesh.

Solubility with temperature

Technical properties

The solubility or viscosity development can be controlled using temperature as well as the parameters mentioned in the chapter 'solubility at room temperature'

1 Introduction / Experiment

The three galactomannan types vary quite strongly in their solubility behaviour at different temperatures.

Locust bean gum (VIDOGUM L) is not soluble at room temperature. When added to water (25°C) the carubin swells slightly and gives only very low viscosities. For locust bean gum to be totally soluble, temperatures of more than 80°C are necessary over a period of time.

4

Tara gum (VIDOGUM SP) and guar gum (VIDOGUM G and GH) are readily soluble at room temperature. The speed of their solubilisation increases dramatically with higher temperatures.

2 Experiment

Gum types / Concentration

1% VIDOGUM SP 175

1% VIDOGUM GH 175

Material / Method

Rheomat Viscosimeter: Typ 30

Measure system: Typ B , setting 21

Pump speed: 25 / 30 min⁻¹

Temperatures 20, 40, 60, 80°C

In order to compare the results directly all the mixer conditions in the double-walled reaction vessel and the particle size distribution of the gum were held constant.

A water bath was used for the measurements at the different temperatures. The following holding times were established for the individual temperature zones:

| | | | |
|---------|-----------------------------|---------|--------|
| zone A: | always starting temperature | | 60min |
| zone B: | cooling (or heating) | to 25°C | 60min. |
| zone C: | heating up | to 87°C | 75min. |
| zone D: | cooling | to 25°C | 75min |

Solubility with temperature

Within zone A the viscosities and the data for the solubility behaviour were measured periodically.

The cooling and the heating up to 87°C and recooling to 25°C served to determine the maximum obtainable viscosity (η_{\max} = final value according to zone D).

3 Results / Discussion

3.1 Test evaluation

In order to draw conclusions about the different solubility behaviours with the different starting temperatures according to the obtained η -t-diagram, the following calculations were made:

a) Conversion of the values in time zone A and B in to relative viscosities

$$\eta_{\text{rel}} = \frac{\eta}{\eta_{\max}}$$

b) To compare the different viscosity runs directly with each other under the different temperatures, all viscosity curves have been converted to a temperature of 25°C as follows:

$\eta_1 = \eta_{\text{rel}}$ after 120min (final Zone B) measured at 25°C

$\eta_2 = \text{extrapolated } \eta_{\text{rel}}$ after 120 min measured at x°C

$$\text{conversionfactor} = \frac{\eta_1}{\eta_2}$$

Theoretical η_{rel} -values at 25°C can be obtained by multiplying the existing η_{rel} in zone A by the conversion factor.

3.2 Influence of temperature on the solubility

The following figures 1-2 illustrate graphically these η_{rel} -values against time:

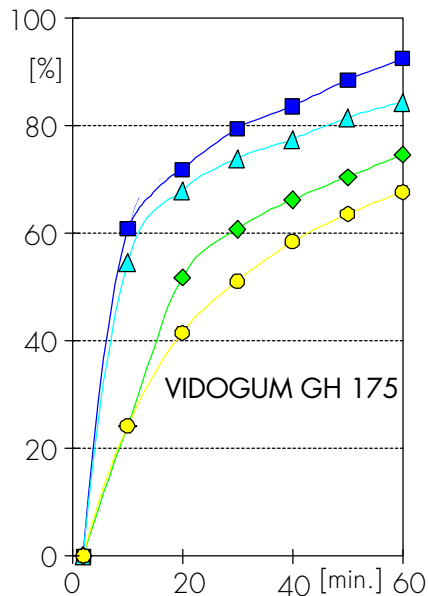


Figure 1

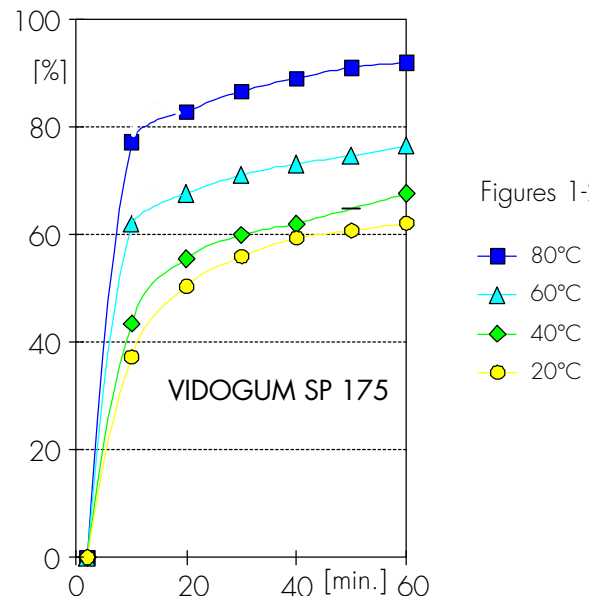


Figure 2

Figures 1-2:

- 80°C
- ▲ 60°C
- ◆ 40°C
- 20°C

Both gum types, **VIDO GUM GH 175** and **VIDO GUM SP 175**, show that increasing the temperature, significantly accelerates the solubility as measured by the viscosity development. The effect of the temperature increase with **VIDO GUM SP 175** is more pronounced, because of its lower cold solubility compared to **VIDO GUM GH 175**.

4 Remarks

Because a constant conversion factor was used for each temperature for the conversion to 25°C (linear derivation), the curves shown in the figure do not exactly correspond to reality. As the work "the temperature influence on viscosity" shows, the curves of the viscosity aren't linear under differing temperatures ($\Delta T = \text{constant}$).

Sequence of addition

Technical properties

Different physical conditions, temperature, particle size etc. affect the solubility of the galactomannans. Also the stage at which the addition is made, as well as the composition of the aqueous phase has an important influence on viscosity development.

1 Introduction / Experiment

The solubility, or viscosity development, was determined using a stabilised blend consisting of VIDO GUM GH, VIDO GUM G and a bio-synthetic polysaccharide, on one hand changing the composition of the aqueous phase and on the other hand varying the stage at which the addition was made.

4

2 Results / Discussion

2.1 Different aqueous phases

Stabiliser blend / Dispersing agent

0,5 + 1,0% blend consisting of VIDO GUM GH, VIDO GUM G, Xanthan
3,0% table salt

Aqueous phases

pur tap water
3% citric acid+ 4% acetic acid in tap water

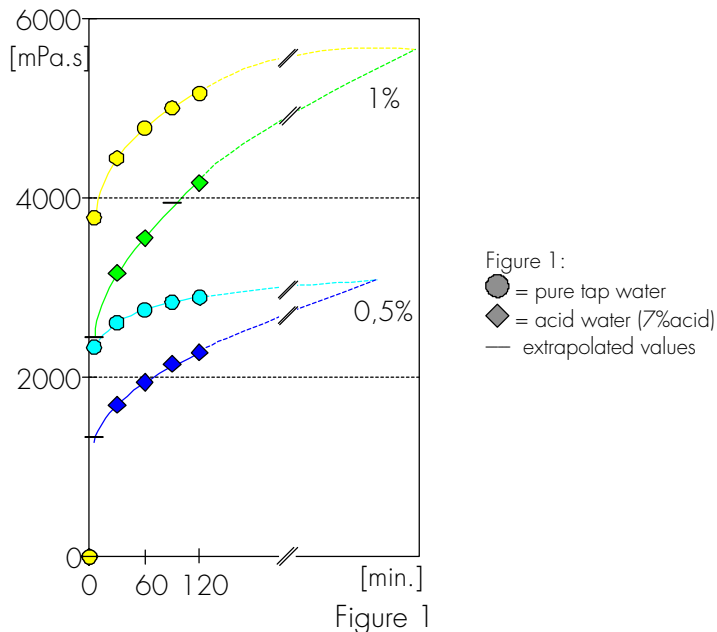
Process conditions

stirring of the stabiliser at 25°C, stirring for 5min at 300U/min and leaving it standing for 1 hour.

Determine the viscosity after 5min and periodically during the hour using a Brookfield Viscositymeter at 25°C.

The resulting curves ($\eta = f_{\text{time}}$) show a significant reduction in the rate of viscosity development (= lower viscosities after time x), depending upon the acidity of the solution. Both applied concentrations of 0,5 and 1,0 % show this effect. Because of this reduction, the time taken to reach the maximum final viscosity will be prolonged (see the steepness of the extrapolated curves). This time can be shortened using mechanical means (stirring, homogenising etc.). The maximum final viscosity is identical with both aqueous phases, only the time taken to reach it varies.

Sequence of addition



2.2 Different time sequences

Stabiliser blend / Dispersing agent / Remaining ingredients

0,5 % blend consisting of VIDO GUM GH, VIDO GUM G, Xanthan
 3,0% table salt (dispersing agent)
 15,5% sugar

Aqueous Phase

4% acetic acid in tap water

Process conditions

- a: dry pre-mix the stabiliser with sugar and salt and while stirring add into the acetic acid phase
- b: dry pre-mix the stabiliser with salt (dispersing agent) and while stirring add into the acetic acid phase. Add the sugar after stirring for 5 min.

Both variants were stirred at 300 U/min. for 30 min. and left standing for a further 30 min. The viscosities were measured periodically during the test time using a Brookfield Viscometer at 25°C.

Sequence of addition

The curves obtained are shown in the figure 2 giving the different viscosity increases against time. This illustration shows clearly that the viscosity development is impeded by the addition of other soluble dry ingredients. To obtain the quickest possible viscosity development, the thickening agent and the stabiliser need to be dissolved separately from and before the rest of the ingredients.

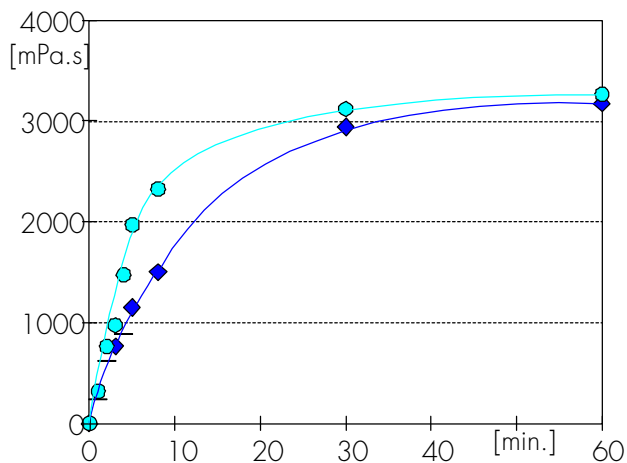


Figure 2:
 ● = addition of stabilizer with salt before the sugar
 ◆ = addition of ingredients together (all in)

Figure 2

Instant solubility

Technical properties

For the use of galactomannans in instant products high solubility and the most rapid build up of viscosity is necessary so that the food product, once mixed with water or milk, is immediately consumable and has a constant viscosity over the moulding time.

1 Introduction / Experiment

Several cold soluble galactomannans were tested in a fruit soup, i.e. a cold dish obtained by mixing with water, with a total dry matter of approx. 20 - 25 % in the end product. For the required texture, an addition of starch is necessary and a cold soluble starch product (distarch phosphate) was included for this purpose.

4

Gum types / Concentration

0,9% VIDOCREM F / 1,8% Starch
0,9% VIDOCREM D / 1,8% Starch
0,9% VIDOCREM B / 1,8% Starch
1,4% VIDOCREM B / 1,8% Starch
1,8% VIDOCREM B / 1,8% Starch
0,9% VIDO GUM GH / 1,8% Starch
4,5% Starch

% referring to the finished dessert

Test condition

Stir the powder blend in water at 20°C and stir with the egg-beater for 1 min.

Determine the viscosity continuously at 20°C during 30 min.

Material / Method

Brookfield-Viscosimeter: Typ LVT
Rotation: 60U/min
Spindle: 4
Measuring temperature: 20°C

2 Results / Discussion

2.1 Application of native galactomannans

As illustrated in the graph slow viscosity development occurs using native guar gum (VIDOGUM GH 200), although a slight improvement could be obtained using a slightly reduced concentration.

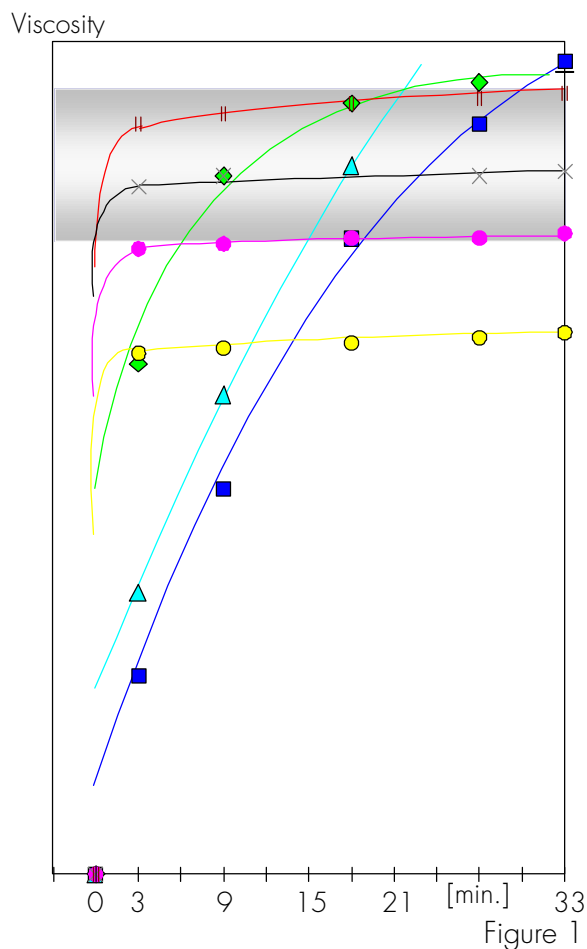










Figure 1:

-  viscosity of commercial instant fruit products
-  0,9% VIDOCREM F + 1,8% starch
-  0,9% VIDOGUM GH 200 + 1,8% starch
-  0,9% VIDOCREM D + 1,8% starch
-  0,9% VIDOCREM B + 1,8% starch
-  1,4% VIDOCREM B + 1,8% starch
-  1,8% VIDOCREM B + 1,8% starch
-  4,5% distarch phosphate

2.2 Depolymerized guar gums

The viscosity development obtained from the pure starch can be modified using the **VIDOCREM** products (depolymerized guar gums). It can be seen that the higher the level of depolymerisation, the quicker the viscosity development. The quickest final texture attainment is obtained with **VIDOCREM B**.

3 Conclusion

To obtain the required final product texture and viscosity development, an equivalent end product can be produced by partially substituting the starch with galactomannans. As shown, especially strongly degraded guar gums (**VIDOCREM B**) are well suited to establish the required parameters.

The significant difference between the end product, made only with starch to the one made with **VIDOCREM B**/starch, is in the mouth feel, which the **VIDOCREM B** makes lighter and shorter. The optimum ratio between starch and **VIDOCREM** depends upon the required texture and does not influence the speed of the viscosity development. Although the required parameters can be obtained without starch, i.e. only with degraded guar gums, it would be better not to use this option for organoleptic reasons.

Water binding capacity

Technical properties

Galactomannans have a remarkable water binding capacity, which is certainly necessary for viscosity development. But it can also be used for the prevention of syneresis, and the depolymerized guar gums especially are primarily used as syneresis inhibitors.

1 Introduction / Experiment

To determine the level of the water binding capacity, the water holding capacity in the form of nascent syneresis was established in a carrageenan gel to which VIDO GUM GH, VIDO GUM G/I and VIDO CREM had been added. During this process the different guar gums were tested and examined at constant concentrations as well as at varying concentrations.

5

| | |
|-----------------------------|--|
| Gum types / Concentration | 0.1 - 0.5 % VIDO GUM GH 200 0.5 % VIDO GUM GH 150 0.5 % VIDO CREM G 150 I 0.1 - 0.5 % VIDO CREM A 0.5 % VIDO CREM B, C ... G |
| Preparation of the solution | The thickening agent is mixed with 10 % Saccharose and 1,0 % carrageenan and dissolved in distilled water (85°C). The gel is filled into gelling rings and analysed after 18 h holding time. |
| Material / Method | Stevens-Textur-Analyser Measuring body TA3 Speed 1.0mm/sec Distance 20mm Filter paper S&S 589 ¹ Supporting surface 33cm ² Flowing time 4min Brookfield Viscosimeter Typ RVF Spindle 2 Speed 20U/min Temperature 25°C |

2 Results / Discussion

The y-axis [in %] on the following graph corresponds to the relative syneresis formation and was calculated as follows:

$$\text{rel. syneresis [\%]} = \frac{\text{Flow distance of the sample [cm]} * 100}{\text{Flow distance of carrageenan-gel [cm]}}$$

Water binding capacity

The comparison of the syneresis susceptibility (rel. Syneresis %) compared with the established viscosity in the damaged gel is illustrated in the graphs below. In figure 1 the concentrations of the guar gums used were constant at 0,5 %. In figure 2 a strongly degraded guar gum (**VIDOCREM A**) was compared to the native guar gum (**VIDOGUM GH 200**) at different concentrations.

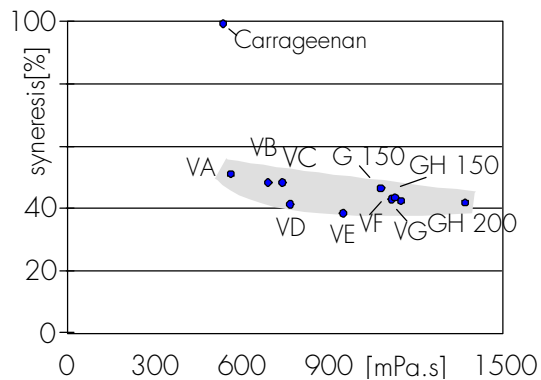


Figure 1

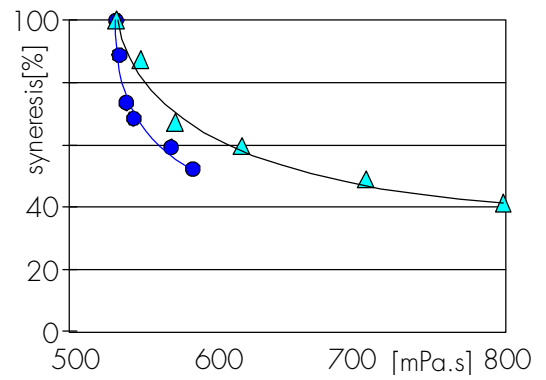


Figure 2

Figure 1: VA = **VIDOCREM A** ; VB = **VIDOCREM B** , etc.
GH 150 = **VIDOGUM GH 150** ; GH200 = **VIDOGUM GH 200** ; etc.

● 0 - 0.5% **VIDOCREM A**
▲ 0 - 0.5% **VIDOGUM GH 200**

Figure 2:

2.1 Syneresis inhibition using Guar Gum

The syneresis inhibition using guar gum is clearly illustrated in figure 1. The differences in the water binding capacity of the guar gums is low, when compared to the significantly improved water binding of the carrageenan gel when guar gum is added to it. It follows that all UNIPEKTIN guar gums are equally suitable for use in the prevention of syneresis.

2.2 Effects on the consistency

No deterioration in the gel texture occurred when adding guar gum.

Significant differences between the guar gums used are noticeable if both syneresis inhibition and viscosity requirements need to be considered.

Strongly depolymerized guar gum (**VIDOCREM A**) increases the viscosity only very slightly, and any changes to the texture are negligible.

Slightly degraded guar gum (**VIDOCREM F**) and native guar gum (**VIDOGUM GH 200**) increase the viscosity considerably in the broken gel and have a possible negative effect on the texture - the gels are more elastic.

The particle size distribution has a lesser effect on the texture.

2.3 Influence on the concentration

The differences between the guar gum types is more significant, if the syneresis inhibition effects of **VIDOCREM A** and **VIDOGUM GH 200** are compared at different concentrations (figure 2). A comparable syneresis inhibition effect can be obtained with a very slightly higher concentration of **VIDOCREM A** when compared with **VIDOGUM GH 200** (lower viscosity values for the same effect) but the negative textural change is clearly smaller. Strongly degraded guar gums are therefore more suitable for use to increase the water binding capacity of foods despite the additional thickening agents used and the corresponding costs incurred. The lower viscosity increases obtained using **VIDOCREM** are significantly advantageous with respect to the mouth feel. Food products can therefore be made that are virtually unchanged in texture but much more stable to syneresis.

Solubility in Ethanol

2.1.2 Solubility of Xanthan gum

| Trial | Xanthan gum | Ethanol 100% | Water | Alcohol con- tent | Remarks |
|-------|-------------|-----------------|-------|----------------------|---|
| | [g] | [g] | [g] | [% w w] | |
| 1 | 2 | 65 | 35 | 65 | Sedimentation |
| 2 | " | " | 79 | 45 | spontaneous hydration resp. high viscous |

2.1.3 Solubility of VIDOCREM B

The test with VIDOCREM B as a thickening agent shows the same results like the native guar gum VIDOGUM GH 200

2.1.4 Solubility of VIDOGUM GH 200 (Constant Galactomannan Concentration)

| Trial | VIDOGUM GH 200 | Ethanol 100% | Water | Alcohol content | Viscosity |
|-------|-------------------|-----------------|-------|--------------------|-----------|
| | [g] | [ml] | [ml] | [% vol.] | [mPa.s] |
| 1 | 1 | 2.5 | 96.5 | 2.5 | 4500 |
| 2 | " | 5 | " | 5 | 3950 |
| 3 | " | 7.5 | " | 7.5 | 3050 |
| 4 | " | 10 | " | 10 | 1850 |
| 5 | " | 12.5 | " | 12.5 | 650 |
| 6 | " | 15 | " | 15 | 95 |
| 7 | " | 17.5 | " | 17.5 | 30 |

Acid stability

Technical properties

Viscosity behaviour of aqueous, acid galactomannan solutions under different processing temperatures such as cold production, pasteurisation and sterilisation.

1 Introduction / Experiment

Galactomannans are only partly pH-stable. Viscosity losses are dependent upon the solution and handling time. The viscosity loss is caused by a hydrolytic separation of the long chain, linear polysaccharide molecules (= depolymerisation). To investigate this viscosity degradation with time, a 1% aqueous galactomannan solution was held at different processing temperatures (25°C, 85°C and 121°C).

Gum types / Concentration

1% VIDO GUM GH 200
 1% VIDO GUM SP 200
 1% VIDO GUM L 175
 1% VIDO CREM C

6

Preparation of the solution

Stir 1% galactomannan gum into cold water and homogenise for 10 min. in the Ultra-Turmix. Heat for 10 min. at 121°C in the autoclave and cool down to 25°C within 20 min. Acidify with citric acid 50 % to the desired pH level.

Material / Method

Brookfield Viscosimeter Typ RVF
 Temperature: 25°C
 Rotation: 20 U/min
 pH level: 3,5 ± 0,1
 4,5 ± 0,1

Temperature/time:

25°C: held at room temperature.
 85°C: solutions heated under reflux to 85°C = first sample. Cooled down to 25°C within 15min.
 121°C: autoclave-heating time approx. 15min to 100°C and approx. 8min to 121°C.
 (p = approx. 1 bar).
 Cooled to 100°C in approx. 4min and to 25°C within 15min.

Acid stability

1.1 Initial viscosity

The viscosities, and the calculation of the relative viscosities, are listed as follows:

| Product | Viscosity [mPa.s] |
|----------------|--------------------|
| VIDOCREM C | approx. 900 mPa.s |
| VIDOGUM GH 200 | approx. 5500 mPa.s |
| VIDOGUM L 175 | approx. 2300 mPa.s |
| VIDOGUM SP 175 | approx. 4400 mPa.s |

$$\eta_{rel.} = \frac{\eta_x * 100}{\eta_{(Initial\ solution)}}$$

2 Results/discussion

2.1 Stability at room temperature (25°C)

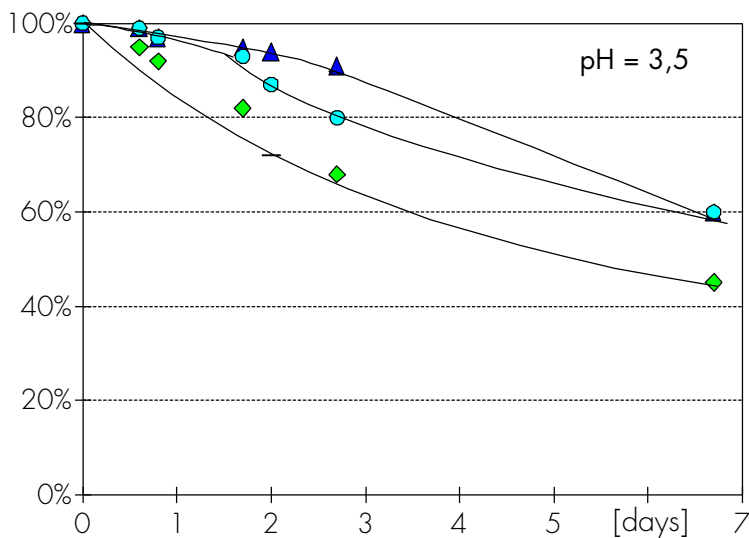


Figure 1:

- ▲ VIDO GUM SP 175
- VIDO GUM GH 200
- ◆ VIDO GUM L 175

Figure 1

Acid stability

2.2 Stability during the pasteurisation (85°C)

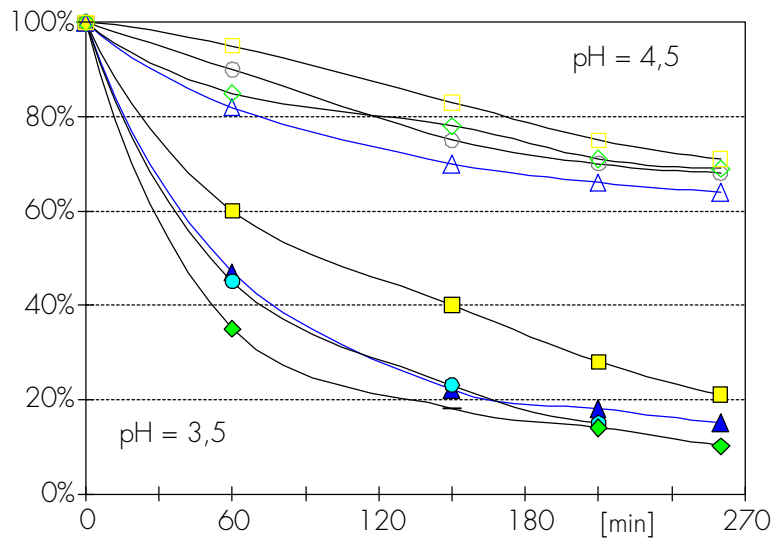


Figure 2:
 ▲ VIDOGUM GH 200 △
 ● VIDOGUM L 175 ⊖
 ◆ VIDOGUM SP 175 ◇
 ■ VIDOCREM C ⊞

Figure 2

Stability during the sterilisation (121°C)

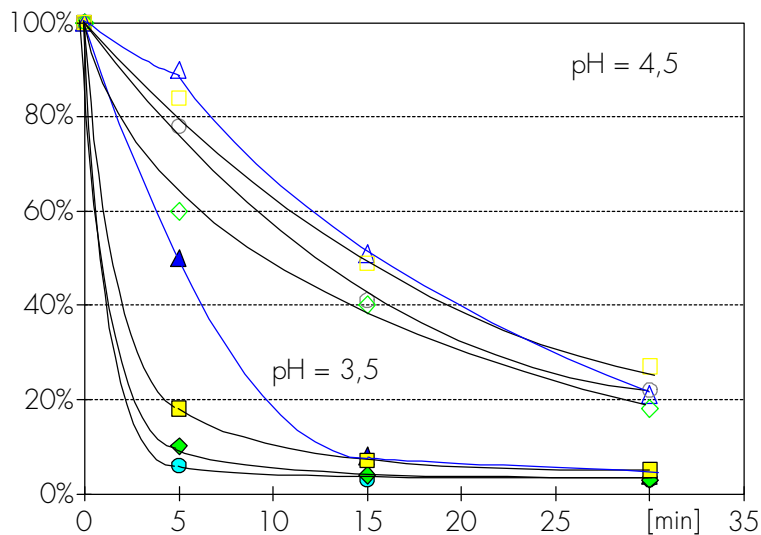


Figure 3:
 ▲ VIDOGUM GH 200 △
 ● VIDOGUM L 175 ⊖
 ◆ VIDOGUM SP 175 ◇
 ■ VIDOCREM C ⊞

Figure 3

3 Conclusion/remarks

As expected and shown in the literature the galactomannans show a viscosity loss in aqueous, acid solutions which depends on the pH-value and temperature. No significant difference exists between the different galactomannan types under the tested conditions.

These tests were carried out with pure aqueous solutions, i.e. no buffer systems or interactions etc. which could prevent the acid hydrolysis of the galactomannans. The viscosity loss against time, temperature and pH shown in the following tables is therefore the most extreme possible case.

When applying galactomannans to complete foods, an improved acid stability can be expected due to the protective effects mentioned, such as buffer systems and interactions with other food additives.

Ultra-high-temperature

Technical properties

Viscosity stability of aqueous galactomannan solutions under Ultra High Temperature (UHT) conditions at varying pH-values

1 Introduction / Experiment

Tests were made with 1 % aqueous galactomannan solutions with different pH-values to determine the loss of viscosity after the UHT-treatment. For this purpose the solutions were made in a Stephankutter and kept at 85°C for 5 min. Afterwards the warm solutions were passed through a UHT-plant and heated up to approx. 135°C and then immediately cooled down to 20 - 25°C.

For the tests in an acid medium a citric acid solution (50 %) was added to the solution before it was passed through the UHT-plant.

As a reference solution, part of the 85°C solution was cooled down immediately to 20 - 25 °C.

Gum types / Concentration

1% VIDO GUM L 175
 1% VIDO GUM GH 175
 1% VIDO GUM G 250
 1% VIDOCREM C
 Dispersing agent 2% table salt

7

Preparation of the solution

Solutions are heated up to 85°C with direct steam injection (Stephan kutter)

Material / Method

UHT-Pilot plant: Type GEA
 Temperature: approx. 135°C
 Holding time: approx. 2 - 5sec.
 pH-range: 3,8 - 6,6
 Sampling temperature: 20 - 25°C
 Brookfield-Viscometer: Type RVF
 Spindle: 2-3
 Rotational speed.: 20U/min
 Measuring temperature: 25°C

2 Results / Discussion

The relative viscosities at varying pH-values are illustrated in the diagram below (η_0 = viscosity of the reference solution = 100 %)

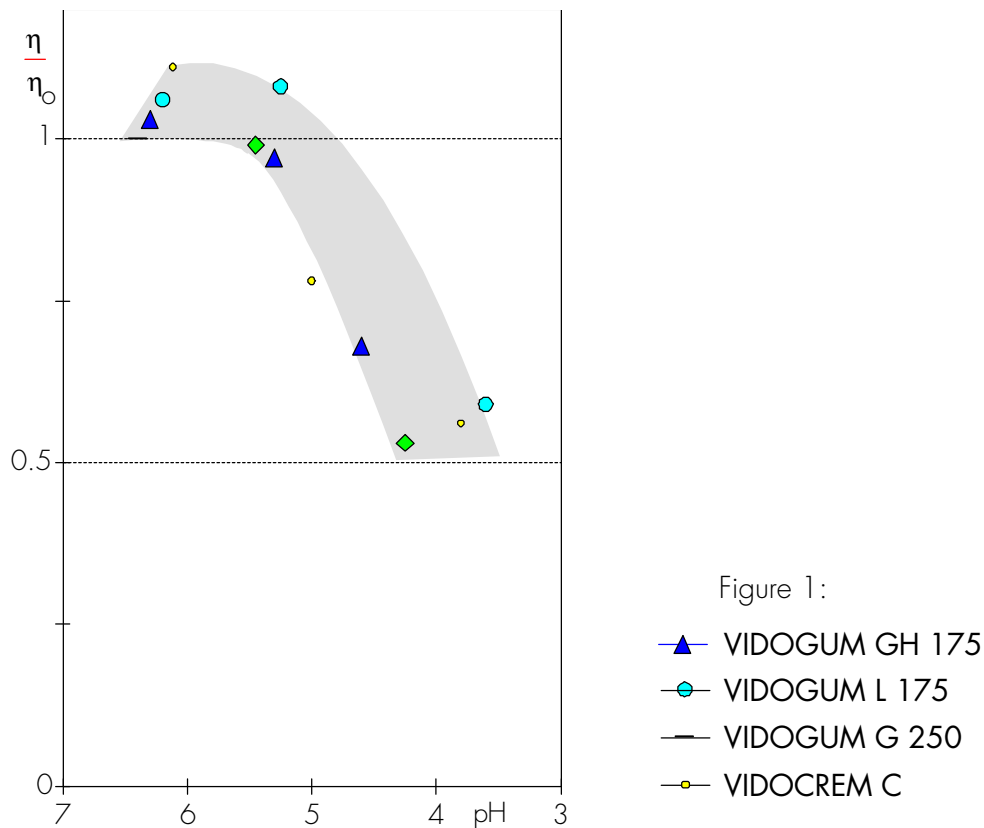


Figure 1

2.1 Influence of pH and temperature

No significant viscosity losses occur with galactomannan gums at a pH above 5 in spite of high temperature processing. Therefore galactomannans can be used in food products which are destined for UHT treatment, without worrying about any loss of effectiveness or viscosity. This is not true for food products at pH values below 5. Due to acid hydrolysis of the galactomannan chain an irreversible viscosity loss results.

The observations made indicate that all the galactomannans react in the same way under UHT treatment.

Homogenisation

Technical properties

Influence of homogenisation on pure aqueous galactomannan solutions as well as galactomannans combined with xanthan and carrageenan

1 Introduction / Experiment

The stability at different homogenisation pressures and at different pH-levels was analysed with 1 % aqueous galactomannan solutions and 0,5 - 1,0 % aqueous galactomannan/xanthan or kappa carrageenan solutions. The solutions were produced in a Stephankutter and left for 5min at 85 °C. Subsequently the 85°C solution was passed into a Gaulin-homogeniser and, after having taken a sample, cooled down in a water bath to 25°C.

Gum types / Concentration

1% VIDO GUM L 150, 175, 200

1% VIDO GUM GH 175, 200, 250

1% VIDO GUM G 120, 200, 250

1% VIDOCREM A, C, E, F

0,5% VIDO GUM L 175/κ-Carrageenan (30/70)

1% VIDO GUM L 175/Xanthan (50/50)

1% VIDO GUM SP 175/κ-Carrageenan (40/60)

Preparation of the solution

pH range:

3,6 / 4,6 / 6,7

Homogenisation pressures [bar]:

0/100/200/280

Temperature:

85°C

Material / Method

Brookfield Viscosimeter

Typ RVF

Stevens-Texture-Analyser

Temperature:

25°C

Measuring body:

TA2 / TA3

Penetration depth:

20mm

Speed:

0,5cm/min

8

2 Results / Discussion

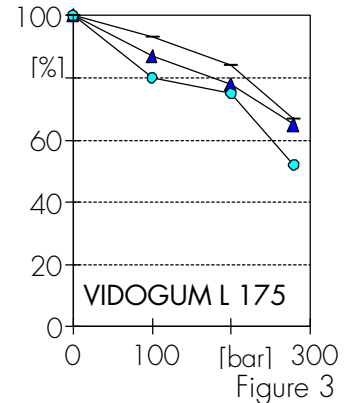
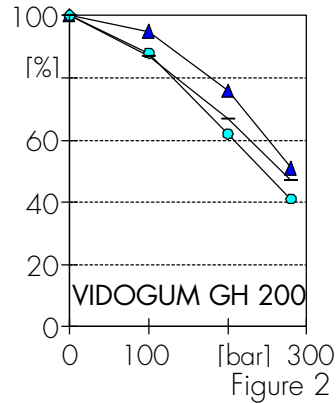
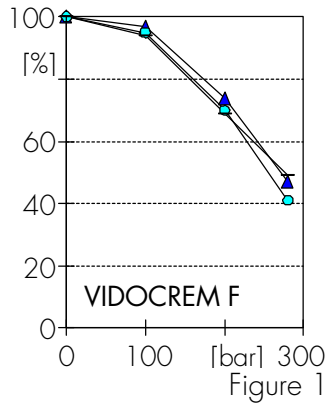
2.1 Pure Galactomannans

2.1.1 Influence of pH-value

The fluctuations occurring in each gum type (figures 1 - 3) are most probably due to test variations. This supposition is confirmed by the almost identical results in figure 1 as well as by the fact that in figure 3 no logical differences are noticeable (pH 4,6 and 6,7 are identical, pH 3,6 shows the smallest loss).

The viscosity loss due to homogenisation does not depend on the pH.

2.1.2 Viscosity loss at different pH-values ($\eta_{rel.}$ (f) bar)



Figures 1 - 3:
 ▲ = pH 6,7
 ● = pH 4,6
 ◆ = pH 3,6

2.1.3 Influence on galactomannan solutions

All gum types show a more or less marked viscosity loss caused by the homogenisation pressure.

2.1.4 Difference between the gum types

The 200-mesh products were taken for this comparison.

Figures 4, 5 and 7 show that differences exist between guar gums (VIDOGUM G, GH) and locust bean gum (VIDOGUM L) as well as between VIDOGUM G and GH as regards the residual viscosity after homogenisation at varying pressures.

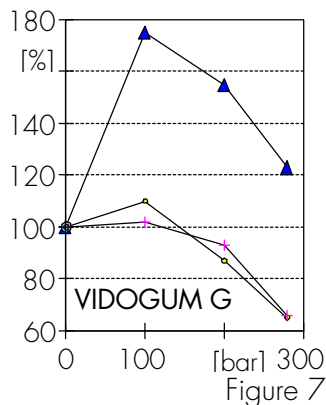
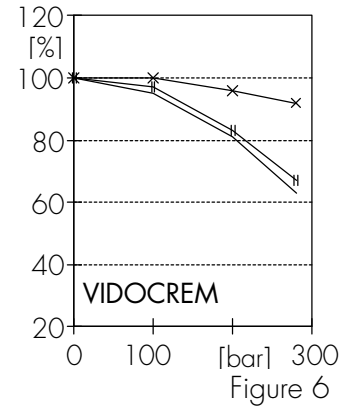
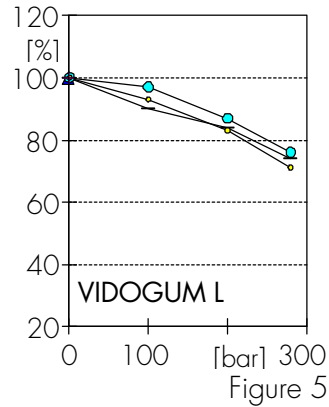
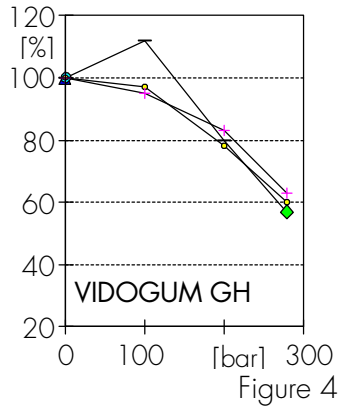
VIDOGUM L compared with guar gums is significantly more stable after homogenisation at pressures of < 100 bar, i.e. smaller viscosity loss

VIDOGUM G is more stable after homogenisation at pressures < 100 bar than the VIDOGUM GH type. At higher pressures their residual viscosities become closer

VIDOCREMS of the high viscosity type, i.e. VIDOCREM F, behave in the same way as the initial product VIDOGUM GH 200

Homogenisation

2.1.5 Viscosity loss at different particle sizes ($\eta_{rel.}(f)$ bar)



Figures 4 - 7:

- ▲ = Grain size approx. 120mesh
- = Grain size approx. 150mesh
- ◆ = Grain size approx. 175mesh
- = Grain size approx. 200mesh
- + = Grain size approx. 250mesh
- x = VIDO CREM A
- || = VIDO CREM C
- = VIDO CREM E

2.1.6 Different VIDO CREM - Types

Figure 6 clearly illustrates that very strongly degraded **VIDO CREM** types, i.e. low initial viscosity, are much more stable to pressure homogenisation. With increasing pressure this differing behaviour becomes more and more obvious.

2.1.7 Influence of the particle size

It seems that with **VIDO GUM L** the particle size has no influence on the residual viscosity after homogenisation at the pressures tested.

But with **VIDO GUM GH + G** a higher viscosity loss occurs with smaller particle sizes of the gum. The coarser gum types are able to increase their viscosity after homogenisation. This can be explained by the fact that more galactomannan molecules are liberated by the mechanical strain (homogenisation pressure) and are thus compensating for the viscosity loss caused by molecular destruction of the already active polysaccharides.

Homogenisation

2.1.8 Influence of the viscosity-ratio „cold-/hot viscosity“

Caused on the one hand by the standardisation of the particle size distribution and on the other hand by the different production processes of **VIDOGUM G** and **GH**, gums result with a defined differing before and after heating viscosity ratio. This defined behaviour exerts a big influence on the resulting residual viscosity after homogenisation. The smaller the ratio of before and after heating viscosity, i.e. the smaller the degree of dissolution, the more stable these gums are during homogenisation. A solution of the 'poorly' soluble **VIDOGUM G 120** gum, for example, after homogenisation at a pressure of 280 bar, shows an even higher viscosity than the corresponding initial solution.

2.2 Galactomannans with other hydrocolloids

2.2.1 Change of the gel stability and gel consistency

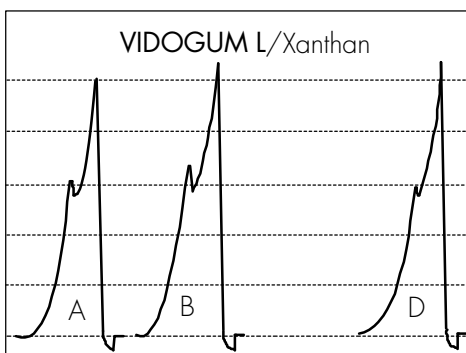


Figure 8

Figures 8 - 10: A: without Homogenization
 B: 100 bar homogenization pressure
 C: 200 bar homogenization pressure
 D: 280 bar homogenization pressure

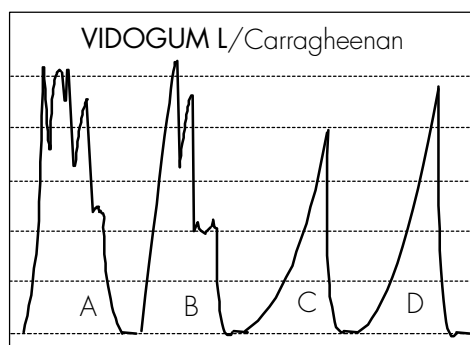


Figure 9

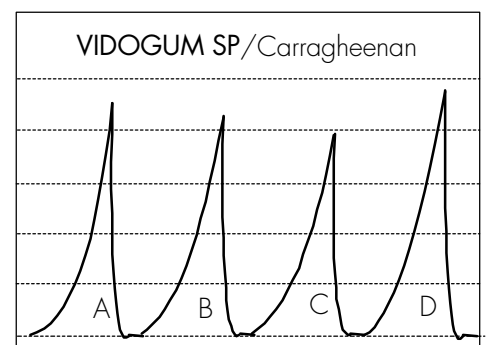


Figure 10

Figures 8 - 10 show that the gel strengths of the three different gel types is not changed significantly by a pressure homogenisation step (up to 280 bar). However, gels in combination with carrageenan are made more sensitive to syneresis. This greater susceptibility to syneresis is most probably directly related to the degrading of the galactomannan molecule, i.e. viscosity loss indicates lower water binding ability. This effect could not be observed in gels with xanthan, since the stable xanthan molecule probably absorbs any syneresis that occurs.

Although galactomannans are degraded when submitted to pressure homogenisation, when combined with other hydrocolloids they have the same gel strength. This leads to the conclusion that gel strength is not related to the initial viscosity of the galactomannan.

2.3 Influence of the molecules

Some of the homogenised solutions were also analysed for free galactose and free mannose. No free sugar units were found. This indicates that the polysaccharide molecule is not changed in its galactose-mannose composition during homogenisation, but that the mannose main chain is split (smaller molecules = lower viscosities) Therefore the low viscosity **VIDOCREM A, B** and **C** (strongly degraded or depolymerized guar molecules) are less sensitive to pressure homogenisation.

Freeze/thaw stability

Technical properties

Freezing is an important technology to prolong the shelf life of foodstuffs. Before consuming such products a thawing and/or a further heating process is usually necessary. For this reason it is important to know how the galactomannan solutions and gel mixes with galactomannans behave under these conditions.

1 Introduction / Experiment

VIDOGUM products are used in frozen products as thickening and stabilising agents. Also VIDOGELE products, i.e. galactomannans in combination with other gelling hydrocolloids can be used. The stability during the freezing and thawing process as well as a further heating step was tested. Conclusions will be drawn as to the criteria upon which the choice of the most suitable type should be based for use in frozen products.

| | |
|---------------------------|---|
| Gum types / Concentration | 0,3 - 1% VIDOGELE L 175 0,7 - 1% VIDOGELE GH 200 0,8 - 1% VIDOGELE SP 200 0,8 - 1% VIDOCREM E 0,5 % VIDOGELE L 175 / κ-Carrageenan (30/70) 1% VIDOGELE L 175 / Xanthan (50/50) 1% VIDOGELE SP 200 / Xanthan (50/50) 1% VIDOGELE SP 200 / κ-Carrageenan (40/60) |
|---------------------------|---|

Preparation of the solution

The solutions and the gels were produced according to the UP-method.

| | |
|----------|---------------------------|
| Freezing | min. 24h at approx. -30°C |
| Thawing | over night at 25°C |

9

Material / Method

| | |
|--------------------------|----------------|
| Brookfield-Viscosimeter: | Typ RVF (25°C) |
| Spindle: | 2-3 |
| Speed: | 20U/min |
| Stevens-Texture-Analyzer | |
| Penetration depth | 20mm |
| Speed | 0,5cm/min |
| Measuring body | TA2 / TA3 |

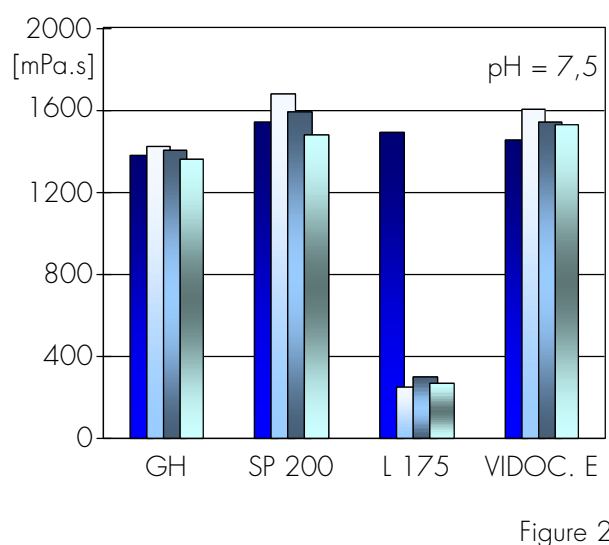
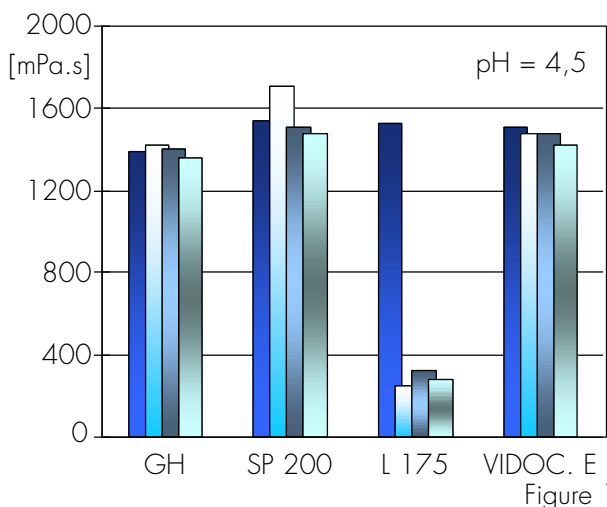
2 Results / Discussion

2.1 Galactomannan-solutions

2.1.1 Comparison of stability at identical viscosities

To obtain a constant viscosity, different concentrations were used. The freezing and thawing process was carried out 3 times. The pH-values of the solutions were regulated with citric acid before the first freezing process.

Figure 1 and 2



As illustrated in the figures, the viscosity values of **VIDOCREM E**, **VIDOGUM SP** and **VIDOGUM GH** remain more or less constant, even after 3 freezing and thawing processes. Also the differing pH-ranges, approx. 4,5 and approx. 7,5, do not show a significant effect. The measured viscosity stability was also supported by the visual assessment of the solutions.

i.e.: no differences are noticeable between the initial solutions and the treated solutions with regard to consistency, mouth feel, etc.

Contrary to the 3 mentioned gum types above, the **VIDOGUM L** (locust bean gum) suffers an extreme viscosity loss after only the first freezing and thawing process, which after a longer standing time (approx. 24 h) at 25 °C is deemed to be irreversible.

The solution obtained was judged to be non-homogeneous, i.e. gel-like solid matter in an aqueous phase.

2.1.2 Influence of the viscosity on freeze/thaw stability

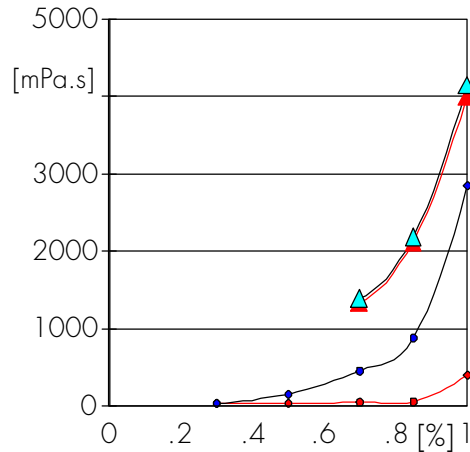
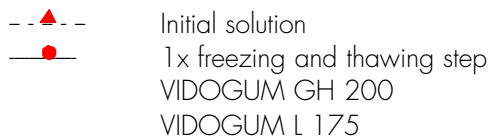


Figure 3

To clarify how far the viscosity loss of **VIDOGUM L** and the viscosity stability of **VIDOGUM GH** are dependent on the initial viscosity, solutions with different concentrations in the neutral range were produced hot and frozen once.

Figure 3 shows that with **VIDOGUM L** throughout the concentration range a more or less marked viscosity difference between the original solution and the thawed solution results. Besides this measured effect a clear inhomogeneity of the solutions was noticed after the freezing and thawing process.



Tests with **VIDOGUM GH** show that, even at high initial viscosities (approx. 4500 mPa.s), almost no viscosity loss is caused by the freezing process. Although the differences in the viscosities measured are negligible, the visual judgement of the solution with the highest initial viscosity did show differences, i.e. the treated solution is more like a gel, which no longer shows a constant outflow.

2.1.3 Influence of the subsequent heating on a 1 time frozen VIDO GUM L solution

For this purpose three 1 % **VIDOGUM L** solutions were produced hot, frozen and thawed again to 25°C. The thawed samples were subsequently heated to 85°C (= hot viscosity) and again cooled down to 25°C.

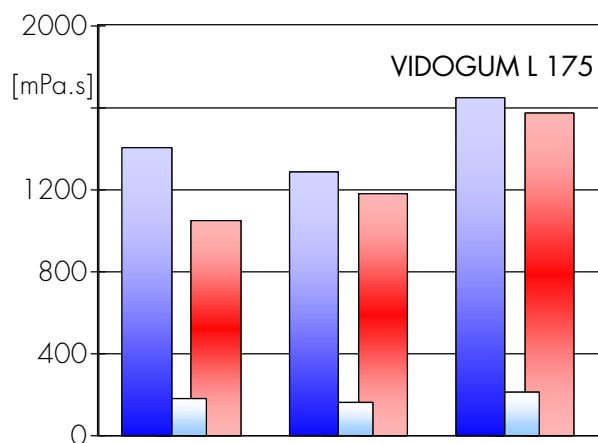


Figure 4

As shown in this illustration the viscosity loss suffered is almost completely reversible by heating to 85°C.

The visual assessment also gave no indication of big differences between the initial and the reheated solutions.



Freeze/thaw stability

2.1.4 Freeze/thaw stability of cold produced solutions

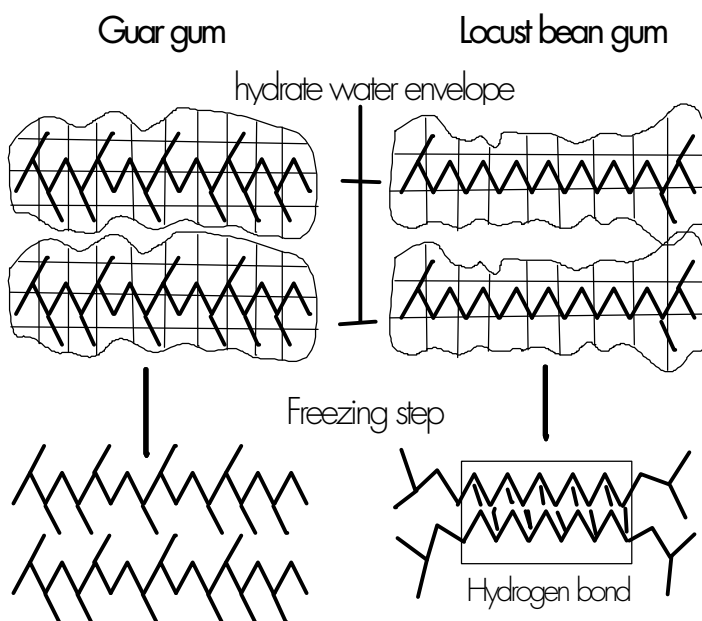
Since solutions of **VIDOGUM GH**, **VIDOGUM SP** and **VIDOCREM E** produced using heat have proved to be stable, we can assume that the cold produced solutions also remain stable, particularly since the initial viscosity would be lower. Tests were therefore only made with **VIDOGUM L** at an applied concentration of 1 % and with a single freezing and thawing process. The values in table 1 show only slight differences with the solutions produced without heat. No significant changes were established in the appearance.

| Initial solution [mPa.s] | Viscosity after freezing/thawing process [mPa.s] |
|--------------------------|--|
| 250 | 220 |
| 140 | 120 |
| 180 | 160 |

2.1.5 Summary/conclusion

We have now seen that hot produced aqueous solutions of **VIDOGUM GH**, **VIDOGUM SP** and **VIDOCREM** do not show any or only negligible viscosity loss after having been frozen to approx. -30°C and thawed to 25°C 3 times. The frozen and thawed solutions shows no significant differences from the initial cold produced solutions of the galactomannan types mentioned which would have the same stability, particularly since the initial viscosity would be lower.

This statement is only valid as long as the initial viscosity does not exceed approx. 4000 mPa.s, since at these high viscosities a single freezing and thawing process results in solutions judged as being non-homogeneous (gel-like) and no longer allowing a steady flow.



Contrary to the more or less easily cold soluble mentioned gum types, the hot produced solution of the "poorly-soluble"

VIDOGUM L shows a distinct viscosity and quality loss after just one freezing and thawing process. A quality loss occurs because a non-homogeneous solution results (= gel-like solid matter in aqueous phase). This statement is true for the concentration range from 0,3 - 1,0 % i.e. for the viscosity range of 50 - 2550 mPa.s. If subsequent heating of the non-homogeneous solution to 85°C occurs, the viscosity loss suffered, as well as the non-homogeneity, is almost 100 % reversible.

Freeze/thaw stability

Contrary to the hot produced solutions, the cold prepared suspensions of **VIDOGUM L** in water are not sensitive to freezing and thawing processes.

The effect of the viscosity loss on hot produced **VIDOGUM L** solutions is surely comparable with starch retrogradation i.e. depending upon the freezing process, the water of the hydrated Carubin-molecule (= active ingredient of **VIDOGUM L**) is extracted, leading to an insoluble secretion. This supposition is strengthened by the fact that the effect noticed is reversible by heating and that, on the other hand, a cold suspension of **VIDOGUM L** (non-hydrated carubin-molecules) suffers no quality and no viscosity loss through the freezing and thawing process.

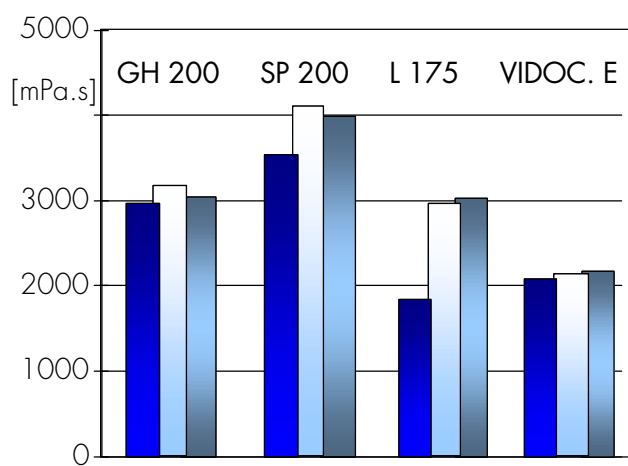


Figure 5



If the freeze/thaw stability is tested in an emulsion e.g. ice-cream-mix instead in water, the results differ (figure 5), especially with **VIDOGUM L**. The cold soluble galactomannans **VIDOGUM GH**, **VIDOGUM SP** and **VIDOCREM** results in the different media are almost identical. With **VIDOGUM L** a viscosity increase results after the thawing process instead of a viscosity decrease. Lipoproteins are present in O/-W emulsions through the interaction between lipids and milk proteins. These build a protective membrane, which is shown as a 3-dimensional network. It is thought that this network reduces the mobility of the aqueous phase and therefore also avoids the formation of the partial gel particles of **VIDOGUM L**, which usually result from freezing.

Therefore the free water in the network is retained within the gel particles and this results in a viscosity increase.

Freeze/thaw stability

2.2 Galactomannan - mixed hydrocolloid gels

2.2.1 Influence on the gel strength

As would be expected, it is found that the mixed hydrocolloid gels would be freeze/thaw stable due to the gel matrix formed. The matrix is built upon micro-crystalline areas (e.g. double-helix band association), which do not dissolve, thus giving the expected result.

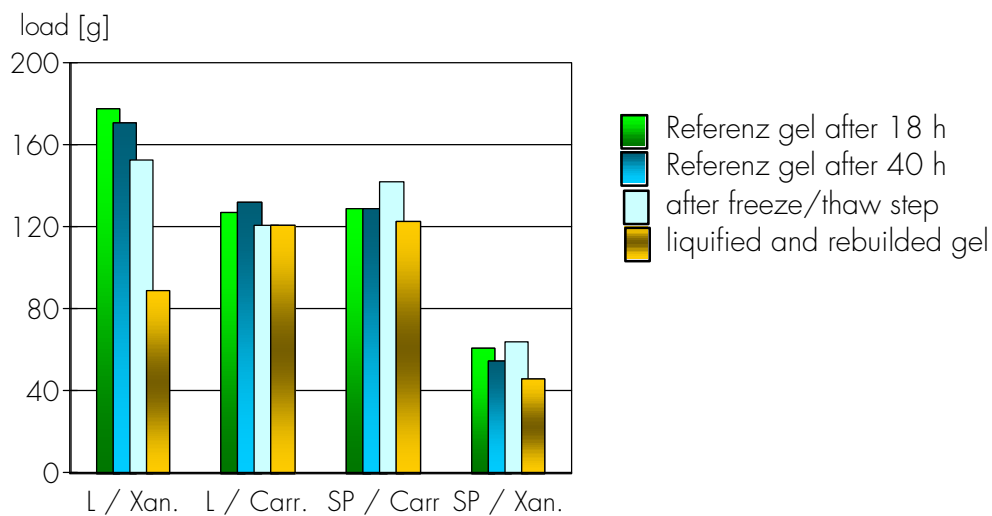


Figure 6

The freezing and subsequent thawing to 25°C results in a minimal loss of gel strength.

2.2.2 Syneresis

It was observed that syneresis was more significant from the test gel after thawing, than from the freshly prepared, unfrozen gel. The frozen and thawed, mixed hydrocolloid gels made with **VIDOGUM SP** were preferred, on visual examination, to those made with **VIDOGUM L**.

2.2.3 Appearance

The **VIDOGUM L** gels showed a significant cloudiness after the freeze/thaw process unlike the **VIDOGUM SP** gels. The elasticity of the **VIDOGUM L** gels is also reduced. For these reasons also the mixed hydrocolloid gels with **VIDOGUM SP** were preferred.

Interaction with modified starch

Technical properties

Galactomannans exhibit synergism when combined with modified starches. The viscosity can be greatly increased by blending with acetylated distarch adipate.

1 Introduction / Experiment

Firstly the size of the viscosity increase of galactomannan-starch blends both at 25°C and after a heating process was analysed. Secondly the stability of such blends under acid conditions (pH = 3,5), and at higher temperatures were examined.

Gum types / Concentration

- 1% VIDO GUM GH 200
- 1% VIDO GUM SP 200
- 1% VIDO GUM L 175
- 1% VIDO CREM C
- 1% acetylated distarch adipate (E 1422)
- 2% galactomannan / starch 1:1

Preparation of the solution

Stir 2% galactomannan/starch in water and homogenise for 10 min. with the Ultra-Turmix. Keep at 121°C in the Autoclave for 10 min. and cool down to 25°C within 20 min. Adjust the solution with citric acid (50%) to the pH required.

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Cold and hot viscosity UNIPEKTIN standard method

2 Results / Discussion

2.1 Influence on the cold viscosity

| | cold viscosity | | viscosity increase | |
|-----------------|---------------------------|------------------------|--------------------|-----|
| | without starch [mPa.s] | with starch [mPa.s] | [mPa.s] | [%] |
| modified starch | - | - | - | |
| VIDO GUM GH 200 | 3600 | 6260 | 2660 | 74 |
| VIDO GUM SP 175 | 2910 | 5600 | 2690 | 92 |
| VIDO GUM L 175 | 80 | 150 | 70 | 87 |
| VIDO CREM C | 440 | 1020 | 580 | 131 |

2.2 Influence on the hot viscosity

| | hot viscosity | | viscosity increase | |
|-----------------|-------------------------|----------------------|--------------------|-----|
| | without starch mPa.s | with starch mPa.s | mPa.s | % |
| modified starch | 10 | - | - | |
| VIDOGUM GH 200 | 4200 | 6080 | 1880 | 45 |
| VIDOGUM SP 175 | 3550 | 6790 | 3210 | 90 |
| VIDOGUM L 175 | 2610 | 5830 | 3220 | 123 |
| VIDOCREM C | 462 | 1490 | 1028 | 223 |

These tests show a distinct viscosity increase when galactomannans are combined with an acetylated distarch adipate, i.e. there is a significant synergistic effect. This phenomenon occurs with the cold soluble galactomannan at 25°C. As shown, the extent of the synergistic effect is dependent on the type of galactomannan and therefore also the galactose/mannose ratio and the molecule size of the galactomannan. The lower the galactose level, the more significant the viscosity increase, i.e. a smaller viscosity increase in the series LBG→Tara→Guar. The smaller the molecule, the bigger the viscosity increase, i.e. a larger viscosity increase using VIDOCREM than using VIDOGUM GH.

2.3 Synergistic effect in the acid medium at 85°C

The following figures 1 to 4 illustrate an improved acid stability because of the interaction with acetyl. distarch adipate. As the tests show, the degree of the acid stability improvement decreases from VIDOGUM GH → VIDOGUM SP → VIDOGUM L. This means that the galactose/mannose ratio has an important effect.

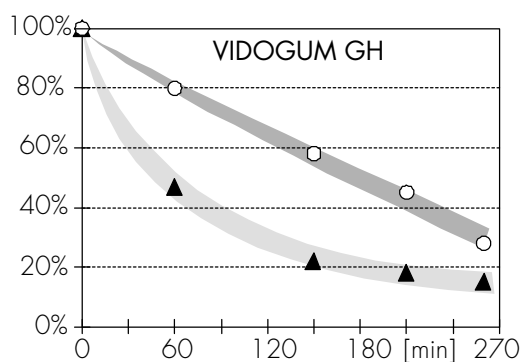


Figure 1

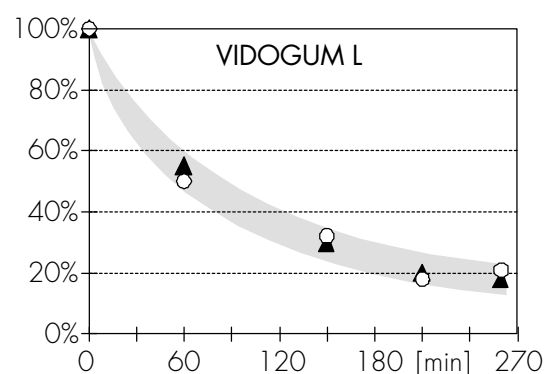


Figure 2

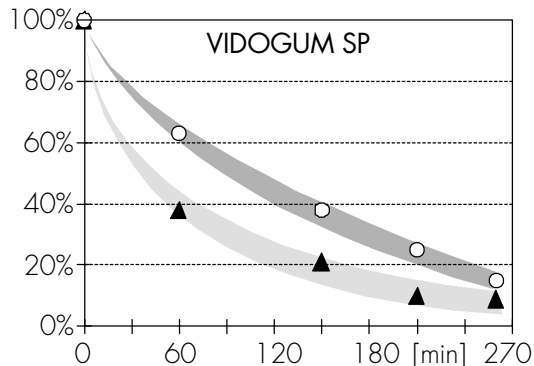


Figure 3

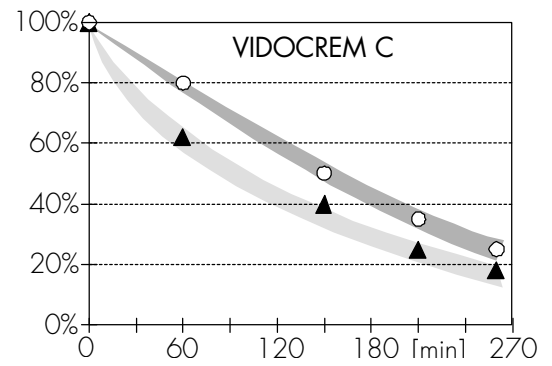


Figure 4

Diagrams 1-4: ○ galactomannans + starch 1+1 ▲ galactomannans pure

The viscosity stability in acid aqueous solutions (pH 3,5) at 85°C can sometimes be improved using the interaction between galactomannans and acetylated distarch adipate. Again the effects depend on the galactose/mannose ratio, but in the reverse order. This means that the stability improvement is better with galactomannans with a higher galactose content, i.e. decreasing stability effect in the series Guar → Tara → LBG.

Similarly the synergistic effect on the stability is reduced with lower molecule weight.

Apparently the galactose/mannose ratio of **VIDO GUM L** is changed by acid hydrolysis, so that the synergistic effect is proportional to the viscosity loss of the pure LBG. Over a period of time the synergistic effect is unchanged or strengthened when using **VIDO GUM SP** and, more noticeably, when using **VIDO GUM GH**. This strengthening can be explained if we suppose that the guaran molecule is being hydrolysed to the same extent as it would be without starch. A slight reduction occurs, but the starch exerts a protective effect and thus only slightly affects the total system.

The first possibility i.e. strengthening of the synergism, seems to be more realistic since, in case of a protective effect the system **VIDO GUM L**/starch should theoretically be stable than pure LBG.

3 Summary

The above conclusions indicate that the starch does not protect against acid hydrolysis, since in case of protection, all galactomannan types should theoretically behave identically. They do, however, lead to the conclusion that the galactose/mannose ratio of the guaran molecule, for example, because of the acid-hydrolysis, is changed so that synergistic effect is greater (with a higher ratio the synergism is greater).

A definite increase in viscosity stability can also be observed during creep tests at room temperature of **VIDO GUM GH**/starch and **VIDO GUM L**/starch solutions in an acid medium in the same way as tests at 85°C.

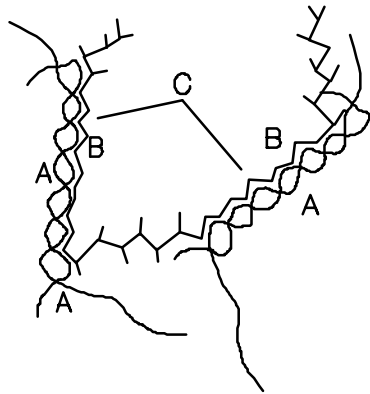
Interaction with κ -Carrageenan

Technical properties

Locust bean gum and tara gum exhibit synergistic interactions with kappa-Carrageenan, which can result in a significant gel strength increase. By adjusting the ratio of the gums the texture and structure of the gel can be affected.

1 Introduction / Experiment

The galactomannans locust bean gum and tara gum, because of their molecular structure can form intermolecular interactions. Hydrogen bonding can take place between the galactose free areas of the galactomannan (B) and the double helix structure of the carrageenan molecule (A) as shown by the microcrystalline areas (C) in the diagram. The gel network is therefore strengthened. The effects of different blends upon the structure using carrageenan with VIDO GUM L and / or VIDO GUM SP were tested and reported as follows.



Gum types / Concentration

0.5-1% Blends of κ -Carrageenan
 - with VIDO GUM L 175
 - with VIDO GUM SP 175
 - with VIDO GUM PET 0

Blending ratio 0-100%

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Gel preparation

Mix the galactomannan-carrageenan blend with sugar [5%] and stir it into hot water. Boil it for 8min and adjust the evaporated water. Fill the solution into the jellifying rings and let it cool for 16-18h at room temperature.

Gel strength (Stevens-Texture-Analyser)

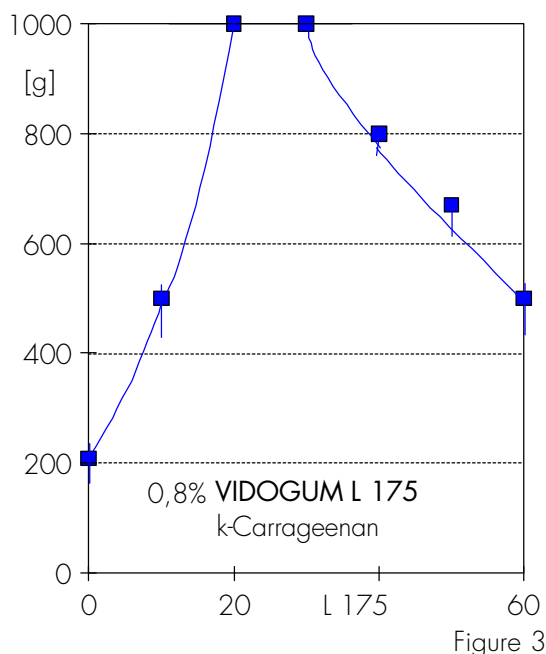
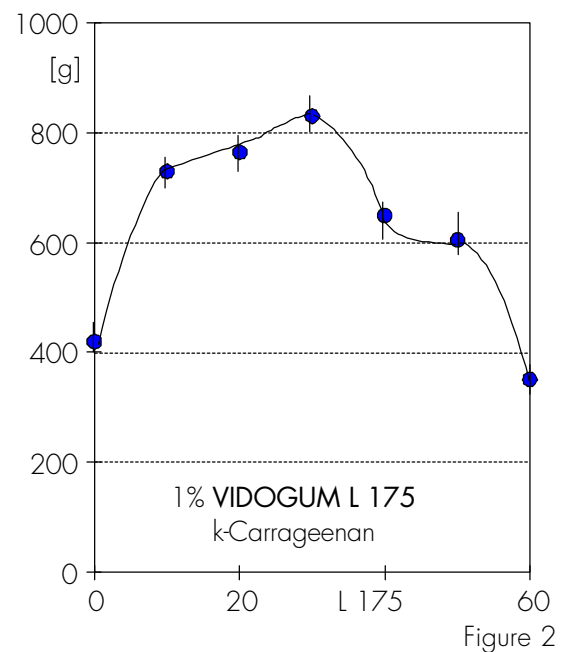
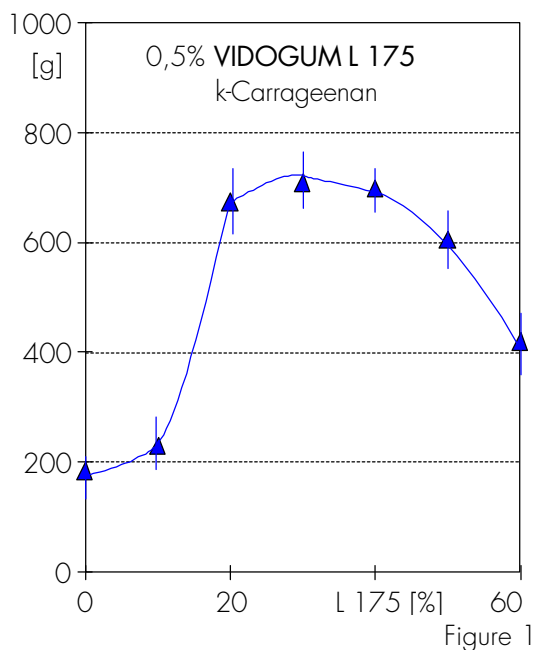
Measuring body: TA2 / TA3
 Speed: 0.5mm/s
 Penetration depth: 20mm
 Measuring Temperature: 20-22°C

2 Gels with locust bean gum

2.1 Ideal blend ratio

The most significant synergistic effect is obtained with the blend ratio 70 % carrageenan/30 % locust bean gum in aqueous sucrose solutions. Other components in and the physical properties of the solution e.g. pH value, salt content etc., can significantly affect the ideal blend ratio, and the synergistic effect of the two gums is less significant in the finished food product.

The stability of the gel can be improved by increasing the proportion of locust bean gum.



Figures 1-3:

- ▲ 20% sugar/measuring body TA3
- 20% sugar/measuring body TA2
- 5% sugar/measuring body TA3

Interaction with κ -Carrageenan

2.2 Change of colour, taste and consistency

The different blend ratios not only affect the gel strength, but can also affect the colour and texture of the gel. This has to taken into account when developing food products.

| blend [1%] | colour | consistency |
|------------------------------------|-----------------------|---------------|
| 100% Carrageenan | bright, clear | hard, brittle |
| 90% Carrageenan 10% VIDO GUM L 175 | opalescent, cream | hard |
| 80% Carrageenan 20% VIDO GUM L 175 | opalescent, cream | hard |
| 70% Carrageenan 30% VIDO GUM L 175 | turbid, cream | hard, elastic |
| 60% Carrageenan 40% VIDO GUM L 175 | turbid, cream | elastic |
| 50% Carrageenan 50% VIDO GUM L 175 | turbid, brownny cream | soft, elastic |
| 40% Carrageenan 60% VIDO GUM L 175 | turbid, dark cream | soft, elastic |

| blend [0.5%] | colour | consistency |
|------------------------------------|------------------------|---------------|
| 100% Carrageenan | bright, clear | brittle |
| 90% Carrageenan 10% VIDO GUM L 175 | opalescent | |
| 80% Carrageenan 20% VIDO GUM L 175 | opalescent, cream | hard, elastic |
| 70% Carrageenan 30% VIDO GUM L 175 | slightly turbid, cream | hard, elastic |
| 60% Carrageenan 40% VIDO GUM L 175 | turbid, cream | elastic |
| 50% Carrageenan 50% VIDO GUM L 175 | turbid, cream | soft, elastic |
| 40% Carrageenan 60% VIDO GUM L 175 | turbid, brownny cream | soft, elastic |

2.3 Influence of preparation temperature

For this purpose 0.5 % gels were produced in 5 % sucrose solutions, consisting of VIDO GUM L 175 and kappa-carrageenan (30/70). The gel production and testing procedures were as mentioned before, except that the preparation temperature varied between 65 °C and approx. 95 °C.

No significant differences were shown between the maximum gel strength and the end gel strength measurements at the different preparation temperatures. It is expected that at preparation temperatures <65 °C the gel strength would decrease, on the basis that the gel strength at 65 °C showed a small decrease. A gel does not form unless a heating stage is carried out. During the strength measurements it was observed that the first structural breakdown of the gel occurred earlier at lower preparation temperatures (65 °C), and that the structural breakdowns were more frequent, is the gels

Interaction with κ -Carrageenan

were more brittle when less heat was used to produce them. This means that the gel texture, in particular elasticity has been affected. This reduced elasticity can be explained by assuming that at the lower preparation temperatures, the **VIDOGUM L 175** and carrageenan intermolecular interactions are in-

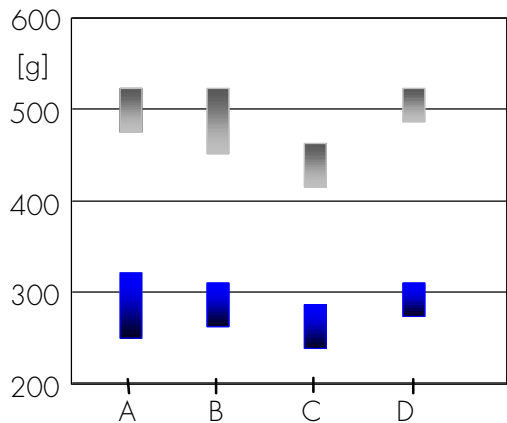


Figure 4

Figure 4:

max. gel strength
 final gel strength

A: ~96°C normal pressure
 B: 80°C normal pressure
 C: 65°C normal pressure
 D: 65°C vacuum at 170mbar

completely formed, allowing the significantly more brittle carrageenan gel structure to predominate.

3 Gels with tara gum

3.1 Ideal blend ratio

Tara gum can also synergistically increase the gel strength of carrageenan, but the interactions are less significant than with locust bean gum. The optimum blend ratio of tara gum and carrageenan is shown in the following diagram.

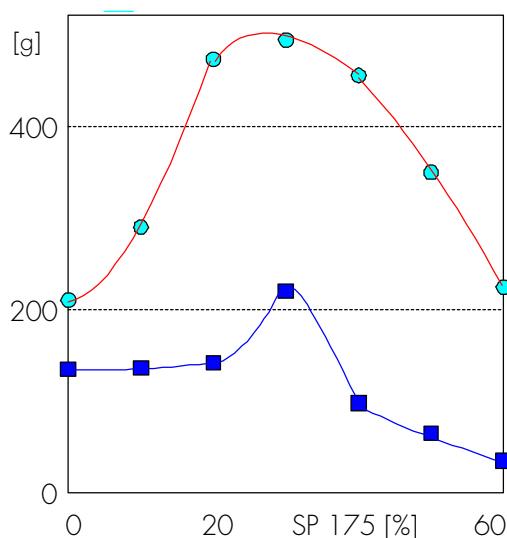


Figure 5

Figure 5:

0.8% VIDO GUM SP 175/ κ -Carrageenan with 20% sugar, measuring body TA3
 0.5% VIDO GUM SP 175/ κ -Carrageenan with 5% sugar, measuring body TA3

Interaction with κ -Carrageenan

3.2 Characteristics of tara gum/carrageenan mixed gels

The gel stability of tara gum/carrageenan mixed gels is significantly lower than the mixed gels using locust bean gum, although the optimum blend ratio is the same at 30 % tara gum/70 % carrageenan. However once again, there are colour and texture changes when using mixed gels with tara gum.

| blend [1%] | colour | consistency |
|-------------------------------------|------------------------|---------------|
| 100% Carrageenan | bright, clear | brittle |
| 80% Carrageenan 20% VIDO GUM SP 175 | opalescent, cream | hard, elastic |
| 70% Carrageenan 30% VIDO GUM SP 175 | slightly turbid, cream | hard, elastic |
| 60% Carrageenan 40% VIDO GUM SP 175 | turbid, cream | elastic |
| 40% Carrageenan 60% VIDO GUM SP 175 | turbid, brownish cream | soft, elastic |

3.3 The effect of concentration upon gel strength

As shown in figure 6, the gel strength and concentration are not related linearly. This is confirmed for Tara gum by the following diagram showing the gel strength at various concentrations of mixed gels

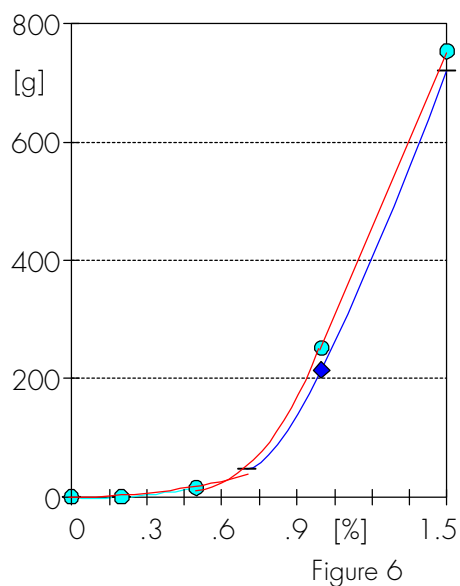


Figure 6:

- VIDO GUM SP 175/κ-Carrageenan (30/70)
- ◆ VIDO GUM PET 0/κ-Carrageenan (30/70)

prepared using **VIDO GUM SP 175** and VIDO GUM PET 0 with carrageenan (ratio 30/70) in 5 % aqueous sugar solutions. The gel strength shows an exponential increase with concentration as the viscosity does.

It is interesting to note that **VIDO GUM PET 0** (petfood grade) reaches the same gel strength as the corresponding food grade, even though the viscosity is less.

4 Conclusion

By mixing κ -carrageenan with VIDOGLUM L or VIDOGLUM SP 175 an increase of the gel-strengths can be obtained as with pure κ -carrageenan, with the following differences:

- mixed gels are significantly cheaper.
- through the change of the ratio VIDOGLUM L/carrageenan the consistency can be adjust from brittle to very elastic.
- mixed gels are more elastic and less sensitive to syneresis.
- mixed gels will eventually show an increase in the turbidity.

Interaction with Agar-Agar

Technical properties

Locust bean gum and tara gum react together with agar-agar giving synergistic interactions which can result in an increase of the gel strength. The consistency and the structure of the gel produced is dependant upon the ratio of the gums used in the blend.

1 Introduction / experiment

The galactomannans locust bean gum and tara gum are capable of entering into intermolecular interactions with agar-agar analogous to their behaviour with kappa-carrageenan, due to their molecular structure. By forming hydrogen bonds between the galactose-free zones in the galactomannan molecules and the double-helix association of agar-agar, micro-crystalline areas result. In this way the gel network gets stronger. The measurement and analysis of different blends of agar-agar with VIDO GUM L and/or VIDO GUM SP are discussed below:

Gum types / Concentration

0-0.8% Agar-Agar
 0.8% Blends of Agar-Agar
 - with VIDO GUM L 175
 - with VIDO GUM SP 175
 Blending ratio 0-70%

Gel preparation

Mix the galactomannan-agar blend with sugar [5%] and stir it into hot water. Boil it for 8min and adjust the evaporated water. Fill the solution into the jelling rings and let it cool for 16-18h at room temperature.

11

Gel strength (Stevens-Texture-Analyser)

Measuring body: TA3
 Speed: 0.5mm/s
 Penetration depth: 20mm
 Measuring temperature: 20-22°C

2 Gels with Agar-Agar

Ideal blend proportions

The biggest synergistic effect is obtained in aqueous 5% sugar solution with a blend ratio of 70% agar-agar / 30% locust bean gum or 80% agar / 20% tara gum. In contrast to the behaviour with kappa-carrageenan, the increase of the gel strength is not so strongly marked. The ideal blend proportion is also dependent upon the other components in the system (TS, pH-value, salt content etc.).

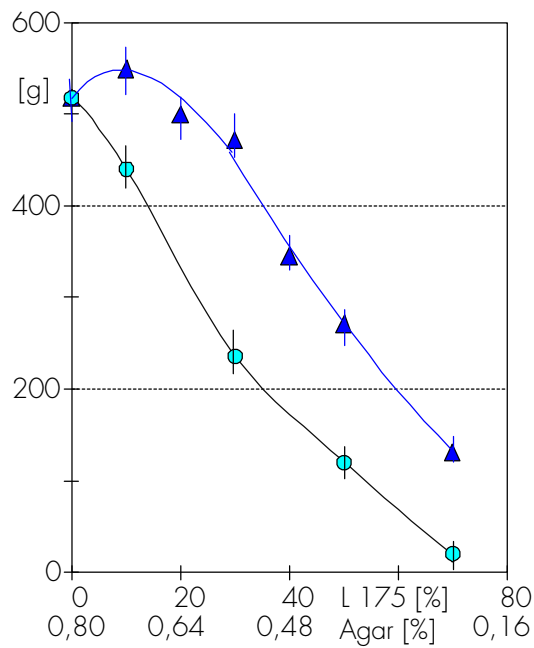


Figure 1

Figure 1:

- ▲ 0.8 VIDO GUM L 175/Agar-Agar
- 0.24-0.8% Agar-Agar

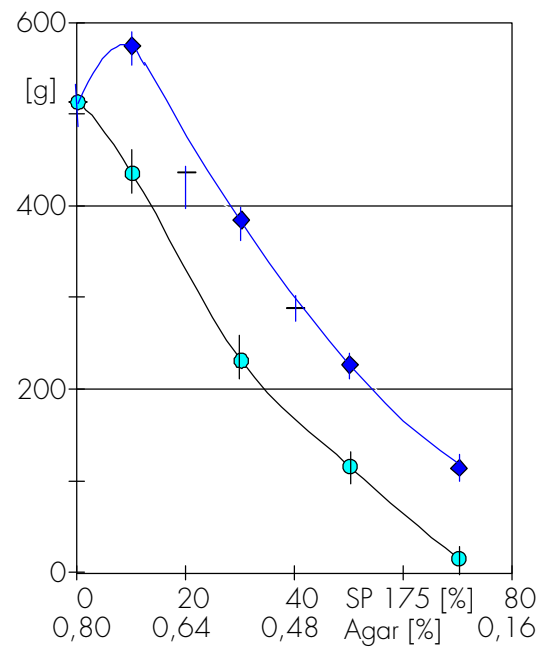


Figure 2

Figure 2 :

- ◆ 0.8 VIDO GUM SP 175/Agar-Agar
- 0.24-0.8% Agar-Agar

The stability of the gels in relation to syneresis is improved by increasing the level of **VIDO GUM L** and the effect is more marked with **VIDO GUM SP**.

2.2 Change of colour, taste and consistency

The different blend proportions not only influence the gel strength but can result in gels differing in colour and taste, both of which have to be considered in the development of foods.

| Blend ratio [0.8%] | colour | consistency |
|----------------------------------|-----------------------|---------------------|
| 100% Agar-Agar | white / turbid | firm |
| 90% Agar-Agar 10% VIDO GUM L 175 | white / turbid | firm |
| 80% Agar-Agar 20% VIDO GUM L 175 | white / turbid | firm |
| 70% Agar-Agar 30% VIDO GUM L 175 | white / turbid | firm / elastic |
| 60% Agar-Agar 40% VIDO GUM L 175 | white-yellow / turbid | elastic |
| 50% Agar-Agar 50% VIDO GUM L 175 | bright-cream / turbid | soft / elastic |
| 30% Agar-Agar 60% VIDO GUM L 175 | cream / turbid | very soft / elastic |

| Blend ratio [0.8%] | colour | consistency |
|-----------------------------------|-----------------------|---------------------|
| 100% Agar-Agar | white / turbid | firm |
| 90% Agar-Agar 10% VIDO GUM SP 175 | white / turbid | firm / elastic |
| 80% Agar-Agar 20% VIDO GUM SP 175 | white / turbid | elastic |
| 70% Agar-Agar 30% VIDO GUM SP 175 | white-yellow / turbid | elastic |
| 60% Agar-Agar 40% VIDO GUM SP 175 | bright-cream / turbid | soft / elastic |
| 50% Agar-Agar 50% VIDO GUM SP 175 | cream / turbid | soft / elastic |
| 30% Agar-Agar 70% VIDO GUM SP 175 | brownish / turbid | very soft / elastic |

Due to naturally occurring substances in the galactomannan gums slightly cream to brownish gels result as the ratio increases. Pure agar-agar-gels are slightly opalescent to white turbid.

3 Conclusion

By mixing agar-agar with VIDO GUM L or VIDO GUM SP 175 identical gel-strengths can be obtained as with pure agar, with the following differences:

- mixed gels are significantly cheaper
- mixed gels are more elastic and less sensitive to syneresis
- mixed gels will eventually show an increase in colour from cream to brown

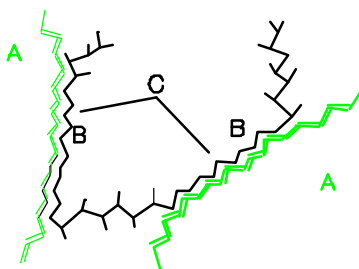
Interaction with Xanthan

Technical properties

Galactomannans exhibit synergism in aqueous solutions with xanthan gum but with differences which depend upon the galactomannan type. Gels can be formed with xanthan gum and VIDO GUM L or VIDO GUM SP. When xanthan gum is used with VIDO GUM GH, VIDO GUM G and VIDO CREM there is synergy, but only a viscosity increase is noticeable.

1 Introduction

The galactose-free portions of the locust bean gum and tara gum molecules (B) are capable of forming hydrogen bridges with the xanthan molecule (A) and because of their irregular distribution of the galactose molecules, this can result in gel formation via the helix-band-association (C). This formation (C) is known as the microcrystalline area of the complex formed. In contrast to the above galactomannans, the galactose-free portions of the guar gum molecule are very small so that only very small microcrystalline zones can be formed which are not sufficient to form a gel at the concentrations commonly in use. The following tests should show how the synergism mentioned above is affected under various conditions.



2 Experiment with tara and locust bean gum

Gum types / Concentration

0.5-1% Blends of Xanthan
 - with VIDO GUM L 175
 - with VIDO GUM SP 175
 Blending ratio 0-100%

Aqueous phase

5% sugar or 5.8% NaCl
 5% sugar with citric acid pH 3-7

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Gel preparation

Mix the galactomannan-xanthan blend with sugar or salt and add it into hot water. Boil it for 8min and adjust the evaporated water. Fill the hot solution into the jellying rings and let it cool for 16-18h at room temperature.

Gel strength (Stevens-Texture-Analyser)

Measuring body: TA2 / TA3
 Speed: 0.5mm/s
 Penetration depth: 20mm
 Measuring temperature: 20-22°C

3 Results/Discussion

3.1 Ideal blend ratio

The greatest synergistic effect between **VIDOGUM L** and xanthan gum is obtained with a 50/50 blend of xanthan gum and locust bean gum in both test solutions. The same blend ratio (50/50) between **VIDOGUM SP** and xanthan gum also gives the maximum attainable gel strength (figures 1+2). The extent of the synergistic reaction with tara gum is significantly lower, which is as expected because of the higher galactose level in the tara polysaccharide.

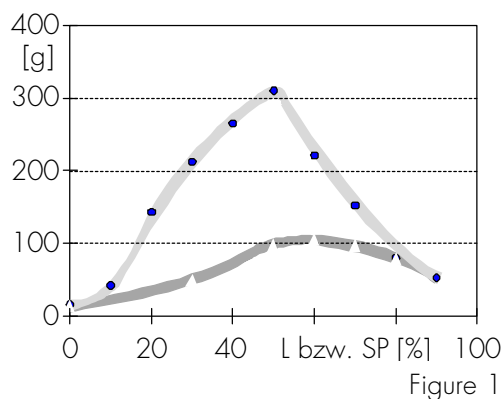


Figure 1: 1% Galactomannan/Xanthan with 5% sugar
 ● VIDO GUM L 175/Xanthan
 △ VIDO GUM SP 175/Xanthan

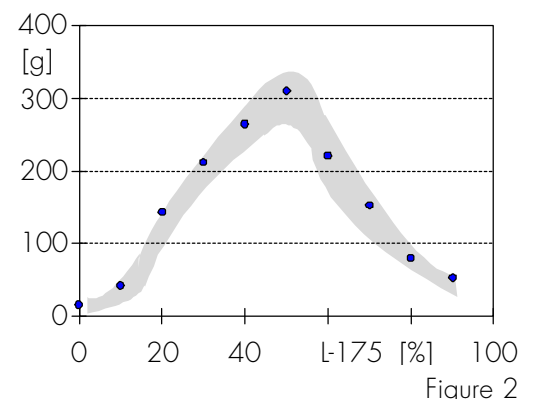


Figure 2: 1% VIDO GUM L 175/Xanthan with 5.8% NaCl

3.2 Influence of the aqueous phase

In contrast to the gels in sugar solution, the gels in table salt solution showed several 'cracks' when the gel strength was measured, i.e. when penetrated, the gel was partially broken, leading to a momentary decrease in strength. This effect caused the relatively high standard deviations of the results obtained. Gels formed with xanthan gum and **VIDOGUM L** in the presence of salt are very sensitive to mechanical strain.

3.3 Influence on colour and consistency

Using different blend ratios not only affects the gel formation and stability but also the colour and consistency.

| Blend ratio [1%] | colour | consistency |
|---------------------------------|----------------------------|----------------------|
| 100% Xanthan | clear | no gel |
| 80% Xanthan/ 20% VIDO GUM L 175 | opalescent, slightly cream | gel |
| 60% Xanthan/ 40% VIDO GUM L 175 | turbid, cream | gel |
| 50% Xanthan/ 50% VIDO GUM L 175 | turbid, cream | gel |
| 20% Xanthan/ 80% VIDO GUM L 175 | turbid, brown | slight gel formation |

Interaction with Xanthan

In contrast to mixed gels with carrageenan or agar-agar, mixed gels with xanthan gum exhibit a very different mouth feel because of the higher basic viscosity, this is usually a considerable disadvantage in most dessert applications.

3.4 Preparation without a heating step

No stable gels are formed in saccharose or table salt solutions, when mixed cold but a viscous to "jelly"-like solution is formed depending upon the concentration.

| Blend ratio [1%] with 5% sugar | cold viscosity [mPa.s] |
|-----------------------------------|---------------------------|
| 100% Xanthan | 1400 |
| 70% Xanthan/30% VIDO GUM L 175 | 4350 |
| 60% Xanthan/40% VIDO GUM L 175 | 5600 |
| 50% Xanthan/50% VIDO GUM L 175 | gallert |

3.5 Influence of the pH value

As shown in the following figure, at pH-values < 3.5 only weak or no gels were formed. This can be explained in two ways

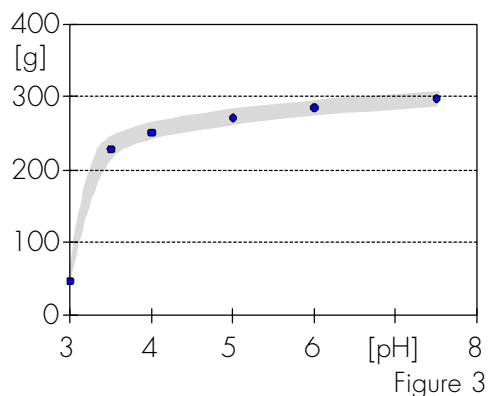


Figure 3:
Gel strength of 1% VIDO GUM L 175/ Xanthan in function of the pH-value

explained in two ways

a.) In the case of the acid concentration being too high, the galactomannan, in this case VIDO GUM L, is hydrolysed, so that larger galactose free zones occur in the molecule, where a mostly insoluble linear polysaccharide is formed, which prevents the required interaction for gel formation.

b.) The xanthan molecule contains some glucuronic acid. At the low pH of 3.0, the dissociation of the acid groups is largely prevented, so that the synergistic reaction with the carubin (locust bean gum) molecule can not take place.

The texture and consistency of the gels formed are more or less identical to those formed at pH-values nearer the neutral range.

3.6 Application in food products

Because of the relatively high viscosity of xanthan gum solutions even at low concentrations, the production of such gels is not easy. Also heat transfer is impeded, which results in more energy being needed, and this can result in burning or sticking to the make-up vessel walls. Generally blends consisting of VIDO GUM L or VIDO GUM SP with xanthan gums are not used for dessert gels, but more to stabilise delicatessen products such as dressings, low calorie mayonnaise, mustard etc.

4 Experiment with guar gum

| | |
|---------------------------|--|
| Gum types / Concentration | 0.5-1% Blend of Xanthan - with VIDO GUM GH 200 Blending ratio 0-100% |
| Aqueous phase | Tap water deionised water 2% sugar or 0.8% NaCl |
| Viscosity measurement | UNIPEKTIN standard method |

Ideal blend ration

As shown in the figures 4+5, the ideal blend ratio (= max. synergism effect) depends upon the composition of the aqueous phase. The highest viscosity increase is obtained with deionised water at the ratio approx. 1:1. This is only theoretical, since foods always contain some dissolved salts. The consideration of the ideal blend ratio for VIDO GUM GH and xanthan gum has therefore been changed to their use in tap water or in the presence of such salts.

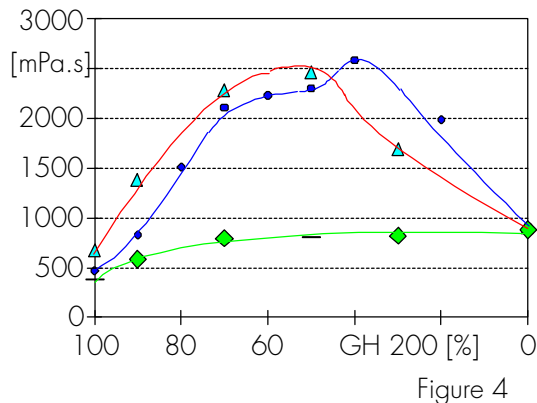


Figure 4: 0.5% VIDO GUM GH 200/Xanthan
 ▲ deion. water + 2% sugar
 ● deion. water
 ◇ deion. water + 0.8% NaCl

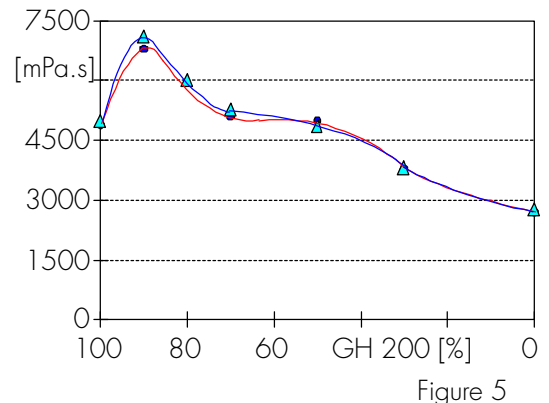


Figure 5: 1% VIDO GUM GH 200/Xanthan
 ▲ Tap water + 2% sugar
 ● Tap water

4.2 Consistency / Stability

Because of xanthan gum's excellent stability in acid, aqueous solutions, blends with VIDO GUM GH or VIDO CREM also show good pH-stability.

An observable textural change occurs in the solutions produced, however, and also the use of VIDO GUM GH and xanthan gum and especially VIDO CREM and xanthan gum gives such a stabilising and thickening effect that a noticeably shorter consistency and texture is obtained in the food.

Interaction with Tragacanth

Technical properties

Gel strengths and viscosity after heating tests on different blends of locust bean gum or guar gum with Gum Tragacanth

1 Introduction / Experiment

Gum Tragacanth is a hydrocolloid of the plant exudate group, that is used, among other things, as a thickening agent and stabiliser in dairy products. The tests should show if there are any synergistic effects giving either a viscosity increase or gel formation when Gum Tragacanth is used with VIDO GUM L 175 or VIDO GUM G 120.

Gum types / Concentration

1% blends of Tragacanth
 - with VIDO GUM L 175
 - with VIDO GUM G 120
 Blending ratio 0-90%

Gel preparation

Pre-mix thickening agent with 0.55% NaCl and 1.13% CaCl₂, disperse in water and heat.. Slightly cook for 8 min., adjust the evaporated water and fill in gelling rings. Cool down over night at approx. 20°C.

Gel strength (Stevens-Texture-Analyser)

Measuring body: TA2 / TA3
 Speed: 0.5mm/s
 Penetration depth: 20mm
 Measuring temperature: 20-22°C

Viscosity

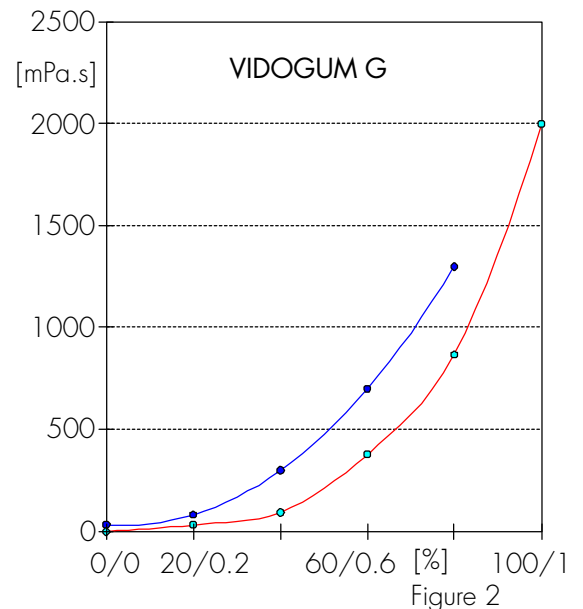
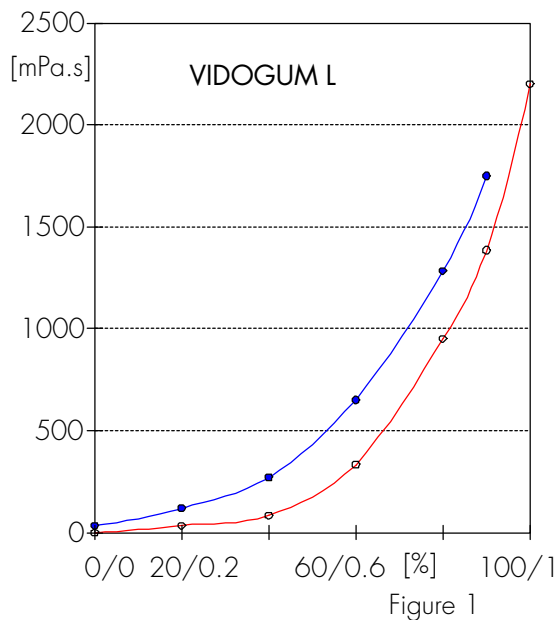
Brookfield: Typ RVF
 Rotation: 20U/min
 Temperature: 25°C

2 Gel formation

None of the tested blends showed a gel formation. This means that there is no synergistic reaction between Gum Tragacanth and VIDO GUM L or VIDO GUM G resulting in gel formation under the test conditions.

3 Viscosity values

The viscosity curves obtained for the blend ratios between VIDO GUM L 175/Gum Tragacanth and VIDO GUM G 120/Gum Tragacanth are illustrated in figures 1 + 2. The corresponding viscosity values of the pure aqueous galactomannan solutions are also given. The apparent conclusion is that the combination with Gum Tragacanth gives approx. the same viscosity increase with temperature as with the corresponding pure galactomannans:



Figures 1+2: ○ Galactomannan pure
● Galactomannan / Tragacanth

4 Summary

There is therefore no synergistic effect, resulting in a viscosity increase, between Gum Tragacanth and VIDO GUM L 175 or VIDO GUM G 120 under the test conditions.

Interaction with Carboxymethylcellulose

Technical properties

Galactomannans in combination with Carboxymethylcellulose (CMC) exhibit synergism resulting in substantial viscosity increases as well as altered rheological properties. These interactions occur with Locust Bean Gum, Tara Gum, and Guar Gum, but especially with VIDOCREM products.

1 Introduction / Experiment

CMC, produced from cellulose, gives good solubility and rapid viscosity development because of its carboxyl group. Because of its relatively high stability to low pH systems, it has a fairly wide range of applications as a stabiliser and thickener. Galactomannans, because they are linearly branched hydrocolloids, show similar characteristics, and when using blends there are not only economic advantages, but the organoleptic and textural characteristics of a product may be altered and controlled to meet customer and market requirements.

Gum types / Concentration

Blends consisting of CMC with:

- VIDOGUM L 175
- VIDOGUM SP 175
- VIDOGUM GH 200
- VIDOCREM C

All blends used at 1%, blend ratio 0-100%

Material / Method

These were all prepared using the UNIPEKTIN standard method.

| | |
|-------------------------|------------|
| Brookfield Viscosimeter | Typ RVF |
| Spindle: | 2 - 3 |
| Speed | 20 U/min. |
| Measuring temperature: | 25°C |
| Haake Rotovisco: | Type RV 12 |

2 Results / Discussion

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2.1 Influence on the viscosity

As with the galactomannans, increasing concentrations of CMC result in an exponential increase in viscosity. For this reason a constant total gum concentration of 1% was used to investigate the extent of the synergy between CMC and galactomannans.

Interaction with CMC Type 10'000

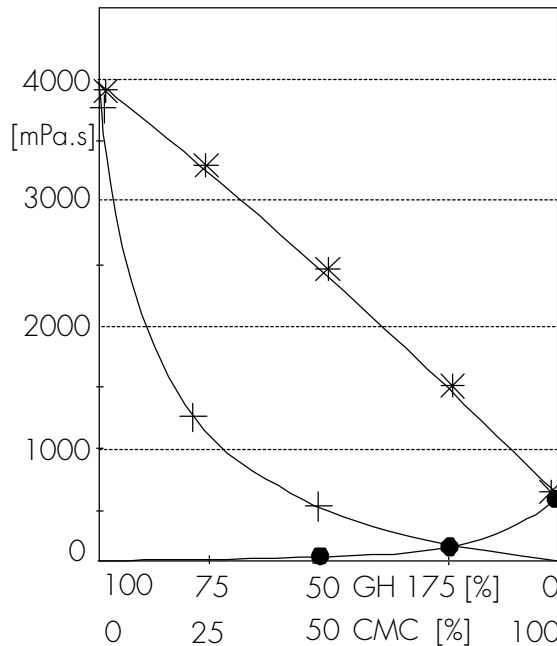


Figure 2

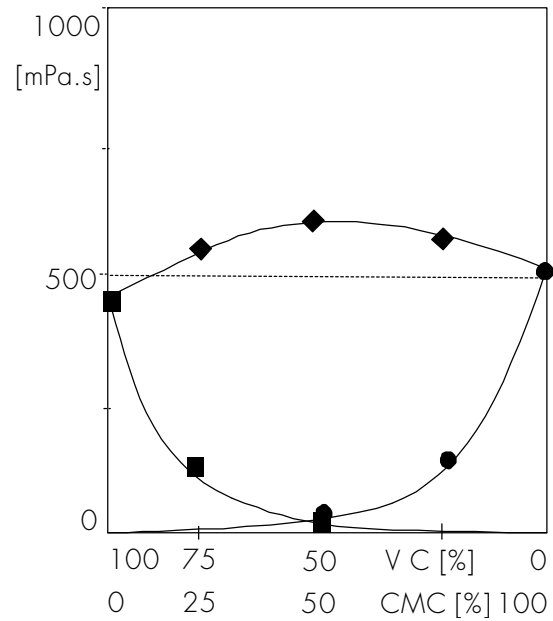


Figure 1

- Figure 1 and 2:
- CMC 10'000
 - + VIDOGUM GH 175
 - * VIDOGUM GH 175 / CMC 10'000
 - VIDOCREM C
 - ◆ VIDOCREM C / CMC 10'000

The figures show the relationship between the viscosity of a blend and the sum of the viscosities of the two individual components. The resulting measurements show that a distinct increase in viscosity is obtained using blends with **VIDOGUM GH 175**, **VIDOGUM SP 175** and **VIDOGUM L 175**, and there are no significant differences between the interactions obtained with these three natural, unmodified galactomannans. Contrastingly, the thermally depolymerised guar gum **VIDOCREM C** shows an even more marked increase in viscosity in combination with CMC.

These results show that the **VIDOCREM** process of shortening the guar molecule establishes a much greater synergistic effect with CMC.

One possible mechanism for the synergistic effect is the adsorption of the CMC into the galactomannan molecule. The electrostatic repulsion from the anionic CMC stretches the partially coiled structure of the nonionic galactomannan molecule, thus resulting in increased viscosity.

Interaction with Carboxymethylcellulose

2.1.2 Interaction with CMC Type 30'000

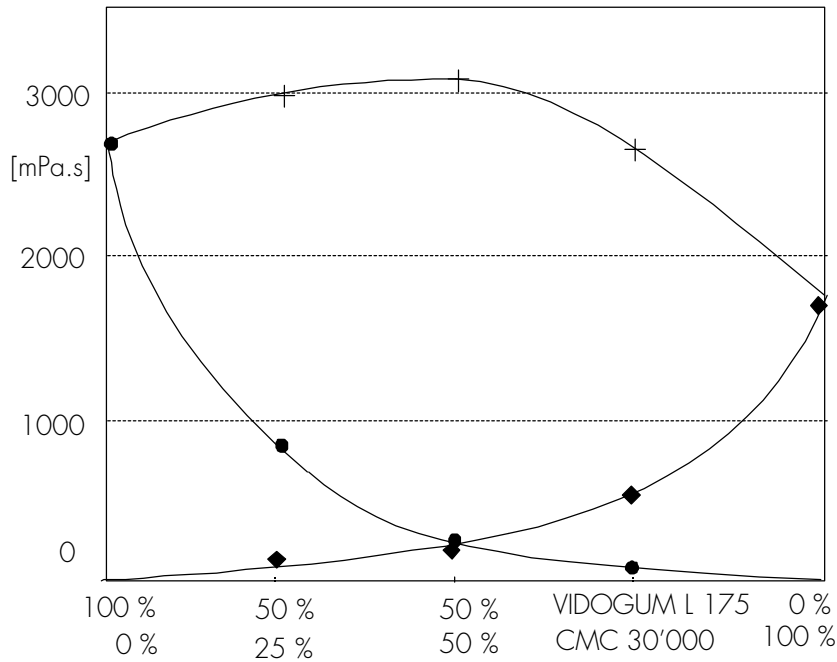


Figure 3:

- VIDO GUM L 175
- + VIDO GUM L / CMC
- ◆ CMC 30'000

Figure 3

CMC Type 30'000 produces much higher viscosities than Type 10'000. The diagram shows an example using a blend with **VIDO GUM L 175** where a stronger synergistic interaction is clearly demonstrated. The scale of the synergistic interaction is therefore dependant upon the type of galactomannan; the higher viscosity CMC giving a stronger synergistic interaction with galactomannans.

2.1.3 Ideal blend ratio.

The greatest synergistic reaction between galactomannans and CMC is obtained with a 50/50 mix of the two hydrocolloids, and this is the same whether dissolved in water, sugar solution [5%], or salt solution [5%].

2.2 The effect of blends upon the rheological properties.

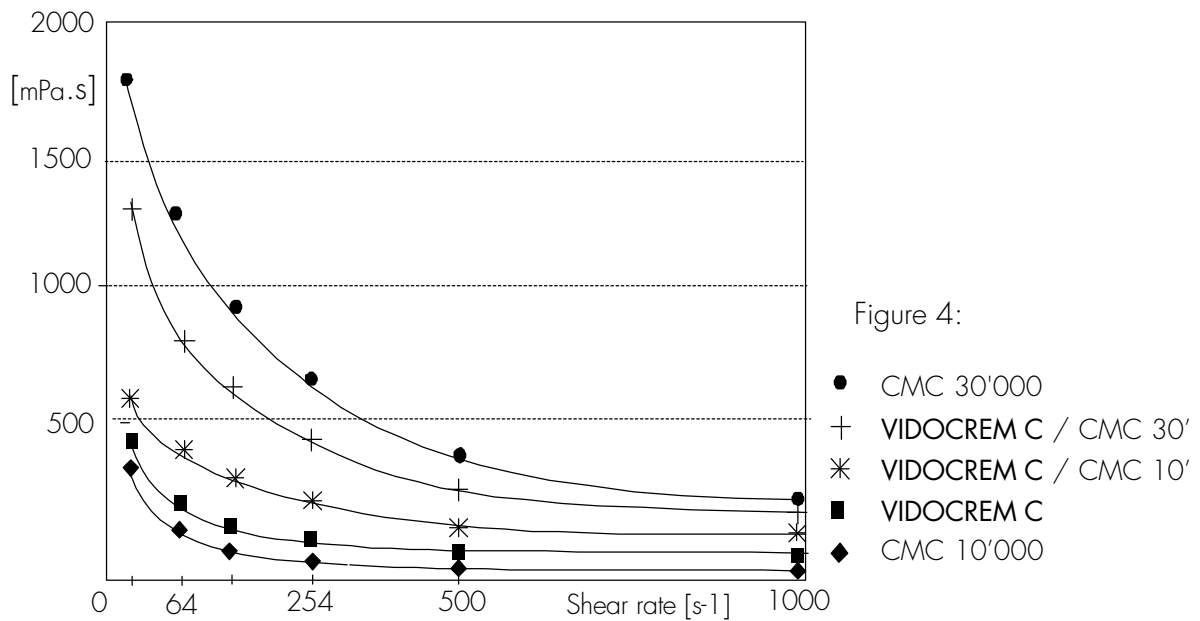


Figure 4

The texture of CMC solution is long and the larger the molecular weight of the CMC, the longer the texture of the solution. The effect of blends or hydrocolloids with CMC on the texture is additive, in other words, using VIDOCREM C, which has a short texture, a 50/50 blend with CMC will be between the short texture of VIDOCREM C and the long texture of CMC; also the higher the ratio of CMC in the blend, the longer the texture.

2.3 Acid stability.

Aqueous [1%] hydrocolloid solutions were standardised using citric acid to a pH of 3.00 to test acid stability. In order to exclude any microbiological effects, sodium benzoate was used as a preservative.

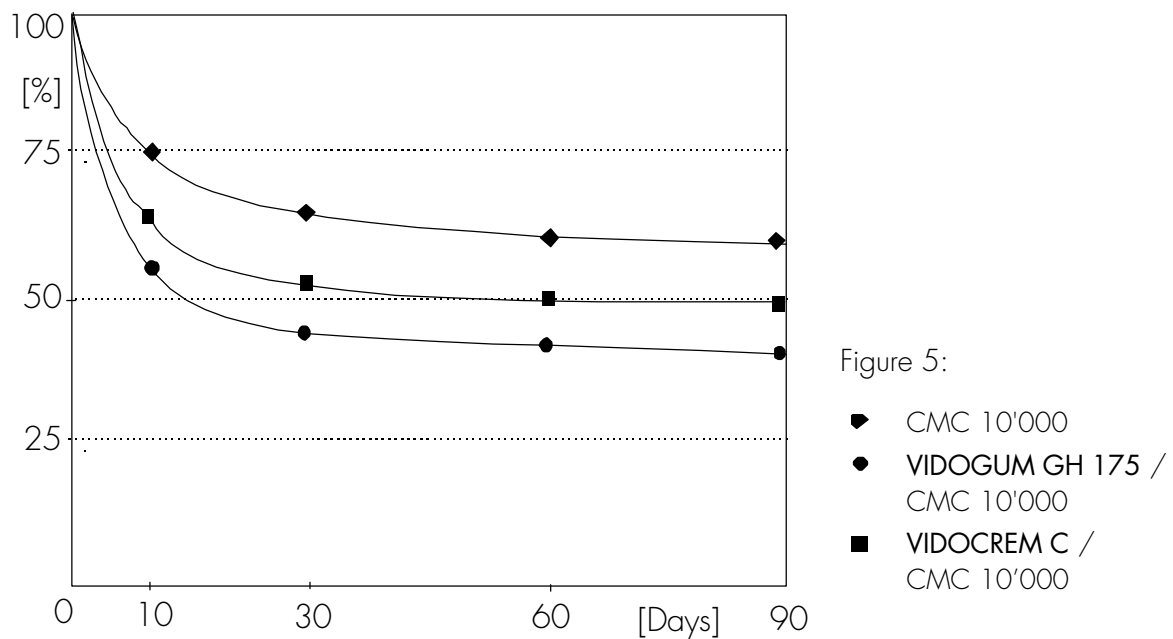


Figure 5:

- ◆ CMC 10'000
- VIDOGLUM GH 175 / CMC 10'000
- VIDOCREM C / CMC 10'000

Figure 5

Galactomannans and CMC show a permanent loss of viscosity over time due to acid hydrolysis of the polysaccharide chains, however, CMC has a significantly better stability at pH 3.00. Using a combination of 50% VIDOGLUM GH 175 and 50% CMC 10'000, there is no evidence of any protective effect occurring between the two polysaccharides Galactomannan and Carboxymethylcellulose. In practical applications with pH 3.00 pure galactomannans and combinations are therefore only limited suited to each other.

It is important to note, that the above tests were carried out in pure aqueous solutions, in there was no buffering systems or other ingredients present to prevent the acid hydrolysis of the hydrocolloids. The viscosity loss is therefore a „worst possible case“ situation, as in food products there will be other ingredients present, which will exhibit a degree of protective effect on the hydrocolloids. (see Chapter 7; Acid Stability).

Gelling and Thickenig Agent

Summary

| Description Synonym | Origin | Basic Components | Kind of for- mation | Func- tional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|--|--|--|---|--|---|-------------|---|
| Seaweed- polysaccharides Agar | Marine algae Gelidium and Gracilaria spe- cies (red sea- weed) | D-galactose 3,6-anhydro- L-galactose | glycoside linkage β - 1,3 β - 1,4 linear | OH- groups | small amounts of <i>sulphate ester</i> ester groups of glucuronic acid , occasional pyruva- te, <i>methyl ether groups</i> | anionic | gelling agent, stabilisation |
| Carrageen Irish Moss Gelose | Chondrus-,Gi- gartina- and Eu- cheuma species (red seaweed) | D-galactose 3,6-anhydro- D-galactose | glycoside linkage β - 1,3 β - 1,4 linear | OH- groups | depending on the fraction considerable, but chan- ging amounts of sulphate ester groups | anionic | gelling and tickening agent, stabili- ser emulsions sta- biliser K-ions influ- ence the gel strength and formation |
| Furcellaran Dutch Agar | Furcellaria spe- cies (red sea- weed) | D-galactose 3,6-anhydro- D-galactose | glycoside linkage β - 1,3 β - 1,4 linear | OH- groups | depending on the fraction variable amounts of <i>sulphate ester groups</i> , but less than Carrageenan | anionic | gelling and tickening agent, stabiliser emulsions stabiliser. K-ions influ- ence the gel strength and formation |
| Alginic acid <i>Alginates</i> | Macrocystis and Laminaria spe- cies (brown seaweed) | D-mannuronic acid L-guluronic acid | glycoside linkage β - 1,4 α - 1,4 linear | OH- groups COOH- groups | none | anionic | gelling and tickening agent, stabiliser gel formation with Ca-ions |
| Propylene glycol alginate | same as alginic acid, <i>derivatisa- tion</i> of the car- boxyl groups by propylene oxide | same as alginic acid | same as algi- nic acid | OH- groups COOH- groups | hydroxypropylester groups, degree of esterifi- cation 40-85 % | anionic | gelling and tickening agent, stabili- ser, emulsion stabiliser, emulsifying agent |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of formation | Functional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|------------------------------------|---|---|--|--------------------------------|-----------------------------|-------------|--|
| Galactomannans | seed endo- sperm of legu- me species | | glycoside linkage | | | | |
| Locust Bean Gum Carubin, | locust bean gum tree, Ceratonia siliqua L. (Taub) | D-mannose 73-86 % D-galactose 14-27 % galactose/ mannose ratio approx. 1:4 | β - 1,4 (main chain) α - 1,6 (short galac- ose side chain) transition from linear to slightly bran- ched | OH- groups | none | neutral | thickening agent, stabiliser, synergistic effect on the gel formation with seaweed poly- saccha- rides and xanthan, filling agent for low-calorie food |
| Tara Gum | tara bush Caesalpinia spinosa L. and related Caesalpinia species | D-mannose 70-80 % D-galactose 20-30% galactose/ mannose- ratio approx. 1:3 | glycoside linkage β - 1,4 (main chain) α - 1,6 (short galac- ose side chain) transi- tion from line- ar to slightly branched | OH- groups | none | neutral | thickening agent, stabiliser, slightly less in synergistic effect on the gel formation with seaweed poly- saccha- rides and xanthan than LBG, filling agent for low-calorie food |
| Guar Gum Guaran | guar plant, Cyamopsis tetragonoloba L. (Taub) | D-mannose 64-67 % D-galactose 33 - 36 % galactose/ mannose- ratio approx. 1:2 | glycoside linkage β - 1,4 (main chain) α - 1,6 (short galac- ose side chain) transition from linear to slightly bran- ched | OH- groups | none | neutral | thickening, bonding agent almost no sy- nergistic effect on the gel formation with seaweed poly- saccharides and xanthan. filling agent for low-calorie food |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of formation | Functional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|--|--|--|--|--------------------------------|--|-------------|---|
| Biosynthetic Polysaccharides | | | | | | | |
| Xanthan Gum | controlled fermentation of carbohydrates with xanthomonas campestris | <i>main chain:</i> D-glucose <i>trisaccharide side branches:</i> D-mannose D-glucuronic acid D-mannose | glucoside linkage β - 1,4 α - 1,3 β - 1,2 β - 1,4 strongly branched | OH-groups COOH-groups | α -1,3 linked D-mannose naturally esterified with acetic acid β - 1,4 linked D-mannose naturally partially in 4,6 position with pyruvate | anionic | gelling agent (in combination with galactomannans). Thickening agent, suspension stabiliser |
| Gellan gum | controlled fermentation of carbohydrates with pseudomonas elodea | <i>main chain:</i> D-glucose D-glucuronic acid D-glucose D-rhamnose <i>tetrasaccharide:</i> D-glucose D-glucuronic acid D-glucose D-rhamnose | glucoside linkage β - 1,4 β - 1,4 β - 1,4 β - 1,4 repeating tetrasaccharide | OH-groups COOH-Gruppen | each tetrasaccharide unit contains at the same glucose unit an acetyl and L-glycerylgroup. | anionic | gelling agent thickening agent, suspension stabiliser |
| Plant exudates | | | | | | | |
| Gum arabicum arabic gums acacia gum | Exudate of tropical bushes through scarring of the trees with a knife Acacia senegal (L.), and related acacia species | <i>main chain:</i> D-galactose <i>main branching:</i> D-glucuronosido-1,6- resp. 4-O-methyl-D-glucuronosido-1,6-D-galactose <i>Side branches of the ramifying of the side branches:</i> L-rhamnose L-arabinose | glucoside linkage β - 1,3 $\alpha, \beta^* - 1,6$ | OH-groups COOH-groups | methoxylation on position 4 on the end groups of glucuronic acid | anionic | emulsion, suspension stabiliser, gelling- and thickening, agent |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of formation | Functional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|---|--|---|---|---|--|---------------------------------------|--|
| Tragacanth Tragacanth | astragalus gum- mifer, labill, and related astraga- lus species | <i>main chain:</i> D-galacturonic acid <i>Side branches:</i> D-xylose <i>extension of the side branches:</i> D-galactose Lfucose L-arabinose | glucoside linkage α - 1,4 β - 1,3 α, β^* - 1,2 * kind of bon- dings not sol- ved restless, strongly bran- ched | OH- groups COOH- groups (Traga- canthin) | COOH- groups naturally metholyated (Bassorin) | anionic | thickening agent, suspen- sion, emulsify- ing stabiliser |
| Karaya Gums Indian Tragacanth | sterculia urens, Roxb. and related Sterculia- Arten | D-galacturonic acid D-galactose L-rhamnose | glucoside linkage α - 1,4 * α - 1,4 * α - 1,2 * * structure and linkage ratio not yet solved restless, bran- ched | OH- groups COOH- groups | OH-groups partially acetylated natural- ly | anionic | thickening agent, suspen- sion, emulsify- ing stabiliser |
| Pektinstoffe | integrated part of all land plants (middle lamella) | <i>main sequences:</i> D-galacturonic acid bond through L-rhamnose <i>branching:</i> D-galactose L-arabinose | glycoside linkage α - 1,4 α, β (?) - 1,2 * β , - ?* α - ?* slightly bran- ched * Kinds of lin- kages not yet solved | COOH- groups OH- groups | natural pectins: COOH- groups which are usually esterified to over 70 % with methanol COOCH ₃ <i>commercial pectins:</i> 1. high methoxyl (HM-pectins): more than 50 % ester groups COOCH ₃ 2. low methoxyl (LM-pectins): less than 50 % ester groups COOCH ₃ 3. amidated pectins (LMNH pectins) less than 50 % ester groups COOCH ₃ maximum 25 % amide groups CONH ₂ | anionic anionic anionic | gelling agent (dry matter 63 till max. 83 % pH = 2,7 - 3,6). stabiliser gel- ling agent (15- 55 %; pH = 3,0- 6,8). Gel for- mation with Ca-ions gelling agent (15-82%; pH = 3,1-6,8). bonding, thik- kening agent, stabiliser, gel formation with Ca-ions |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of formation | Functional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|--|---|------------------|--|--------------------------------|---|-------------|--|
| Cellulose and Cellulose-derivate Microcrystal-line cellulose | cellulose from plants which is partially broken down by mineral acids and very finely ground (with addition of CMC) | D-glucose | glycoside linkage β - 1,4 linear | OH-groups | none | neutral | suspension, emulsifying stabiliser, swellable release and distribution agent |
| Methylcellulose (MC) | chemical modification of alkali cellulose with methyl chlorid | D-glucose | glycoside linkage β - 1,4 linear | OH-groups | OCH ₃ -groups, hydroxyl groups in C ₂ and C ₆ of glucose methoxyl content between approx. 40 und 75 % | neutral | suspension, emulsifying stabilisers, thickening agent |
| Methyl ethyl cellulose (HEMC) | chemical modification of alkali cellulose with methyl chloride and ethylene oxide | D-glucose | glycoside linkage β - 1,4 linear | OH-groups | O-CH ₃ - groups O-CH ₂ - groups CH ₂ OH- groups, mixed ethers, hydroxyl groups on C ₂ C ₃ and C ₆ of glucose, variable but together between 25-70 % of methyl and hydroxyethyl ethers | neutral | suspensions, emulsifying stabiliser, and thickening agent. Filling material for low-calorie foodstuffs |
| Carboxy-methylcellulose (CMC), Celluloseglycol ether, Natriumcelluloseglycolat, | chemical modification of alkali cellulose with chloracetic acid or its sodium salt | D-glucose | glycoside linkage β - 1,4 linear | OH-groups | O-CH ₂ - COOH-resp. OCH ₂ - COONa- groups, about 3 - 35% carboxy methylate attached to C ₂ and especially C ₆ hydroxyl group of the glucose. Mixed ethers containing hydroxy ethyl and hydroxy propyl are possible | anionic | thickening agent, emulsifying and suspension stabiliser |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of forma- tion | Func- tional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|--|---|--|--|--|--|---|---|
| Hydroxypropyl- methyl cellulose (HPMC) | Chemical deriva- tisation of alkali cellulose with propylene oxide and methyl chlor- ide | D-Glucose | glycoside linkage β - 1,4 linear | OH- groups | OCH ₃ - groups OCH ₂ -CHOH- CH ₃ groups, mixed ethers, Hydroxyl on C ₂ , C ₃ und C ₆ glucose units between approx. 55% methyl- and approx. 2-12% hydroxypropyl- ethers | neutral | suspensions, emulsifying, stabiliser thickening agent, Filling material for low calorie foods |
| Hydroxypropyl- cellulose (HPC) | chemically modi- fied cellulose with propylene oxide and meth- yl chloride | D-glucose | glycoside linkage β - 1,4 linear | OH- groups | OCH ₂ -CHOH- CH ₃ groups, mixed groups on C ₂ , C ₃ and C ₆ of glucose substituted with about 55 % methyl and 2 - 12% hydroxy- propyl groups | neutral | suspension, emulsifying sta- bilisers, thik- kening agent, filling material for low-calorie foodstuff |
| Starch and Starch derivatives Starch | spare coal hy- dratical plant origin out from seeds (gramine- en) and bulbs (rhizomen and Sprossknollen) natural different plants not modi- fied. Not food- stuff additives in the sense of the positive list | 2 components: 1 1. <i>Amylose</i> D-glucose 2. <i>Amylopectin</i> D-glucose branching: D-glucose | glycoside linkage α - 1,4 linear main chain α - 1,4 α - 1,6 strongly bran- ched | OH- groups OH- groups | natural products contains about 4% phosphate esters | almost neutral to slightly anionic | oldest gelling (pudding), and thickening agent, partially also used as suspension and emulsifying sta- biliser. Must be dispersed prior to dissolving. |
| Starch treat with acid, base, and/or en- zyme | made cold water soluble with the respective rea- gent, some are pasty starches | same as starch | same as starch | OH- groups | same as starch | almost neutral to slightly anionic | same as starch but more or less cold water so- luble |
| Esterified Star- ches <i>Starch adipates</i> <i>Distarch adipates</i> | partially modi- fied starches with adipinic acid | same as starch | same as starch | OH- groups | -O-CO- (CH ₂) ₄ -COO groups , the amount of ester can vary, someti- mes acetylated | anionic | same as starch, but more or less cold water so- luble |

Gelling and Thickenig Agent

| Description Synonym | Origin | Basic Components | Kind of formation | Functional Groups (primary) | Substitution (secondary) | Unit charge | Application |
|--|--|---|------------------------------|--|---|---|--|
| Starch acetates (mono starch acetate) | partially esterified starch with acetic acid | same as starch | same as starch | OH-groups | O-CO-CH ₃ - groups variable amounts of ester groups | almost neutral to slightly anionic | same as starch, but more or less cold water soluble |
| Starch phosphate Mono starch phosphate, Di-starch phosphate, Phosphated starch phosphates Acetylated di-starch phosphate, Hydroxy-propyl-di-starch phosphate | partially esterified with phosphoric acid | same as starch | same as starch | OH-groups | O-PO(ONa) ₂ groups, variable degrees of phosphate esters can be modified with acetyl (ester) or hydroxypropyl (ether) groups | anionic | same as starch, but with stronger 'pudding' effect (cold pudding), more cold water soluble |
| Etherified starch <i>Dihydroxypropylstarch</i> Di-starch glycerol, Acetylated di-starch glycerol, Hydroxy-propyl-di-starch glycerol | starch modified with glycerol or epichlorohydrin | same as starch | same as starch | OH-groups | groups, variable amounts of ether groups -O-CH ₂ -CHOH-CH ₂ -OH- and further modified with various amounts of acetyl or hydroxy-propyl groups | almost neutral to slightly anionic | same as starch but more or less cold water soluble |
| Hydroxy-propyl starch | chemically modified starch with propylene oxided | same as starch | same as starch | OH-groups | variable amounts of -O-CH ₂ -CHOH-CH ₃ -groups | almost neutral to slightly anionic | same as starch, but better cold water solubility |
| Bleached or oxidised starches | chemical treatment of natural starches with oxidation agents (hypochlorite, chlordioxide, hydrogen peroxide, etc.) | same as starch | same as starch | OH-groups | additional small amounts of -COOH-groups | slightly anionic | as starch, but better cold water solubility |
| Gelatins Gelatins | animal connective tissue (bones, skin, tendons) | amino acid, especially glycine, proline, hydroxyproline, glutamic acid, alanine | peptide-linkage R-CO-NH-R | NH ₂ -groups COOH-groups | none | depending on the isoelectric point and pH-value cationic or anionic | gelling agent, stabiliser for suspension and emulsions |