Rotational Viscosity Testing of Plant-based Dairy Alternatives and Thickening Agents with ViscoQC

How do thickening agents change the flow behavior and stability of food products? This application report shows rotational viscosity tests with ViscoQC for developing new products as well as simple quality control tests of plant-based dairy alternatives.

1 Introduction

Thickening agents are hydrocolloids which are used to increase the viscosity of products without significantly changing their other properties like taste and flavor. Hydrocolloids are a group of polysaccharides which have a thickening or gelling effect when mixed with water. Depending on the type of polysaccharide they are either extracted from plants, seaweeds, or produced by microbials synthesis. Typical examples are xanthan gum, guar gum, carrageen, pectin, gum arabic, etc.

Thickening agents are commonly used in the food industry to thicken sauces, soups, puddings, etc. Apart from in the food industry, thickening agents are also required in the production of personal-care products, pharmaceuticals, and paints and inks.

A growing sector in the food industry are plant-based dairy alternatives. In order to reach consumer acceptance of those products, they need to replicate the textural properties of the animal-based products. Among others hydrocolloids are used as food additives to improve the texture of e.g. plant-based milk, yoghurt, cheese or meat. In order to control the texture of the plant-based product, viscosity testing of the end-product with a rotational viscometer is required.

The application report shows example measurements of xanthan gum for research and development of food products as well as quality control measurements of plant-based milk with the rotational viscometer ViscoQC 100/300.

2 Experiment

Table 1 shows the measurement configuration and test methods used for viscosity testing of 0.1 % xanthan gum solution in water. Xanthan gum is used in food products with a concentration between 0.05 % to 0.5 % to improve the creaminess.

Hint: *Alternatively, a ViscoQC 100 – L can be used for quick single-point viscosity checks at the production line instead of ViscoQC 300 – L.*

Sample	Xanthan gum (0.1 %)	
Instrument	ViscoQC 300 – L	
Spindle	CC26	
Temp. device	PTD 80	
SW package	V-Curve	
Method 1	**Speed Scan (SpS)**	
	Start	10 s^{-1}
	Stop	100 s^{-1}
	Number of points	10
	Target time	30 s
	Temperature	25 °C
	Sensor-/T-Ready	On
Method 2	**Temperature Scan (TS)**	
	Start	15 °C
	Stop	80 °C
	Number of points	10
	Target time	30 s
	Shear rate	80 s^{-1}
	Sensor-/T-Ready	On

Table 1: Configuration for viscosity testing of xanthan gum solution in water (0.1 %).

Hint: *For some thickening agents the US and Eur. Pharmacopeia require a viscosity test.*
Examples:

- *Xanthan gum needs to be viscosity tested with ViscoQC – L, L3 spindle at 60 rpm and 24 °C.*
- *Carrageenan needs to be viscosity tested with ViscoQC – L, L1 spindle at 30 rpm and 75 °C according to USP. Ph. Eur. does not specify the exact spindle or speed for the test.*

Table 2 shows the measurement configuration and test method for a comparison measurement of milk alternatives (hazelnut milk, almond milk) and cow milk.

Sample	Hazelnut, almond, cow milk	
Instrument	ViscoQC 300 – L	
Spindle	CC26	
Temp.° device	PTD 80	
SW package	V-Curve	
Method	**Speed Scan (SpS)**	
	Start	10 s^{-1*}
	Stop	100 s^{-1}
	Number of points	10
	Target time	30 s
	Temperature	25 °C
	Sensor-/T-Ready	On

*The cow milk test started at 70 s^{-1} to ensure a torque value >10 %.

Table 2: Configuration for viscosity testing of plant-based milk products.

3 Results and discussion

Xanthan gum is a very effective thickener and stabilizer for a wide range of food products. It is tasteless and is obtained by means of the bacterium *Xanthomonas campestris*. Already low concentrations of the polysaccharide result in a high viscosity solution in comparison to other thickening agents.

Figure 1 confirms the shear-thinning flow behavior of xanthan gum. The induced shear-thinning behavior improves the mouth feel in final products, the processability like pumping and mixing as well as the pourability. Additionally, the mathematical model "Power law" can be used to characterize the flow behavior of liquids (Table 2).

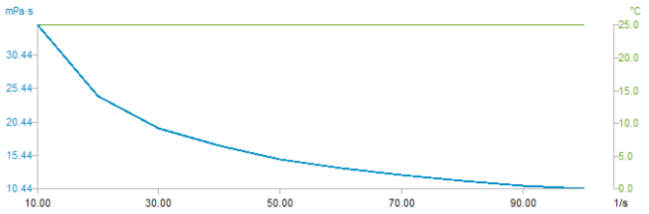

Figure 1: Viscosity curve of xanthan gum solution (0.1%) at 25 °C.

Hint: *With ViscoQC 300 + V-Curve a viscosity curve can be generated after the measurement is finished. Go to Menu > Data memory > Analysis > Analysis measured data.*

Mathematical model	Power law
Consistency Index	117.4 mPa.s
Flow Index	0.4731

Table 3: Power law analysis of xanthan gum solution (0.1 %).

Figure 2 shows the change in viscosity over the temperature range of 15 °C to 80 °C. Xanthan gum has a very good thermal stability compared to other thickeners. That means the final product stays stable regardless whether it is stored in the refrigerator, at room temperature, or whether it is heated.

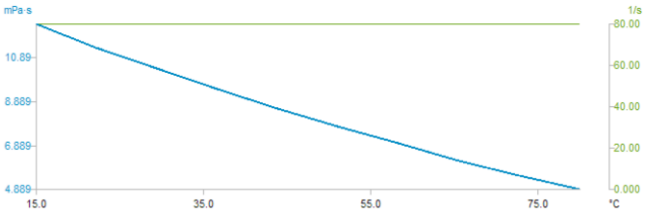

Figure 2: Temperature curve of xanthan gum solution (0.1 %) at 80 s^{-1}.

Figure 3 shows the different flow behavior and viscosity of milk products. Plant-based milk alternatives have a shear-thinning flow behavior also caused by thickeners, whereas cow milk shows Newtonian behavior. Almond milk has a higher viscosity than hazelnut milk. The viscosity of plant-based milk beverages is mainly responsible for consumer acceptance as it gives the product a mouth feel similar to cow's milk.

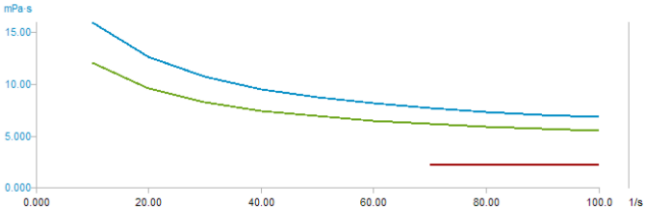

Figure 3: Viscosity curve of milk products at 25°C. Blue: Almond, Green: Hazelnut, Red: Cow

Hint: *With ViscoQC 300 + V-Curve measurements can be compared in case the same test method is used. Go to Menu > Data memory > Analysis > Compare measured data.*

4 Summary

Viscosity is one of the main quality aspects to determine consumer acceptability of plant-based food products for which thickening agents are used to increase the viscosity and improve the texture.

The measurements show that the ViscoQC 100/300 with DIN systems is perfectly suited for quality control of plant-based milk products as well as for developing new products using thickening agents.

The measuring system must be selected depending on the viscosity range of the products.

For analyzing e.g. pasty plant-based spread a Heli-Plus with T-bar spindles or vanes are recommended.

If you have further questions regarding this application report, please contact your local Anton Paar representative.

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