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Can Carbomer be effectively replaced with natural polymers?

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Introduction and aim

- Demand for ‘greener’ alternatives to synthetic polymers
- Natural rheology modifiers - great variety of structures; inferior to synthetic polymers in the formulation stability and sensory aspects
- Classification from Food science into thickening and gelling agents

The aim of this project:

To replace Carbomer using a combination of natural polymers of polysaccharide type, focusing on the rheological, textural and sensory properties

Materials: natural polymers used

- **'Thickening' polysaccharides**

Xanthan gum

Cellulose gum

Konjac gum

Guar gum

Thickening mechanism

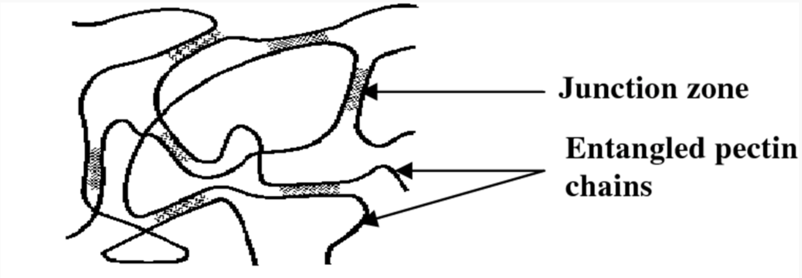
Main factors:
Temperature
Molecular mass and shape

- **'Gelling' polysaccharides**

Carrageenan

Gellan gum

Gelling mechanism



Main factors:
Temperature
Presence of ions

Materials: emulsion formulation

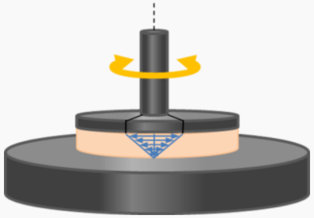
1. Each natural polymer was first assessed as:
- a single polymer in hydrogel
- a single polymer in emulsion

2. This was followed by:
- a combination of polymers in hydrogel
- a combination of polymers in emulsion

		INCI Name	% (w/w)
Phase A		Deionized water	Up to 100.00
		Glycerin	2.0
		Rheology modifier	*Fit within the viscosity range*
Phase B		Butyrospermum Parkii (Shea) Butter	7.5
		Capryl/ Caprylic Acid Triglyceride	7.5
		Cetearyl Glucoside (and) Cetearyl Alcohol	4.0
Phase C		Benzoic acid	0.5
		Sodium hydroxide	As required to achieve target pH
		Citric acid	As required to achieve target pH
		Deionized water	q.s

Methods: physico-chemical tests

Rheological tests



Oscillatory method

- Oscillatory stress sweep from 1 to 500 Pa, at 1 Hz (measures viscoelasticity)
- Parameters: complex modulus G* (rigidity) and phase angle δ (elasticity)

Continuous flow methods

- Shear rate sweep from 10 - 250 s^{-1} (measures viscosity)
- Three-step thixotropy: 60 sec at 10 s^{-1}, 60 sec at 250 s^{-1} and again 60 sec at 10 s^{-1} (measures the rate of instant structure recovery)

Texture analysis

- Immersion/de-immersion of a cylinder probe (measures hardness, compressibility, stringiness and adhesiveness)

Methods: sensory tests

Part I:
Sensory profiling test

Panel: 8 semi-trained panellists

Objective: To select the representative sample that is perceived to be the most similar to Carbomer.

Assessment: Four creams (including one with Carbomer), controlled conditions, six sensory attributes

Part II:
Paired difference test

Panel: 40 naïve panellists
(16 sighted, 32 blind-folded)

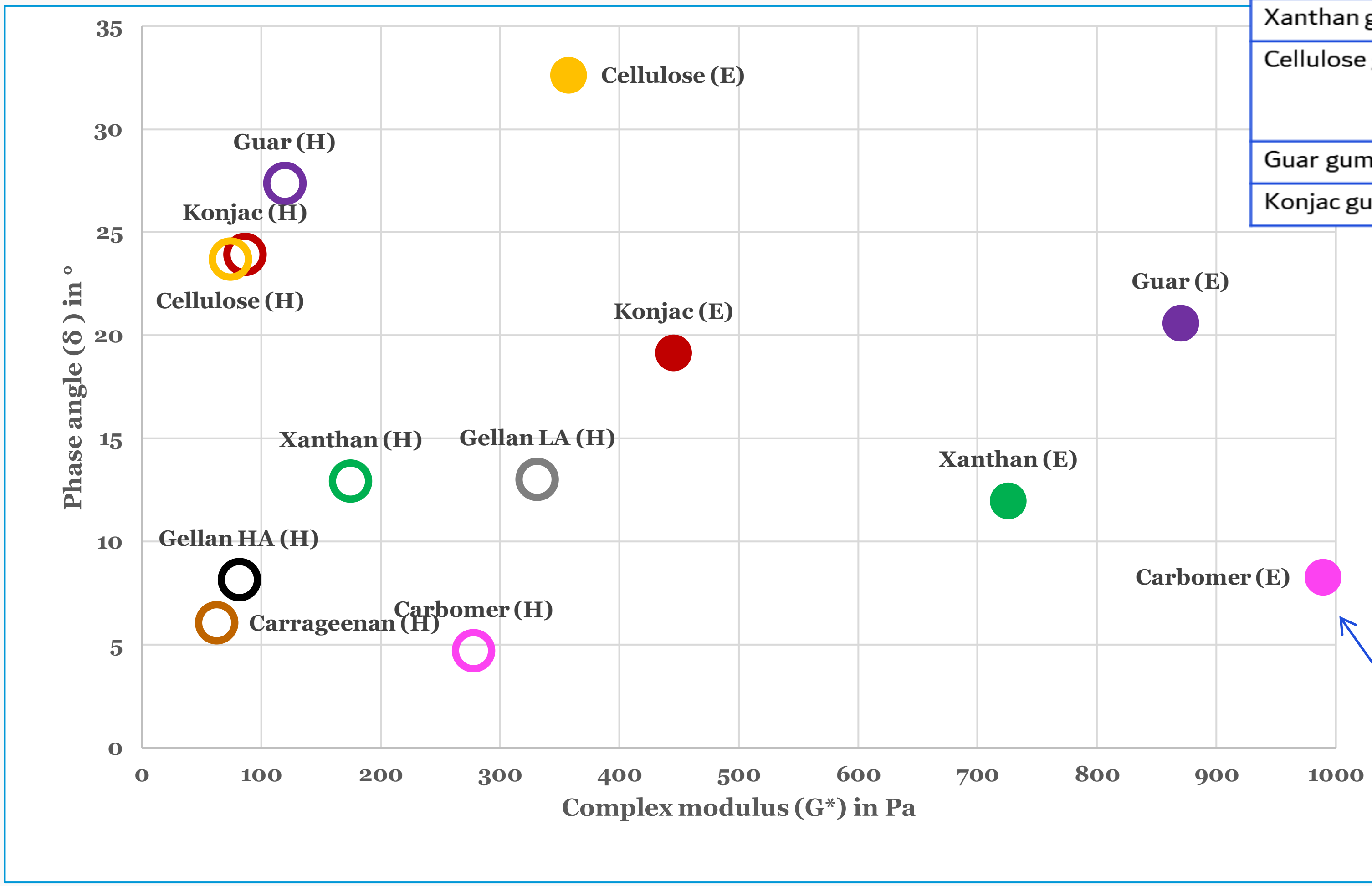
Objective: To determine if there is a perceived difference between the representative sample and Carbomer.

Assessment: Two creams, controlled conditions, assessed in parallel on different hands; **preference test** also performed.

Results

Viscoelasticity plot for the hydrogels and corresponding emulsions

Polymer	Conc (% w/w)
Carbomer	0.30
Xanthan gum	5.60
Cellulose gum	2.00
Guar gum	1.80
Konjac gum	0.80



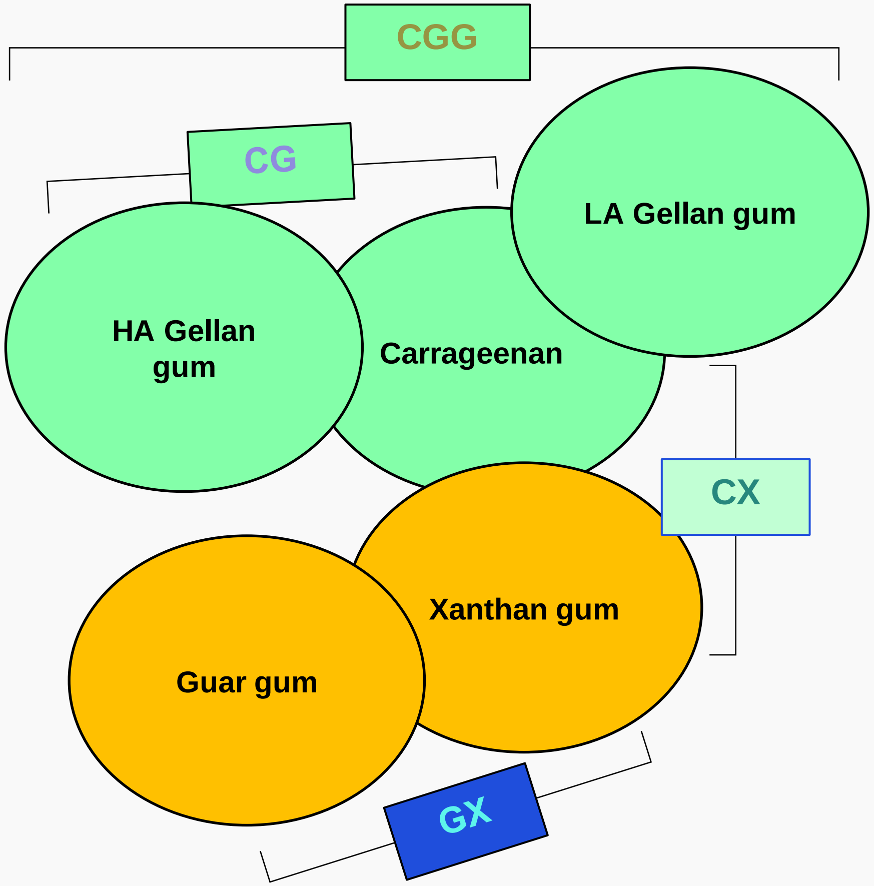
Different from other emulsion samples

Open circles: Hydrogels

Closed circles: Emulsions

Results

Combinations of polymers tested, based on preliminary experiments



Code	Combination
CG	Carrageenan – 1% Gellan gum HA – 0.2%
CGG	Carrageenan – 0.6% Gellan gum HA* – 0.3% Gellan gum LA** – 0.2%
GX	Guar gum 0.8% Xanthan gum – 1.5%
CX	Carrageenan – 1% Xanthan gum – 0.7%

***** HA – high acyl content
**LA – low acyl content

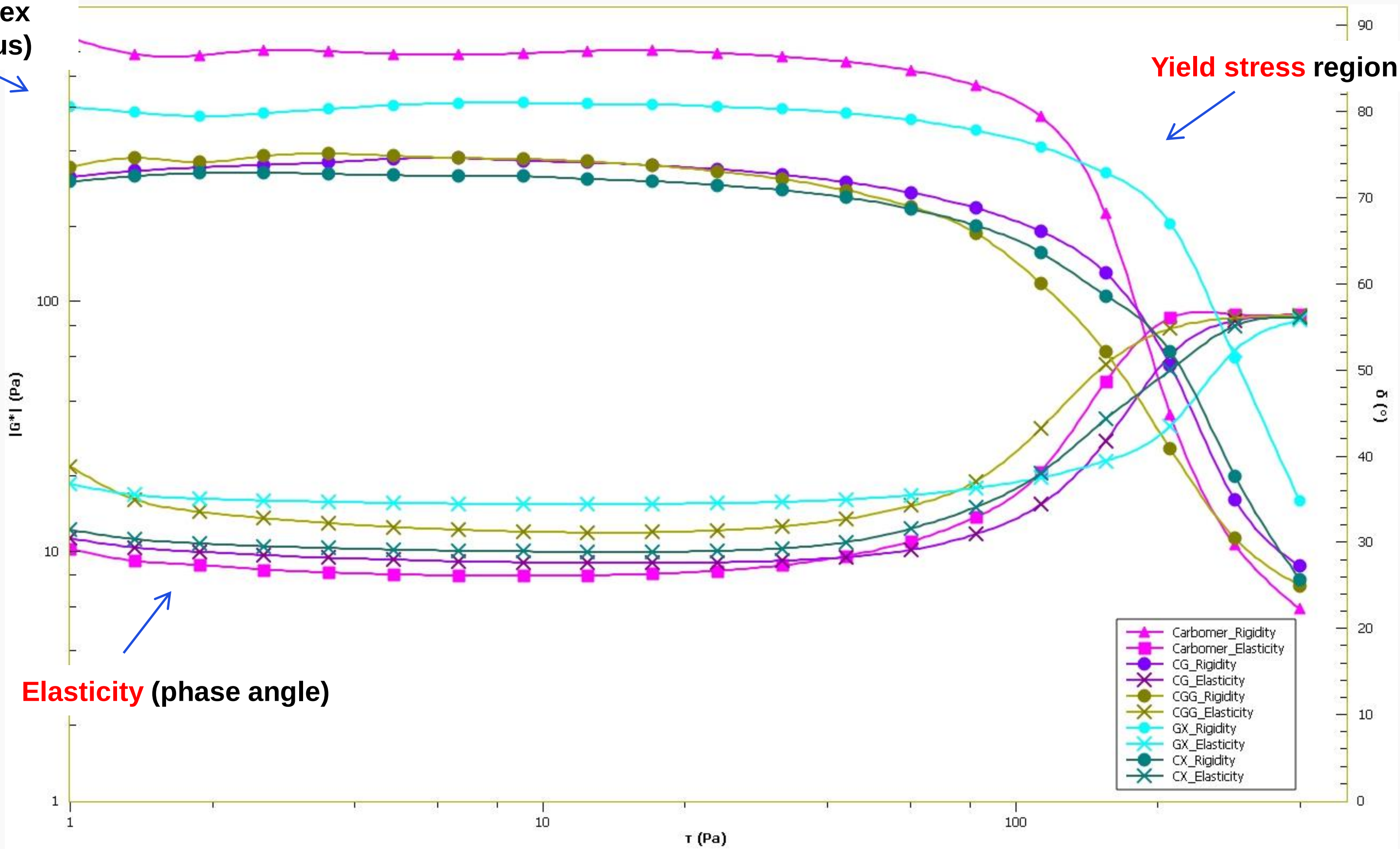
The four combinations were chosen based on the rheological tests of more than 20 combinations.

Results

Oscillatory stress sweep results for the polymer combinations

Rigidity (complex modulus)

Yield stress region



Elasticity (phase angle)

Results

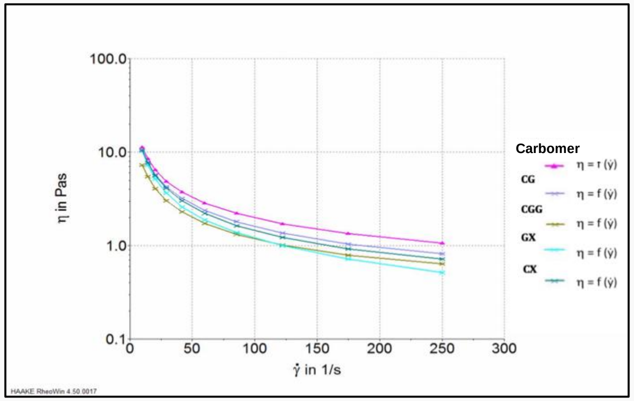
Continuous flow results

Hydrogels | **Emulsions**

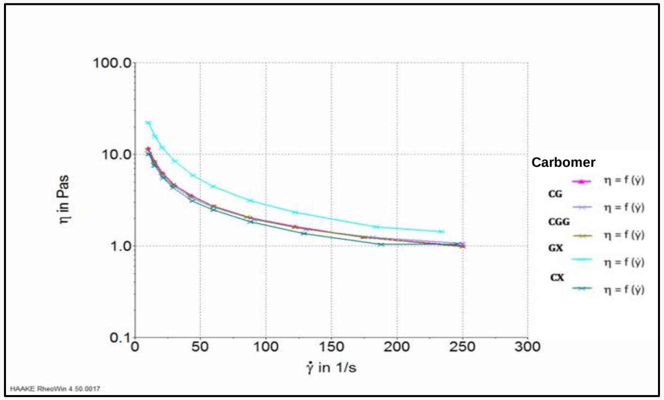
Shear rate sweep

Shear thinning flow in all samples, viscosity higher in emulsions

Hydrogels

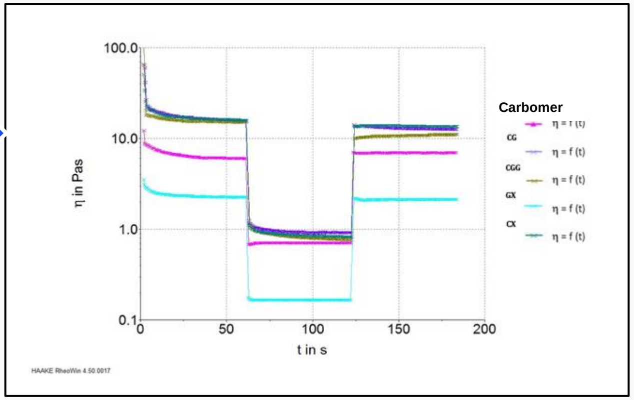


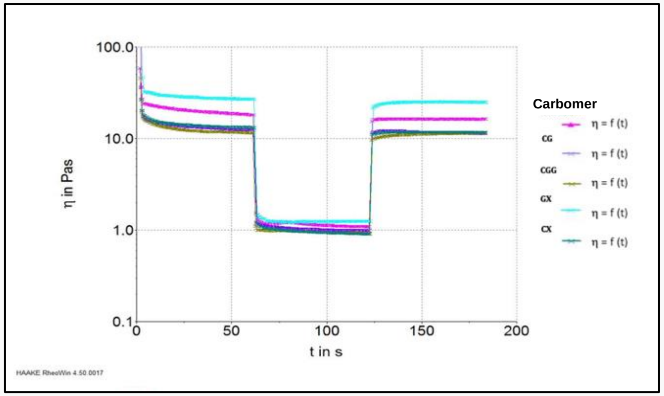
Emulsions



Three-step thixotropy test

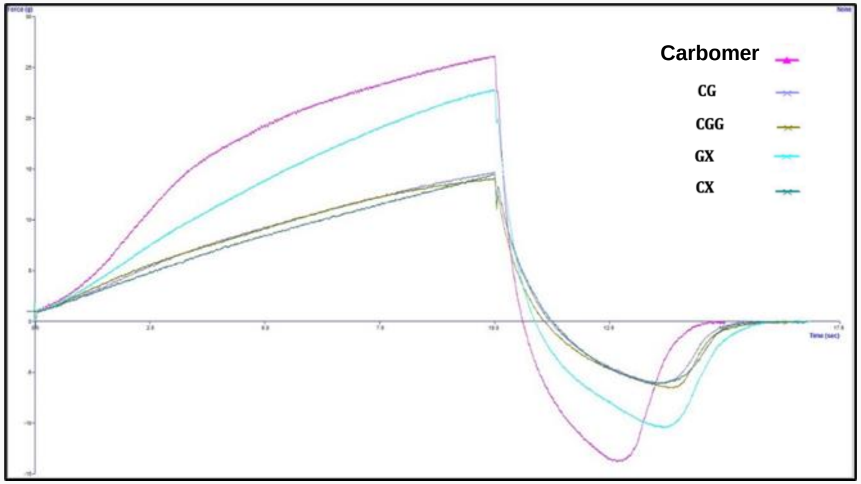
Quick recovery (low thixotropy) in most emulsions, different rank order in hydrogels





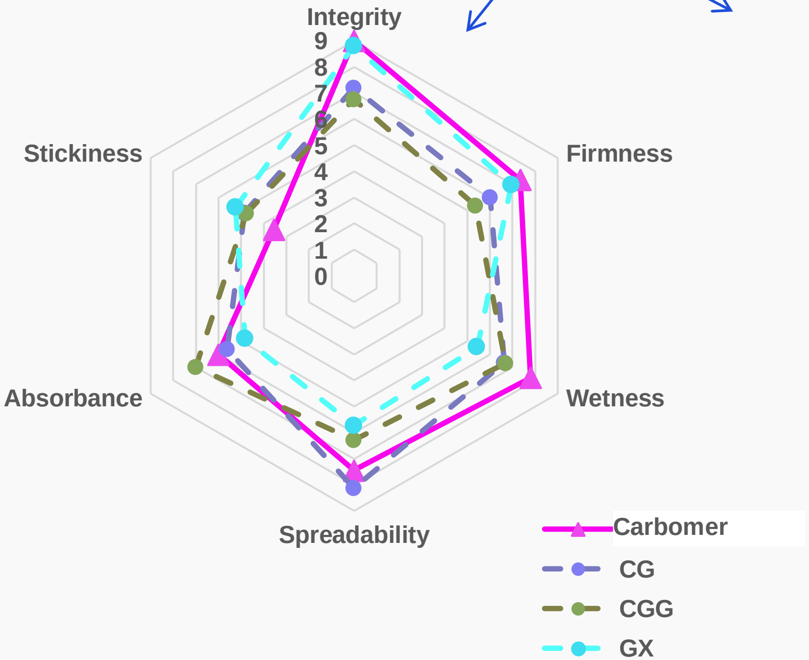
Results

Texture analysis of the emulsions with different polymer combinations



Sample GX selected as the best match from the TA

Sensory profiling results



Attribute	Mean rankings				Z-Value	p-value
	Carbomer	CG	CGG	GX		
Absorbance	**2.00**	2.43	3.14	2.43	4.05	0.256
Spreadability	**2.75**	3.00	2.38	1.88	3.45	0.327
Wetness	**3.21**	2.43	2.57	1.79	5.89	0.117
Firmness	**3.19**	2.19	1.88	2.75	4.98	0.174
Integrity	**3.50**	2.00	1.50	3.00	12.00	0.007
Stickiness	**2.00**	2.25	2.88	2.88	3.75	0.290

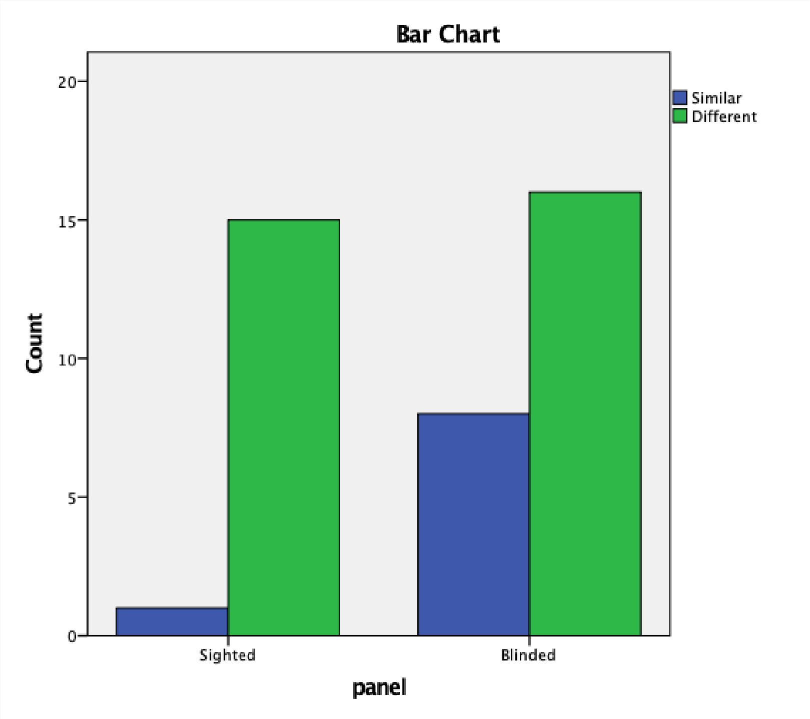
Sample CG selected as the best match by the panel

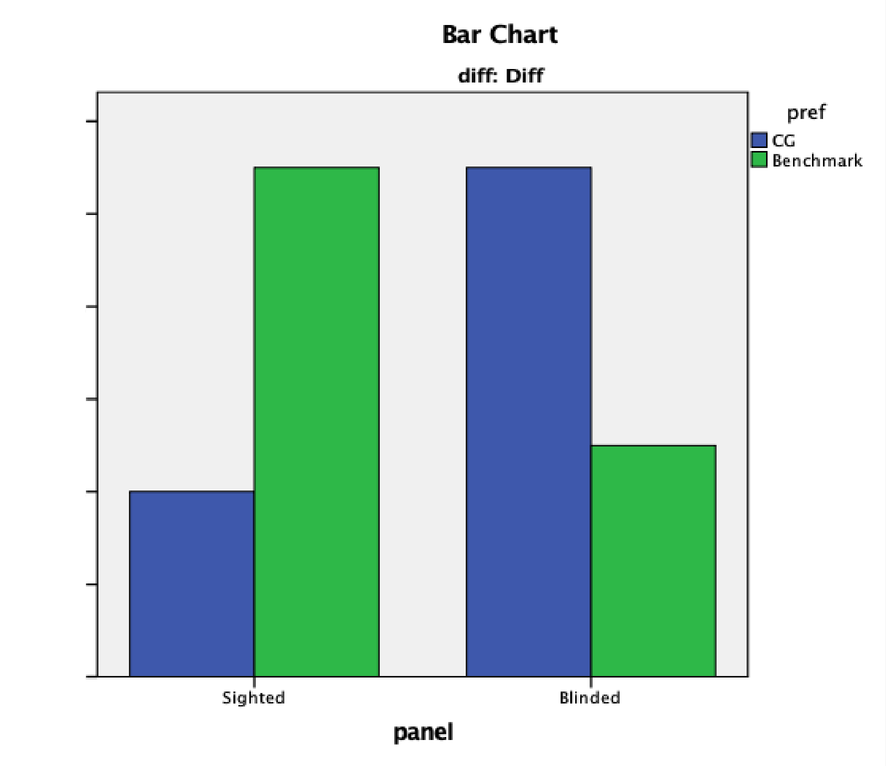
Results

Sensory test results, comparing emulsions with CG and Carbomer

Paired difference test

Preference test





77% of participants perceived a difference

Change in preference (blinded panel preferred emulsion CG over Carbomer), due to the white residue temporarily left on skin by CG

Conclusions

- Viscoelastic plot has been proven to be a useful rheological tool.
- Carbomer cannot be replaced by a single natural polymer.
- Natural ‘gelling’ agent(s) should be combined with ‘thickening’ agent(s) to increase the mechanical strength of the network.
- Sensory testing can not be completely replaced by instruments; the two methods should be combined.
- Linear/elastic polysaccharides could be included in the combinations, to remove the white residue and increase consumer acceptance.

References

Lukic, M., Jaksic, I., Krstonosic, V., Cekic, N. and Savic, S., A combined approach in characterization of an effective w/o hand cream: the influence of emollient on textural, sensorial and in vivo skin performance, International Journal of Cosmetic Science, 34(2), pp. 140-149 (2011)

Madlin, B., Baltazar, D., Stevic, M. C. and Tamburic, S., Water resistance vs. rheology control: an exploration, Cosmetics & Toiletries, Vol. 135, 2, 44-56 (2020)

Saha, D. and Bhattacharya, S., Hydrocolloids as thickening and gelling agents in food: a critical review, Journal of Food Science and Technology, 47(6), pp. 587-597 (2010)

Tai, A., Blanchini, R. and Jachowicz, J., Texture analysis of cosmetic/pharmaceutical raw materials and formulations, International Journal of Cosmetic Science, 36 291-304 (2014)

Tamburic, S., Craig, D.Q.M., Rheological Evaluation of Polyacrylic Acid Hydrogels, Journal of Pharmacy and Pharmacology 1(3), pp. 107-109 (1995)

Tamburic, S., Sisson, H., Cunningham, N. and Stevic, M.C., Rheological and texture analysis methods for quantifying yield value and level of thixotropy, SOFW Journal, 143(6), pp. 24-30 (2017)

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