Rheological and sensory properties of starch ingredients evaluated in a food product model

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Introduction

Texture is of major importance for the acceptability of food by consumers. Because of Its textural properties starch is extensively used as gelling agent in food products. The functional properties of starch largely depend on its molecular structure[1]. In small-scale food models starch functionality can be evaluated in complex systems with compositions similar to full-scale food products[2].

In this study nine potato starches with different molecular, structures due to chemical or genetic modification were evaluated in a milk-based food product model. The study was undertaken In order to evaluate the rheological and sensory properties of starch ingredients with different molecular structures and to explore correlations between rheological and sensory properties of the model products.

Materials and methods

Nine native, genetically modified or chemically modified starches were tested in a food model product (Dutch vla). The texture characteristics of the starch-based products were characterized sensory and rheological analyses.

Test starches

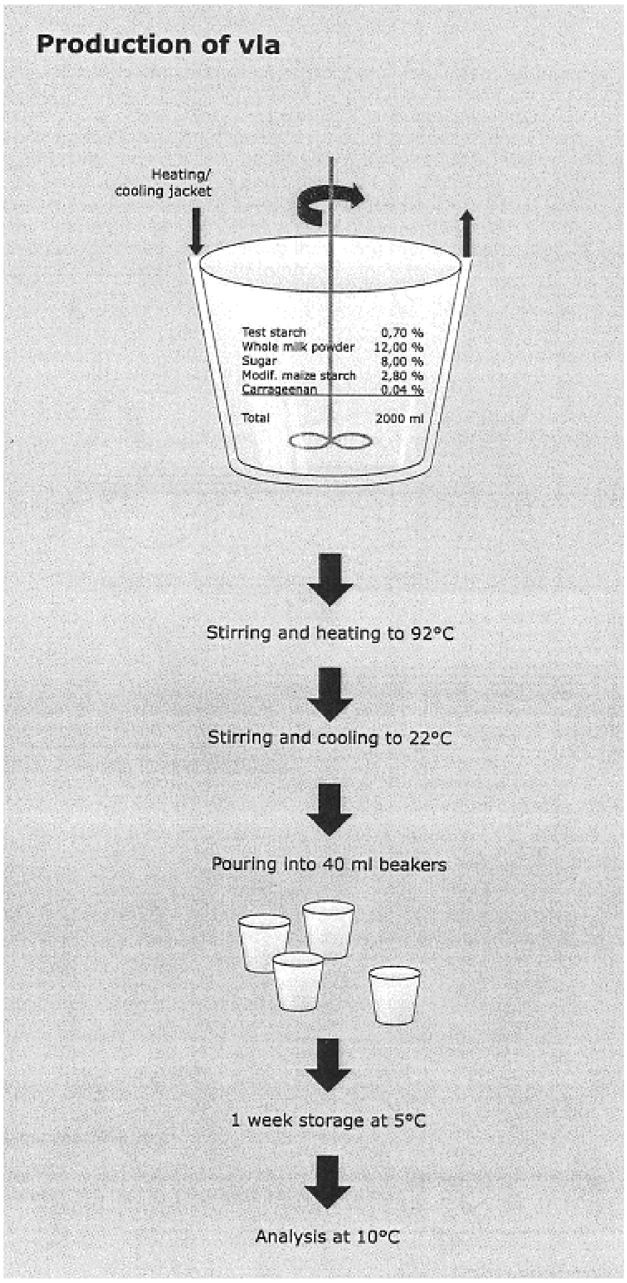
Name	Description
NP	Native potato starch
AP	Acetylated Potato starch
HP	Hydroxypropylated Potato starch
NM	Native maize starch
B2 B4 B8	Starches from GMO Potatoes where the activity starch branching enzymes is reduced to give less branched amylopectin, longer amylopectin chains and a more crystalline molecular structure.
G24 G33	Starches from GMO potatoes where E. coli glycogen branching enzyme has been Inserted to give more branches in amylopectin, shorter amylopectin chains and a less crystalline molecular structure.
NP and AP were produced by KMC, Denmark; HP was produced by ISI, Denmark, NM was obtained from Cerestar Scandinavia NS, Denmark; B2, B4, B8, G24 and G33 were produced by Danisco Biotechnology, Denmark.	

Texture attributes for sensory evaluation of vla

Descriptor	Definition
Gel-ts	The degree of shape retention of the hole in the product when a spoonful is removed
Consistency	The resistance of the product towards a horizontal movement of the spoon
Stringy-ts	How the product falls from the spoon (ant: short)
Sticky-ts	The degree to which the product sticks to the spoon.
Firm-tm	The force required to press the sample against the palate with the tongue.
Sticky-tm	The degree to which the product adheres or sticks to the tongue, palate, mouth or teeth
Creamy-tm	The degree to which the product is perceived as miscible, thick and smooth In the oral cavity
Melting-tm	How fast the product melts in the mouth
Suffix -ts: texture perceived by a spoon; -tm: texture perceived in the mouth	
Sensory analyses were carried out at 10°C and performed in duplicates	

Rheological analysis of vla

Method	Parameters
Stress sweep	Stress range 0.1-10 Pa at 1 Hz.
Frequency sweep	Frequency range 0,1-10 Hz.
Viscometry	Shear rate range 1 to 300 s^{-1}, data fitted to Power law: $= K^{(n-1)}$.
Spreadability	Concentric cylinder consistometer (dia. 30 mm, height 20 mm), reading after 2 min.
All rheometer analysis were carried out on a Bohlin CS rheometer with 40 mm plate-plate geometry at 10°C. All analyses were carried out in triplicates	



Results

Sensory profiles of the manufactured model products are presented in Fig. 1A and Fig. 1B. The GMO starches showed little variation in sensory profiles (Fig. 1A). Generally, B-starches with a more crystalline molecular structure gave slightly firmer, more gelled and less stringy textures, whereas G-starches with a looser structure gave more viscous and stringy textures.

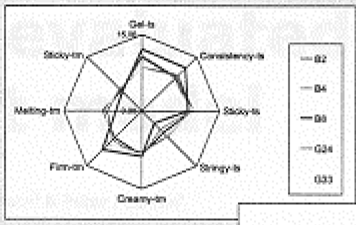


Figure 1A.
Sensory profile of GMO starches.

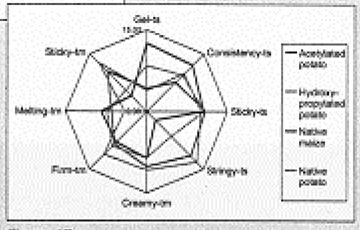


Figure 1B.
Sensory profile og native and chemically modified starches.

Chemical modifications of potato starch induce larger differences in functionality (Fig. 1B). Products prepared with acetylated or hydroxypropylated potato starches were less gelled, more stringy and gave a more creamy and sticky feeling in the mouth.

Products made with native maize starch which is traditionally preferred for vla production, were more gelled, less stringy, with a higher consistency and a reduced sticky feeling in the mouth as compared to potato starches (Fig. 1B).

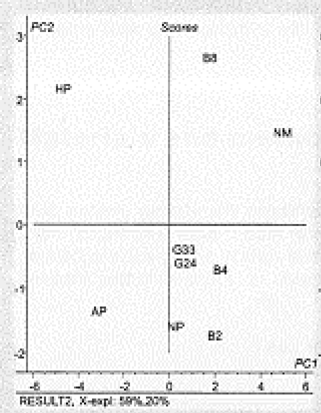


Figure 2A. PCA scores plot of sensory and rheological data

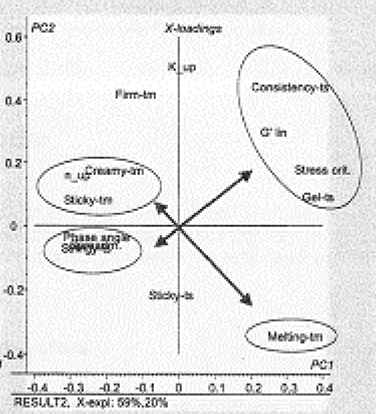


Figure 2B. PCA loading plot of sensory and rheological data

From Fig. 2A it is seen that the native and chemically modified starches had very different characteristics while the GMO starches were more similar except for 68. The texture characteristics of 68 were to same extent similar to native maize starch.

In Fig. 2B correlations between sensory and rheological variables are seen. Sensory variables related to a gelled structure are located in the upper right-hand corner. These variables are correlated to G' and the critical stress from a stress sweep. They are inversely correlated to the parameters related to a viscous (high phase angle), stringy and spreadable structure. A high flow index, n, is correlated to a creamy mouthfeel indicating that less shear thinning behavior gives a more creamy mouthfeel. Creamy is inversely correlated to melting indicating that a creamy product does not melt rapidly in the mouth.

The sensory parameter *stringy* is a key parameter in starch based food products. Therefore partial least square regression (PLS) was made in order to model and predict *stringy* on the basis of the all the rheological variables. *Stringy* can be predicted with a correlation coefficient of 0,91. for the validated model (Fig. 3A, top). The variables G'lin (1 Hz) and the phase angle (1Hz) contribute the most to the model (Fig. 3A, bottom). Therefore a new model was made based alone on the whole curves of G' and the phase angle from the frequency sweep (Fig. 36). However, this model only predicted stringy with a correlation coefficient of 0,77. The other rheological variables consequently contribute significantly to the prediction model.

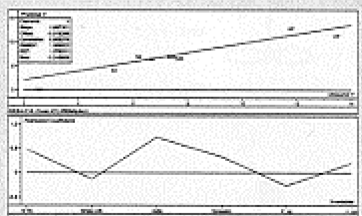


Figure 3A. PLS prediction of stringy from all instrumental parameters.

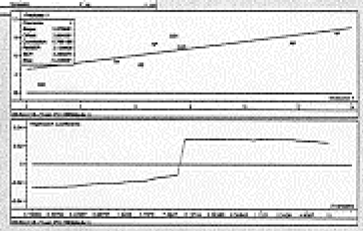


Figure 3B. PLS prediction of stringy from frequency sweep curves.

Conclusion

Starches with different mo1ecular structure gave different texture properties when tested in a model food product. A compact molecular structure of starch gave a gelled, short and non-sticky texture. A looser molecular structure gave a stringy and creamy texture.

Correlations between rheological and sensory parameters of the food models products were found. *Stringy* could be predicted from the frequency sweep curves alone with a correlation coefficient of 0,77. When instrumental. parameters from three more analysis were included the correlation coefficient went up to 0,91.

References

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