Rheological and Sensory Properties of Starch Ingredients Evaluated in a Food Product Model

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ABSTRACT

Nine potato starches with different molecular structures were evaluated in a milk-based food product model. The textural properties of the products were characterised by sensory and rheological analyses. Chemically modified starches with a loose molecular structure overcooked resulting in a sticky and stringy texture. Genetically modified starches with more compact structures were less overcooked giving a gelled and shorter texture. Correlations between rheology and sensory analyses were found.

INTRODUCTION

Texture is of major importance for the acceptability of food by consumers. Because of its textural properties starch is extensively used as a thickener or as a gelling agent in food products. The functional properties of starch largely depend on its molecular structure. The molecular structure of starch can be modified through physical, chemical, enzymatic or genetic modification giving rise to a large variety of functional properties. A model product test system is a valuable tool in evaluating new starch ingredients in food. In small-scale food models starch functionality can be evaluated in complex systems with compositions similar to full-scale food products, thus giving results that can be extrapolated to real food products[1].

This study was carried out in order to evaluate the rheological and sensory properties of starch ingredients with different molecular structures.

MATERIALS AND METHODS

Native potato starch (NP) and acetylated potato starch (AP) were produced by KMC, Denmark; hydroxypropylated potato starch (HP) was produced by ISI, Denmark. Genetically modified starches with highly branched amylopectin (B2, B4 and B8) and with reduced branching (G24 and G33) were produced by Danisco Biotechnology, Denmark. Native maize starch (NM) was obtained from Cerestar Scandinavia A/S, Denmark.

Vla was manufactured in 2000 ml batches using 0.7% test starch, 12% whole milk powder, 8% sugar, 2.8% modified maize starch "C*Tex06201", and 0.035% carrageenan. All ingredients were heated to 92°C and cooled to 22°C while stirring continously.

Rheological properties of the products were evaluated by stress sweep, frequency sweep and viscometry (Bohlin CS rheometer with 40 mm plate-plate geometry, stress range 0,1-10 Pa at 1 Hz, frequency range 0,1-10 Hz, shear rate range of 1 to 300 s^{-1}).

Spreadability analysis was performed using a consistometer with a concentric cylinder (diameter 30 mm and height 20 mm, reading after 2 min.).

Table 1. Texture attributes for sensory evaluation of vla

Descriptor	Definition
Gel-ts	The degree of shape retention of the hole in the product when a spoonfull is removed
Consistency-ts	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 percieved as miscible, thick and smooth in the oral cavity
Melting-tm	How fast the product melts in the mouth
Suffix –ts: texture percieved by a spoon; -tm: texture percieved in the mouth	

A sensory panel of eight trained assessors evaluated the texture characteristics of vla using a consensus set of descriptors (Table 1).

All analyses were carried out at 10°C and performed in triplicates.

RESULTS AND DISCUSSION

Sensory profiles of the manufactured model products are presented in Fig. 1A and Fig. 1B. The GMO starches show similar profiles (Fig. 1A). Generally, B starches give slightly firmer, more gelled and less stringy textures, whereas G starches give more viscous and stringy textures as a result of overcooking. Due to reduced amylopectin branching B starches have more compact molecular structures and higher gelatinization temperatures (results not shown). Consequently, these starches are less sensitive to overcooking.

Chemical modifications of potato starch induce larger differences in functionality (Fig. 1B). Products prepared with acetylated or hydroxypropylated potato starches are less gelled, more stringy and give a more creamy and sticky feeling in the mouth which can be a result of overcooking. Due to the substituted groups these starches have a looser starch structure that gelatinize easily[2].

Native maize starch is traditionally preferred for vla production. Due to stronger intermolecular bonding as compared to potato starch, maize starch will gelatinize at higher temperatures and is less sensitive to overcooking[2]. Consequently, products made with native maize starch are more gelled,

Table 2. Results from rheological analyses of vla.

Starch	Phase angle [°]	Stress crit. [Pa]	G'lin [Pa]	Spreadmeter [mm]	Power law K	Power law n
B2	11,3	3,17	111,3	51,8	32,7	0,21
B4	10,8	3,31	115,1	50,8	33,5	0,21
B8	10,8	3,26	116,4	52,4	37,0	0,25
G24	11,3	2,85	109,0	52,8	35,0	0,25
G33	11,0	3,06	114,3	53,2	36,2	0,25
NP	11,0	2,89	104,3	54,4	33,8	0,25
AP	12,0	2,67	110,9	55,8	35,4	0,29
HP	12,7	2,70	110,6	55,1	38,6	0,33
NM	9,7	3,84	132,4	51,0	39,0	0,21

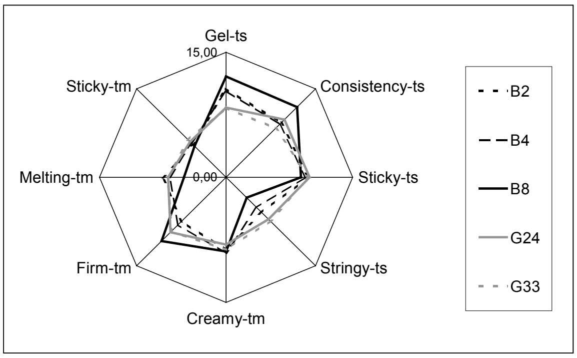

Figure 1A. Sensory profiles of vla prepared with GMO starches.

less stringy, with a higher consistency and a reduced sticky feeling in the mouth as compared to potato starches (Fig. 1B).

Results from the rheological analyses of food models are shown in Table 2. Products made with GMO starches have similar rheological properties. When comparing the chemically modified starches (AP and HP) with the native potato starch (NP) it is clear that substituted starches give a weaker and more viscous structure with a lower G'lin, a higher phase angle, a higher degree of spreading and a higher flow index, n. The strongest structure is obtained when a native

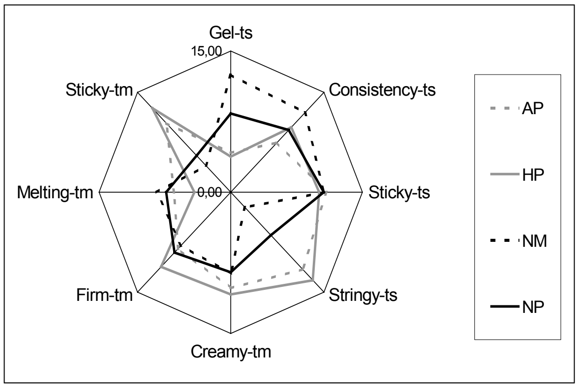

Figure 1B. Sensory profiles of vla prepared with native and chemically modified starches.

maize starch is used.

In Fig. 2 an overview of all results is given in a PCA scores and loading plot. It is seen that the native and chemically modified starches have very different characteristics while the GMO starches are more similar except for B8. The texture characteristics of B8 are to some extent similar to native maize starch. Native maize starch gives a gelled structure as opposed to acetylated potato that gives a viscous and stringy structure.

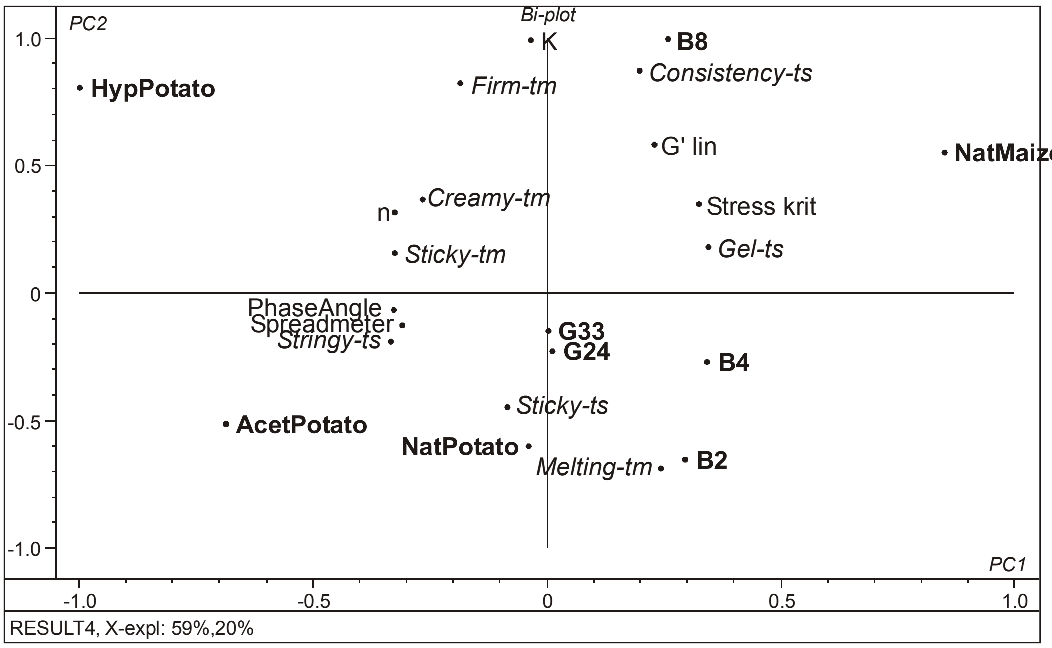

Figure 2. PCA scores and loading plot of results from sensory and rheological analysis of vla. Samples in bold, sensory parameters in italics and rheology parameters in normal type.

In Fig. 2 correlations between sensory and rheological variables are found. Sensory and rheological variables related to a firm and gelled structure are located in the upper right-hand corner inversely correlated to the sensory and rheological 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 behaviour gives a more creamy mouthfeel. Creamy is inversely correlated to melting, so a creamy product is a product that does not melt rapidly in the mouth.

CONCLUSION

Native potato and native maize starch gave different sensory texture profiles in vla. Chemical modification of potato starch by acetylation and hydroxypropylation gave starches that overcooked in vla. Reduction of amylopectin branching in potato starch by genetic modification produced starches that were less overcooked in vla. Correlations were found between sensory and rheological properties.

ACKNOWLEDGMENTS

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