REGULAR ARTICLE

RHEOLOGICAL PROPERTIES OF PASTES AND GELS PREPARED FROM WHEAT AND OAT FLOURS IN WATER SOLUTIONS OF STARCH HYDROLYZATES

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ABSTRACT

During production of β-glucans preparations from oat a large amount of so called residual oat flour is manufactured. It contains all compounds of oat, only amount of dietary fiber is decreased. Such flour could be possibly used in baked goods, or as a thickening agent. In order to evaluate its possible application as thickening agent the rheological investigations of system containing residual oat starch were carried out. They involved performing of pasting profiles and texture profile analysis of flour pastes and gels in the presence of starch hydrolyzate, which recently played a increasing role in food industry as alternative for sucrose. Also commercial wheat and oat flours were investigated as reference material

It was observed differences in pasting profile and texture of gel caused by introduction of starch hydrolyzate into systems containing cereal flours. Obtained results allow to draw conclusion, that such systems can be successfully used as thickeners

Keywords: Residual oat starch, pasting characteristics, TPA

INTRODUCTION

In recent years it is observed a growing awareness towards proper nutritional customs may lead to increased consumption of functional food. Among many foodstuffs β-glucans plays an important role due to their health promoting activity. Such situation provokes increased demand for β-glucans, thus their increased production The mainly sources of glucans are yeasts, seaweed and different species of mushrooms. Oat can be perceived as a good raw material for β-glucans industrial production due to relatively high content of this compound ranging 4 – 7% in whole grain (**Wood *et al.*, 1991**). Oat is common cereal, with relatively small use in human nutrition, but with quite interesting properties like high level of dietary fiber, mineral compounds, and lipids, when compared to other staple cereals. The nutritional value of oat protein exceeds those of other cereals, and it also contains smaller amounts of starch, when compared to other cereals (**Butt *et al.*, 2008; Biel *et al.*, 2009**).

Growing demand for β-glucans produced from oat may lead to situation where surplus of so called residual oat flour (ROF) will appear. This high value product should be utilized or in production of oat starch, alcohol or in bakery product (**Lim *et al.*, 1992**). Other possible way of ROF utilization may be use it as thickening agent in milk desserts, or as a filling in bakery products. In these applications the rheological parameters are of great importance.

The products of starch hydrolysis are used in a wide range of food products due to both their functional and nutritional properties (**Bertolini, 2009**). Currently food industry consumes increasing amounts of different types of starch hydrolyzates, as replacers of classical sweeteners like sucrose.

The objective of our study was to evaluate rheological properties of pastes and gels prepared from residual oat flour, and to compare them with properties of other commercial flours. Gel and pastes were prepared in concentrated solutions of starch hydrolyzate.

MATERIAL AND METHODS

Material

Residual oat starch (ROF) was a kindly donated by MICROSTRUCTURE Ltd (Warsaw, Poland). As a reference material the following commercial flours were used:

- oat flour (COF) was produced by “Bogutyń Młyn” (Radzyń Podlaski, Poland)
- wheat flour type 650 (WF) was produced by PZZ Kraków (Kraków, Poland)

Glucose syrup C* sweet 10347/G 36 (DE=35) was produced by CARGILL (Bielany Wrocławskie, Poland).

Preparation of stock solution of starch syrup

The 50% stock syrup solution was prepared in the following way: 500 g of syrup was dissolved in water, and total mass of solution was set on 1000 g:

Pasting profile of 10% flour suspensions

Samples for pasting profile were prepared in following manner: 10 g of flour (db) was suspend in water (00) or in 50% syrup solution (50) and total mass of sample was 100g. Pasting profile was done in Brabender Micro-visco-amylograph (Duisburg Germany). The following temperature program was set: start at 45°C, then temperature rises to 95°C, then hold for 10 minutes, next cooling to 25°C, and hold for next 10 minutes. Both heating and cooling rate was set on 4.5°C/min. canister revolution was 150 rpm. This analysis was done in triplicate.

Texture Profile Analysis (TPA) of 10% flour gels

Samples for TPA were prepared in proportion as described above Flour suspensions were pasted in water bath, and then samples were poured into plastic container. After cooling containers were closed, and samples were stored in refrigerator. Samples were removed from refrigerator 1 hour before testing in order to attain room temperature. TPA analysis was performed using TA-TX2 texture analyzer, STABLE MICRO SYSTEMS (Surrey, England) using P20 probe. The probe was speed was set on 5 mm/sec., and probe was inserted into sample on 10 mm between compressions there was 5 s relaxation time. Samples were stored up to 7 days. There were five repetitions for each day of analysis.

Statistical analysis

All measurements were done in at least two replicates, and the results were subject to one factor analysis of variance (ANOVA), applying software package Statistica 10 (USA). The significance of differences was evaluated by Duncan's test, at $\alpha \leq 0,05$. The results are represented as mean value ± standard deviation (SD).

RESULTS AND DISCUSSION

Pasting characteristics

Pasting of starch is probably the most important feature deciding/ruling/indicating on possible way of starch/flour application. Pasting of flour is much more complex phenomena, than in case of starch suspensions alone (**Zhou *et al.*, 1999b,c**). Except starch also other components, like proteins or β-glucans play role. So an introduction of additional sugars makes this situation far more complicated.

As can be observed (fig 1.) both origin of flour and presence of hydrolyzate have an influence on pasting characteristics of wheat and oat flours. It can be easily distinguish between oat and wheat flours. Oat flours pastes had similar course of pasting curves, quite different than for wheat flour paste. Wheat flour revealed the lowest viscosity through whole pasting phenomena, attaining only 72 B.U. at peak viscosity, when compared to 470 B.U. and 565 B.U. for commercial and residual oat flours respectively. Pasting temperatures for wheat and residual flours alone were similar, and they were higher than for commercial oat flour.

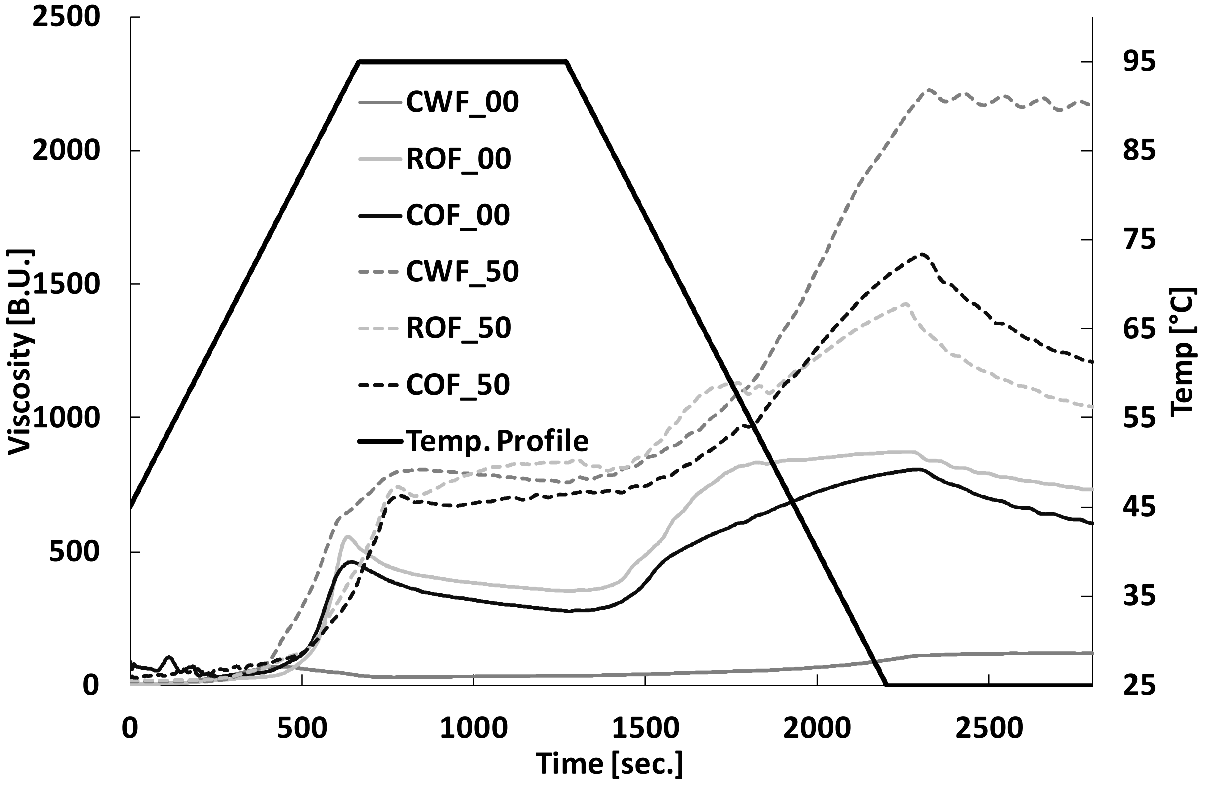

Figure 1 Pasting characteristics of the investigated systems

Breakdown and setback values observed for oat starches were similar to each other, and as can be easily observed those values were higher than in case of wheat starch.

Introduction of hydrolyzate into system dramatically changed the course of pasting phenomena, especially in case of wheat flour suspension. At this moment wheat starch paste revealed the highest viscosity, greatly exceeding that of oat flours at cooling stage. Again both oat flours were characterized by similar course of pasting curves.

Pasting temperature was increased, except for commercial oat flour, where small decrease was observed. Increase was more dramatic in case of wheat flour suspensions exceeding over 10°C. Such situation is interpreted by the stabilizing effect of sugars on starch granule (**Spies and Hoseney, 1982**).

In order to determine the influence of proteins and ß-glucan on pasting properties of oat flour **Zhou *et al.* (2000)** applied the proper enzymes hydrolyzing these compounds. ß-glucans have significant contribution on paste viscosity, but proteins contribution has no such effect. Other investigations confirm the effect of ß-glucans on pasting profile **(Zhang *et al.,* 1997; Colleoni-Sirghie *et al.,* 2004)**.

The influence of oat's flour lipids on Pasting characteristics was a subject of other investigation **(Zhou *et al.*, 1999a)**. Both amount, as well as lipid composition had significant impact on pasting properties, although not such as other flour components. Maximum viscosity and time when it was reached were negatively correlated with lipid content.

Table 1 Hardness of the investigated 10% flour gels prepared with 50% addition of starch hydrolyzate and without it

Syrup level [%]	0			50		
	ROF	COF	CWF	ROF	COF	CWF
1	0.110^{a}_{aA}	0.213^{c}_{bC}	1.028^{b}_{cE}	0.108^{a}_{dA}	0.146^{a}_{eB}	0.253^{b}_{fD}
2	0.112^{a}_{aA}	0.199^{bc}_{aB}	0.793^{a}_{bC}	0.105^{a}_{cA}	0.142^{a}_{dB}	0.244^{ab}_{eC}
3	0.118^{a}_{A}	-	-	0.103^{a}_{A}	-	-
4	0.128^{a}_{aA}	0.185^{b}_{aB}	0.757^{a}_{bD}	0.104^{a}_{cA}	0.129^{a}_{dB}	0.250^{b}_{eC}
5	0.129^{a}_{A}	-	-	0.105^{a}_{A}	-	-
6	0.119^{a}_{A}	-	-	0.101^{a}_{A}	-	-
7	0.131^{a}_{aB}	0.164^{a}_{aD}	0.641^{a}_{bF}	0.104^{a}_{cA}	0.130^{a}_{dC}	0.214^{a}_{eF}

Legend: ROF – residual oat flour, COF – coomercial oat flour, WF – wheat flour

The values with the same superscript in the column (effect of storage time) are not different at α=0,05.

The values with the same small letter subscript in the row/section are not different at α=0,05 (effect of starch origin). The values for starch of one origin with the same capital letter subscript in the row are not different at α=0,05 (effect of syrup addition).

Hardness of 10% gel was monitored during 7 days of storage (Tab. 1). As can be observed ROF gel exhibited quite different behavior than remaining two flour's gels. There was no statistically observed changes for this parameter for ROF gel during period of storage, irrespectively of level of added syrup. That may suggest quite stable structure in the investigated period of time. Also introduction of syrup into system caused no statistical differences in hardness. For the remaining flour's gels it was observed small decrease over a 7 days storage period. Also introduction of syrup leaded to decrease in hardness.

ROF gel exhibited no adhesivness at all, for COF it was observed only for gels prepared in water, and at first day of storage in case of gels with addition of syrup (Tab. 2) . Only CWF gels were characterized by this parameter. During storage the value of this parameter decreased. Also introduction of syrup caused decrease in this parameter (Tab 1).

Table 2 Adhessivenes of the investigated 10% flour gels prepared with 50% addition of starch hydrolyzate and without it

Syrup level [%]	0			50		
	ROF	COF	CWF	ROF	COF	CWF
1	*	22.142^{ca}_{aB}	81.182^{a}_{bB}	*	1.160_{aA}	26.947^{b}_{bA}
2	*	16.099^{b}_{a}	73.625^{a}_{bB}	*	*	25.439^{b}_{A}
3	*	-	-	*	-	-
4	*	13.549^{b}_{a}	57.933^{a}_{bA}	*	*	26.699^{b}_{A}
5	*	-	-	*	-	-
6	*	-	-	*	-	-
7	*	6.846^{a}_{a}	39.673^{a}_{bA}	*	*	14.836^{a}_{A}

Legend: ROF – residual oat flour, COF – coomercial oat flour, WF – wheat flour

The values with the same superscript in the column (effect of storage time) are not different at α=0,05.

The values with the same small letter subscript in the row/section are not different at α=0,05 (effect of starch origin). The values for starch of one origin with the same capital letter subscript in the row are not different at α=0,05 (effect of syrup addition).

CONCLUSION

Performed tests allow to draw conclusion, that residual oat flour can be successfully implemented as food thickener. Addition of glucose syrup into systems greatly influenced the properties of resulting pastes and gels. It resulted in different direction changes of pasting temperature, with more clear effect in case of both wheat flour and starch, where increase was observed. Glucose syrup induced the changes in viscosity parameters, increasing them. Breakdown value was lowered after addition of glucose syrup (with exception for wheat flour suspensions), whereas setback value increased (with exception for suspensions of starch extracted from residual oat flour).

Addition of syrup also greatly influenced the properties of gels. It leaded to decrease of gels hardness, and also caused the vanishing of adhesiveness in case commercial oat flour gels.

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