# FACTORS AFFECTING THE VISCOSITIES OF WHEAT FLOURS EXTRACTS

— research paper —

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**Abstract:** The relation between viscosity and pentosans and protein contents of raw and treated four wheat flour extracts was investigated. The viscosity of extracts correlate very good with protein content and not so good with pentosans content in raw extracts ($R^2$ = 0.9946 and respective $R^2$ = 0.8801). The pentosans become more important in extracts after boiling and filtering. A negative correlation was observed between viscosity and pentosans and protein content, the viscosity of extracts decrease when the pentosans and protein content increase.

**Keywords**: soluble pentosans, soluble proteins, viscosity, wheat flour extracts

## INTRODUCTION

The wheat kernel and flour, in addition to their major components (proteins, starch and lipids) contain other materials, in small amounts but with significant roles in their process. The nonstarch polysaccharides named pentosans with cellulose, arabinogalactans and lignin form the cell wall (Courtin, 2001), (Fessas, 2003). The total pentosans represent about 2 to 3% from flours and the water soluble pentosans represent 1 to 1.5% flours (D'Appolonia, 1971).

The pentosans were classified according with their water solubility in two major classes: water extractable pentosans (WEP) and water unextractable pentosans (WUP). To these two classes we can add another one, enzyme extractable pentosans (EP).

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Pentosans have a great ability to bind large amount of water during kneading. One part of WEP can bind 4.4 part of water while the WUP can bind 9.9 part of water (Kim, 1977). The pentosanases from wheat or other sources can transform the WUP in WEP, so some amount of water became free, unbind. This water affects the rheology of dough. Another property of WEP is to form viscous aqueous solution. This solution has the ability to stabilize the dough pores and improve the gas retention of dough. Courtin and Delcour [6] proposed a mechanism for the cell gas stabilization. The WUP decrease stabilization and increase coalescence of the gas cell. The pentosanases hydrolyze WUP and convert them in to WEP. The WEP increase the viscosities of water film which surround the cell gas and the stabilities of these are increased.

The aim of this study is to study the role of WEP on the viscosity of flours aqueous extract. The aqueous extracts of flours contain the soluble compounds from flours: pentosans, soluble protein and arabinogalactan-peptide (AGP). The viscosity of four extracts was studied by many researchers. Udy, cited by Delcour and Courtin (Courtin, 2002) attributed two third of the intrinsic viscosities of flour extracts to WEP and AGP. Since the intrinsic viscosities of WEP is fifteen-fold higher than that of AGP the high viscosities of flour extracts is virtually completely caused by WEP.

Moore and Hoseney (1990) study the viscosity of flour-water extracts. They find that the viscosities of extracts increase with the time of extraction. After 90 minutes seems the viscosities remain constant, probably because the maximum amount of WEP and another soluble materials were extracted. The viscosities of extracts decrease during their storage. Moore and Hoseney presume that the viscosities of extracts decrease because cleavage of arabinose side chains. In their research they conclude no enzyme is responsible for the decreasing of flour extracts viscosity and they presume the cause is the acid hydrolysis of arabinose side chain and the precipitation of the resulting chains. In our opinion this isn't it a reasonable conclusion because the reduction of viscosity appears even in the extracts with pH 2 and extracts with pH 8, truly, more obvious in the extracts with pH 2 than in extracts with pH 8.

In a previous experiment conducted by us (Ognean, 2007) on two flours the viscosity of flour extracts decrease with the increase of the extraction time, probably because the flours wasn't malted, while the flour from Moore and Hoseney experiment was. The viscosity of boiled and filtered extracts was lower than the viscosity of crude extracts and the lowering of viscosity was not so pronounce that in case of crude extracts. These facts conduct us to the

conclusion that some components from extracts affect the viscosity of flours and they are sensible to heat.

## MATERIALS AND METHODS

Four flour not supplemented provided from the Cibin Mill from Sibiu was used for the experiment (F1 with 13.5% moisture and 0.65% ash, F2 with 13.8% moisture and 0.64% ash, F3 with 13,4% moisture and 1.25% ash and F4 with 13,5% moisture and 1.31% ash).
The flour extracts was obtained by mixing flour with water in ratio 1:5 (w/v). The slurry was incubated at 30°C for 30, 60, 90 or 120 minutes in a water bath with constant stirring. After incubation the slurry was centrifuged at 1000 x g for 10 minutes (Moore, 1990). The crude extracts were analyzed. To obtain the boiled extracts the glass test tube with crude extracts were immersed in boiling water for 10 minutes than cooled in current water and filtered through syringe filter.
The viscosity of extracts was determined with an Ubbelohde viscometer kept at 30°C with an ultratermostat.
The protein content of extracts was determined by Biuret method (Bordei, 2007) and modified by us. Above 3ml wheat flour extract we add 2 ml $CuSO_4$ 5%, 2 ml NaOH 30% and 7 ml distilled water. After 20 minutes the samples were centrifuged at 1000 g (approx. 3000 rpm) and the absorbance of the supernatant was read at a T80 UV/VIS Spectrometer PG Instruments. A calibration curve ($R^2$ = 0.982) was draw using various amounts of extracts with protein content determined by Kjeldhal method. The 5.7 factor was used to calculate de protein amount in flours extracts.
The orcinol method (Hashimoto, 1987) modified by (Delcour et all., 1989) was used to estimate the pentosans contents in water extracts.

## RESULTS AND DISCUSSION

The evolution of the extracts viscosity is presented in Figure 1. Viscosity decrease when the extraction time increases. The extracts prepared from flours with low ash content had a high viscosity than the extracts prepared from the flours with high ash content despite the pentosans content was opposed.
The pentosans content of extract increase in time, in crude and boiled extracts too, when the time of extraction was increase from 30 minutes to 120 minutes. The results are presented in Figure 2a. No major differences

were observed between the crude and boiled extracts showing no pentosans were removed with the sediment after boiling and filtering. A minor concentration generally occurred during the boiling. The protein content of extracts is showed in Figure 2b. The protein content increase with the extraction time and, as expected, the protein content of boiled extracts is lower than in the crude extracts, due the protein denaturation and precipitation. The reduction of protein content by thermic precipitation varies between 20 and 50 % with a average value of 30%.

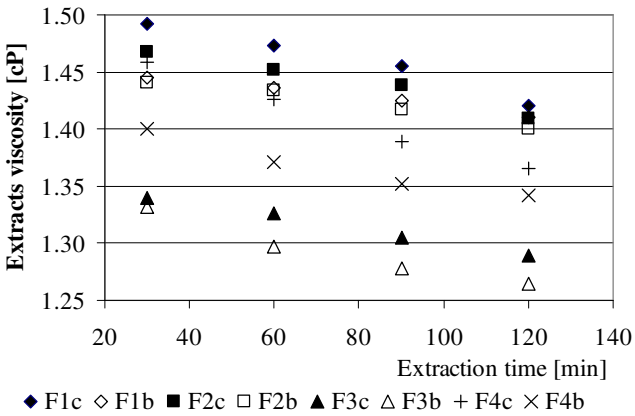


Figure 1. Viscosity of water extracts prepared at different extraction times (in legend *c* represent the crude extracts and *b* the boiled extracts)

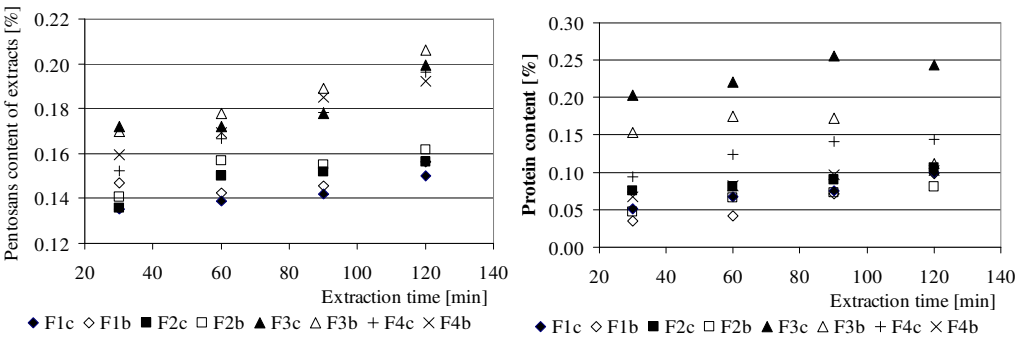


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Figure 2. Pentosans and protein content of flours extracts prepared at different time extracts (*a*. pentosans content, *b*. protein content) (in legend *c* represent the crude extracts and *b* the boiled extracts)

We wanted to determine what components from flour extracts is correlated with theirs viscosity. We assume the protein and pentosans from extracts that both have an impact of viscosity. When we analyzed these by linear regression a good correlation between pentosans content and viscosity of flours extract was observed. The correlation coefficient $R^2$ between viscosity and pentosans content was 0.8011 when al values obtained was analyzed, no matter the time of extraction or thermic treatment. The values of $R^2$ was much lower when the viscosity was plotted against the protein content, $R^2$ = 0.5893.

When the values were grouped in two classes, raw extracts and thermic treated extracts the values of $R^2$ were changed. The values are presented in Figure 3. The correlation coefficient $R^2$ is 0.7707 when the viscosity of raw extracts was plotted against the pentosans content and 0.8443 for boiled and filtered extracts.

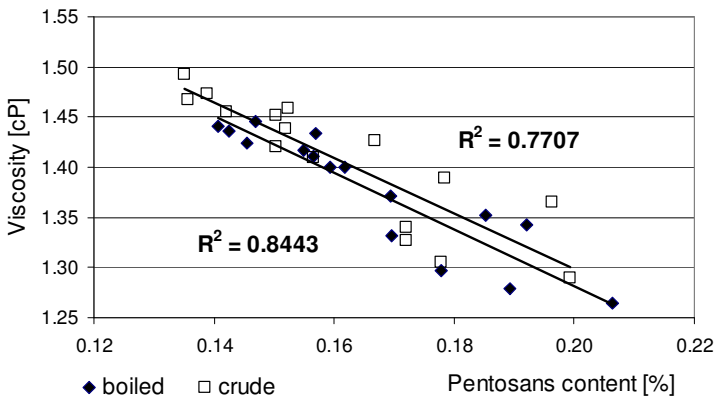


Figure 3. The viscosity and pentosans content of raw and treated flours extracts

In figure 4 is presented graphically the viscosity against the pentosans content for raw (a) and treated (b) extracts, for different extraction times. An interesting behavior of flour extracts is observed. The viscosity of extracts decreases when the pentosans content increase. The correlation coefficient between viscosity and pentosans content of crude extracts was higher when the extraction time was shorter. The correlation coefficient $R^2$ was higher for the treated extracts than for raw extracts. The absolute values of slopes decrease when the extraction times increase for raw extracts. The absolute

values of raw extracts slopes were lower than the absolute values of treated extracts.

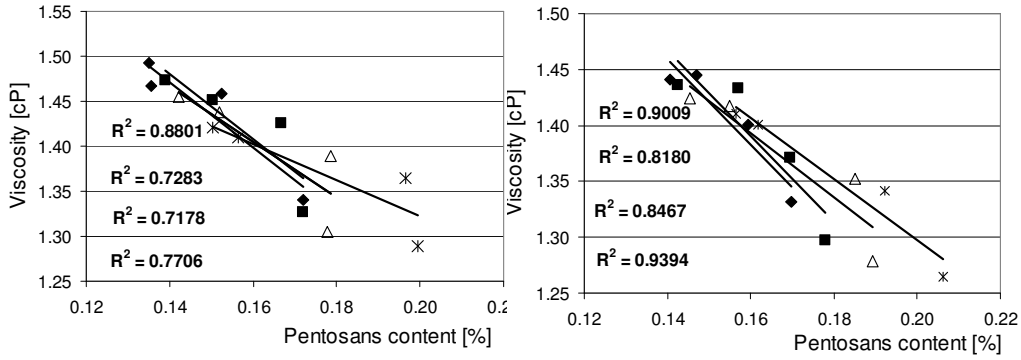


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Figure 4. The viscosity and pentosans content of raw (a) and treated (b) extracts, at different extraction times (♦ 30 min. extraction; ■ 60 min. extraction, + 90 min. extraction, M 120 min. extraction)

Figure 5 present the flours extracts viscosity in relation with theirs protein content. The all data was grouped in two groups, raw extracts and treated extracts. A very god correlation between the viscosity and protein contents could be observed at crude extracts ($R^2$ = 0.9551) and a not so good correlation in case of boiled extracts ($R^2$ = 0.7467). A much lower correlation could be observed when all data was analyzed, with no segregation between data ($R^2$ = 0.5893, data not showed). When extracts was boiled the protein was denatured and their impact on flours viscosity decrease and increased the importance of pentosans content (see figure 3).

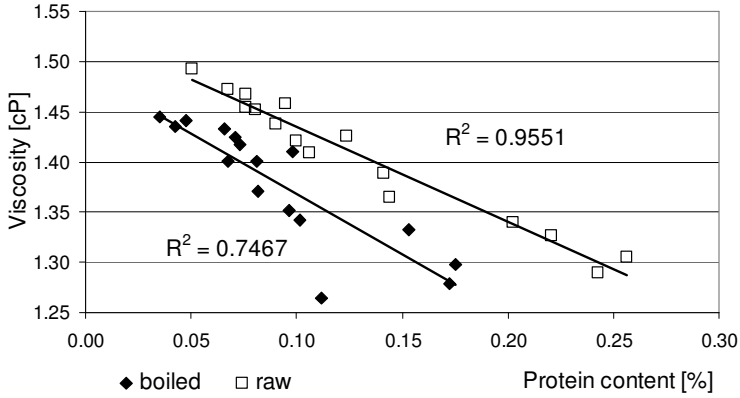


Figure 5. Viscosity and protein content of raw and treated flours extracts

When the data was split using the time of extraction a very good correlation could be observed between the viscosity and protein content, no matter the time of extraction (figure 6.a). The absolute values of slopes were very close for all extraction times, 1.011, 0.9266, 0.8177 and 0.9864 for 30, 60, 90 and respective 120 minutes of extraction. A good correlation between the viscosity and protein content of treated extracts could be observed just for the extracts with short extraction times (figure 6b). For the extracts with 120 minutes extraction time the correlation factor $R^2$ was lowest ($R^2$ = 0.6399). This fact could indicate the protein extracted after 120 minutes and last after thermic treatment had a low influence on viscosity or during the extraction the protein were modified in to a manner which has no influence on extracts viscosity. The absolute values of slopes differ for the different extraction times, these increases when the extraction times increase. The slopes were 0.97, 1.0707, 1.3858 and 4.1745 for 30, 60, 90 and respective 120 minutes of extraction. This could indicate that at long extraction times the remainder proteins after thermic denaturation tend to remain constant.

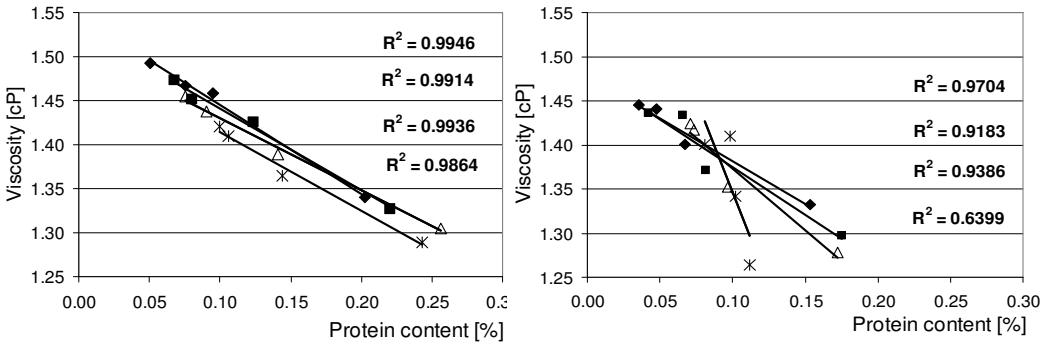


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Figure 6. Viscosity and proteins content of raw (a) and treated (b) extracts, at different extraction times (♦ 30 min. extraction; ■ 60 min. extraction, + 90 min. extraction, M 120 min. extraction)

## CONCLUSIONS

This experiment was realized to find what factors affect the viscosity of wheat flour extracts and in extent the viscosity dough. The soluble protein from raw extracts affect the viscosity much obvious than the soluble

pentosans. The impact of the pentosans was revealed when some of the proteins were removed through boiling and filtering the extracts.
Another question occured during this experiment: why the viscosity of flour extracts decrease despite the pentosans and protein content increase and the protein and pentosans are presumed to be responsible of viscosity of solution. One explanation could be the enzimatic activity of flours. During the extraction the enzymes hydrolyze the soluble protein and pentosans and solubilize protein and pentosans with low molecular weight, which didn't increase the viscosity of solution. The pentosanases and protease activity from flour wasn't measured so we can just hypothesize. But many researchers affirm the pentosanases activity of flours is very low or inexistent and at long extraction time would be solubilized the molecules with high molecular mass which should increase the viscosity. Another hypothesis is the destruction of some covalent or non-covalent complex pentosans-protein and/or between proteins, pentosans. The charts which represent the viscosity of extracts against the pentosans content have minor differences for raw extracts and treated extracts or for extracts with different extraction times. More obvious differences were observed between the charts of viscosity against protein content, especially for treated extracts with long extraction time. During extraction the protein become more sensitive to temperature and the remainder proteins have little effect on viscosity.

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