Swedish University of Agricultural Sciences
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Department of Food Science

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Department of Food Science
Independent project/degree in Food Science- Master´s thesis
15 HEC Advanced level A2E
Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap, no 351
Uppsala 2012

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**Credits:** 30 HEC
**Level:** Advanced, A2E
**Course title:** Independent project/degree in Food Science- Master´s thesis
**Course code:** EX0425
**Programme/education:** Agronomy – Food Science

**Place of publication:** Uppsala
**Year of publication:** 2012
**Title of series:** Publikation/Sveriges lantbruksuniversitet, Institutionen för livsmedelsvetenskap
**No:** 351
**Online publication:** http://stud.epsilon.slu.se

**Key Words:** Wheat bran, rye bran, dietary fibre analysis, sensory analysis, heat treatment, soluble dietary fibre, insoluble dietary fibre

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## ABSTRACT

When grains of wheat and rye are conventionally milled, large quantities of bran classified as by-products are left and are mainly used for animal feed. Bran is a complex material composed of the aleurone layer, nucellar epidermis, a seed coat, a fruit coat and a small proportion of the germ and endosperm depending on extraction rate. The bran fraction consists of approximately 40-50 % dietary fibre which can contribute to increase the nutritional quality of human cereal food. It would also be valuable for the food industry to convert by-products as bran to products with higher commercial values.

The aim of this thesis was to analyse the content and composition of dietary fibre of heat treated wheat and rye bran according to the Uppsala method with some modifications in order to analyse soluble and insoluble dietary fibre separately. Half of the bran samples were precooked, dried and roasted and the other half dried and roasted (uncooked). The aim was also to perform a sensory test according to a line scaling test to evaluate the flavour intensity between selected wheat bran samples and determine the particle size of all bran samples.

The results in this thesis showed that the total dietary fibre (TDF) content decreased with increasing roasting temperature and the uncooked bran samples had a higher content than the precooked. TDF ranged between 41.3-44.8 % for the wheat bran samples (untreated 42.5 %). For the rye bran samples TDF ranged between 43.7-46.6 % (untreated 43.0 %). The insoluble dietary fibre content decreased with increasing roasting temperature which can be due to fragmentation of polysaccharides during the heat treatment. The pre-treated, precooked and uncooked, samples had though a slight increased content of insoluble dietary fibre compared to the untreated wheat and rye bran. The content of soluble dietary fibres was not significantly affected by temperature or pre-treatment in either wheat or rye bran.

The precooked wheat bran samples had a more roasted flavour than the uncooked, where higher roasting temperature led to a more intense flavour. The uncooked samples were sweeter and had a more rancid flavour than the precooked samples. The particle size was in general larger for the wheat bran, especially in the precooked samples, than in the rye bran samples.

## SAMMANFATTNING

Vid malning av vete och råg bildas stora kvantiteter av kli som till största delen används till djurfoder. Kli är ett väldigt komplext material och består av aleuronskiktet, fröskal, fruktskal samt en liten del av grodden och det stärkelserika endospermet beroende på utmalningsgrad. Klidelen består av ungefär 40-50 % kostfibrer som kan bidra till att öka det nutritionella värdet i livsmedel. Utveckling av nya produkter och processer av biprodukter som kli kan leda till att det kommersiella värdet på kli ökar för livsmedelsindustrierna.

Syftet med det här examensarbetet var att analysera halten och sammansättningen av kostfibrer i värmebehandlat vete- och rågkli enligt Uppsala metoden (modifierad för att analysera lösliga och olösliga kostfibrer separat). Kliproverna var antingen förkokta, torkade och rostade eller bara torkade och rostade. Syftet var också att utföra ett sensoriktest enligt en deskriptiv metod där en skala användes för att utvärdera smakintensiteten mellan utvalda vetekliprover, samt att analysera partikelstorleken för alla kliprover.

Kostfiberanalysen av de processade vete- och rågkliproverna visade att totala kostfiberhalten sjönk med ökad rostningstemperatur och att de kliprover som inte genomgick förkokningen hade en högre kostfiberhalt än de kliprover som förkokts. Halten totala kostfibrer för vetekliproverna varierade mellan 41,3-44,8 % (obehandlat 42,5 %). I rågkliproverna var den totala kostfiberhalten mellan 43,7-46,6 % (obehandlat 43,0 %). Halten olösliga kostfibrer minskade med ökad temperatur vilket troligen beror på att en del bindningar i polysackariderna förstördes under värmebehandlingen. Dock hade de förbehandlade kliproverna en något högre halt olösliga kostfibrer än obehandlat vete- och rågkli. Halten lösliga kostfibrer i de värmebehandlade kliproverna förändrades inte nämnvärt jämfört med obehandlat vete- och rågkli.

De förkokta vetekliproverna hade en mer rostad smak jämfört med de prover som inte genomgick förkokningen innan torkning och rostning, samt att den rostade smaken var mer intensiv ju högre rostningstemperaturen var. De kliproverna som endast torkades och rostades hade en sötare och mer härsken smak jämfört med vetekliproverna som förbehandlats. Vetekliproverna hade generellt en större partikelstorlek, speciellt de förbehandlade vetekliproverna, jämfört med rågkliproverna.

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# 1. INTRODUCTION

When grains of wheat and rye are conventionally milled, large quantities of bran classified as by-products are left and are mainly used for animal feed (Craeyveld *et al.*, 2009; Hemery *et al.*, 2007). Many consumers prefer refined white flour to whole grain products due to less attractive textural properties of whole grain products (Noort *et al.*, 2010). Also because whole grain can have a bitter taste especially the bran since bitter tasting compounds are concentrated in the outer layers of the grain (Heiniö *et al.*, 2008; Jensen *et al.*, 2011). Micronutrients, fibre and phytochemicals are located in the bran fraction which can contribute to increased nutritional quality of human cereal food (Hemery *et al.*, 2007). Bran can be incorporated in food as replacement of flour, fat or sugar as enhancers of water and oil retention and emulsion improver but the amount is limited due to undesirable changes like colour and texture (Elleuch *et al.*, 2011). It would be valuable for the industry to convert a by-product as bran to products with higher commercial values (Rose & Inglett, 2010).

# 2. OBJECTIVE

This thesis is included in the project KLIFUNK ("New technologies to improve the properties of bran") where Lantmännen, The department of Food Science at the Swedish University of Agriculture Sciences (SLU) and Sensory, Education & Analysis (SUA) are included. The purpose of KLIFUNK is to increase the use of wheat and rye bran in food and develop new ingredients through different processes to improve functional, sensory and nutritional properties. Therefore the aim of this thesis was to analyse the content and composition of; total, insoluble and soluble dietary fibre of heat treated wheat and rye bran. The particle size of the bran samples was also determined and selected wheat bran samples were evaluated by sensory analysis with a test panel.

# 3. LITERATURE REVIEW

## 3.1. Wheat and rye

Wheat (*Triticum aestivum*) and rye (*Secale cereal* L.) belongs to the grass family, *Gramineae* and strictly speaking the fruit of wheat and rye is a caryopsis but often called "kernel" or "grain" (Delcour & Hoseney, 2010). Wheat and rye caryopsis consists of the same parts; a fruit coat and a seed consisting of germ, endosperm, nucellar epidermis and a seed coat. The fruit coat (pericarp) which surrounds the seed consists of several layers and is joined to the seed coat (testa) which in turn is joined to the nucellar epidermis. The nucellar epidermis is bounded to the aleurone layer which completely surrounds the kernel (endosperm and germ). Botanically the aleurone layer belongs to the endosperm, but at milling the aleurone layer belongs to the bran fraction which also the nucellar epidermis, the seed coat, the fruit coat and a small proportion of the germ and endosperm (depending on extraction rate) does. Bran is composed of several layers and is a complex material with a distinct structure and composition (Hemery *et al.*, 2010). The bran fraction makes up about 11 % of the grain (Rose

& Inglett, 2010). Total dietary fibre (TDF) content (mean value) and content of some of the dietary fibre constituents of wheat and rye bran are listed in Table 1.

Table 1. Mean values of content of TDF and some dietary fibre constituents in wheat and rye bran (% of DM)

| | Bran | |
|---|---|---|
| Constituents | Wheat | Rye |
| TDF | 46 | 44 |
| Ash | 6 | 5 |
| Arabinoxylan | 30 | 23 |
| β-glucan | 3 | 5 |
| Cellulose | 12 | 6 |
| Klason lignin | 5 | 4 |
| Uronic acids | 2 | 1 |

Reference: Craeyveld *et al.*, 2009; Kamal-Eldin *et al.*, 2009; Theander *et al.*, 1992

There is no other food crop that is grown on more land than wheat, mostly because it is hardy and can be grown under different environmental and soil conditions (Delcour & Hoseney, 2010). The main source of cereal consumption in Europe is refined white flour of wheat where the bran fraction (germ and envelopes) is removed (Hemery *et al.*, 2007).

Rye is widely grown in northern Europe used in both animal feed and for human consumption, traditionally consumed as whole grain products (Kamal-Eldin *et al.*, 2009; Rakha *et al.*, 2010). The typical Western diet contains however less dietary fibre than the recommendation of 25- 35 g /day, but a significant part of the dietary intake comes from rye (Rakha *et al.*, 2010).

## 3.2. Whole grain and dietary fibre

There has been significant disagreement about the definition of whole grain, but one definition is AACC Internationals definition which was accepted and approved 1999: "*Whole grains shall consist of the intact, ground, cracked or flaked caryopsis, whose principal anatomical components - the starchy endosperm, germ and bran - are present in the same relative proportions as they exist in the intact caryopsis*" (AACC, 1999). Poutanen *et al.* (2008) summarised that epidemiological studies have shown that a diet rich in whole grain can protect against development of diet-related disorders such as cardiovascular diseases and type-2 diabetes.

Dietary carbohydrates can due to their susceptibility to digestion by the enzymes in human small intestine be divided in to two groups (Topping, 2007). One group of dietary carbohydrates can be hydrolysed of enzymes in the small intestine and one cannot. It is only α-amylase in the small intestine that can hydrolyse one significant polysaccharide, starch, but the specificity depends on the presence of α-1,4 glucosidic links. All other dietary carbohydrates (oligosaccharides and non-starch polysaccharides) are resistant for enzymatic degradation in the human small intestine and are included in the definition of dietary fibre. A

new international definition for dietary fibre has recently been approved by Codex CAC/GL 2-1985 (revised 2010) (Philips & Cui, 2011), which says:

"*Dietary fibre means carbohydrate polymers[1] with ten or more monomeric units[2], which are not hydrolyzed by endogenous enzymes in the small intestine of humans and belong to the following categories:*

- *Edible carbohydrate polymers naturally occurring in the food as consumed,*
- *Carbohydrate polymers which have been obtained from food raw materials by physical, enzymatic or chemical means and which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities,*
- *Synthetic carbohydrate polymers which have been shown to have a physiological effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities.*

*[1]When derived from plant origin, dietary fibre may include fractions of lignin and/or other compounds associated with polysaccharides in the plant cell walls. These compounds may be measured by certain analytical method(s) for dietary fibre. However, such compounds are not included in the definition of dietary fibre if extracted and re-introduced into a food.*
*[2]Decision on whether to include carbohydrates from DP 3 to 9 monomeric units should be left to national authorities."*

A similar definition has been introduced in the EU by the European Commission Directive 2008/100/EC. In this definition all carbohydrates with a degree of polymerisation $\geq 3$ should be included, and it is therefore not optional for EU member states.

The dominant dietary fibres in cereals are cellulose, mixed-linked β-glucans and a range of polysaccharides containing xylans, e.g. arabinoxylans (Theander *et al.*, 1992). Dietary fibre can be divided in two groups; soluble and insoluble (Topping, 2007). Soluble dietary fibres can form solutions when mixed with water (irregularly polysaccharides) which not insoluble dietary fibres (regularly polysaccharides) can (Elleuch *et al.*, 2011). Dietary fibre constituents e.g. arabinoxylan and β-glucan can be both soluble and insoluble whereas cellulose and lignin are classified as insoluble dietary fibre.

The terms "soluble dietary fibre" and "insoluble dietary fibre" are now also used to segregate their documented physiological effects (Topping, 2007). The soluble dietary fibre have been proved to be plasma cholesterol lowering with a reduction of 3-5 % through foods consumed in quantities which consumers are likely to do. It has especially been demonstrated with oats, where the active agents are thought to be soluble β-linked glucans. Soluble dietary fibres are thought to modulate the digestion because of their ability of forming viscous solutions. This modulation is believed to delay fat- and glucose absorption and also the reabsorption of bile acids in the small intestine. This results in less bile acids returning to the liver, which means

that bile acids have to be renewed by increasing the synthesis from cholesterol in the blood, and thereby serum cholesterol is reduced.

Insoluble dietary fibres are in contrast to soluble dietary fibres characterised of their porosity, low density, their ability to increase faecal bulk and reduce the intestinal transit time (Elleuch *et al.*, 2011). Cereal products that are high in insoluble dietary fibre, like wheat bran, can relieve constipation through their bulking effect (Topping, 2007). The quantity to reach this effect is not completely certain, but approximately 20-25 g/person and day.

## 3.3. Heat treatment

Heat treatment of fibre can modify both the chemical composition and the physical properties (Elleuch *et al.*, 2011; Esposito *et al.*, 2005). Already at 1986 Siljeström *et al.* reported that different heat treatments of white wheat flour and whole wheat grains had very little effect on TDF. Insoluble dietary fibre was however reallocated to soluble dietary fibre during severe extrusion cooking, a process that heats foodstuff under pressure and high temperature (Elleuch *et al.*, 2011). Soluble dietary fibre can increase due to mechanically rupture during extrusion of the glycosidic bonds in polysaccharides which release oligosaccharides leading to an increase of soluble dietary fibre (Elleuch *et al.*, 2011; Esposito *et al.*, 2005).

In a study where durum wheat bran was extruded no changes at all in the content of soluble dietary fibre was reported (Esposito *et al.*, 2005). However, it was reported that an increase of insoluble dietary fibre occurred during the extrusion cooking due to formation of resistant starch and Maillard reaction products resistant for degradation (Esposito *et al.*, 2005). Resistant starch and Maillard products are unavailable for digestion and should therefore be included in the term dietary fibre according to Esposito *et al.* (2005) and Theander *et al.* (1992).

Maillard and caramelisation are two chemical reactions that are responsible for non-enzymatic browning of foods, and influence flavour, functional and nutritional properties of processed foods (Fogliano *et al.*, 1999; Rufián-Henares *et al.*, 2006). Free amino groups and reducing sugars needs to be present for the possibility of a Maillard reaction to occur (Rufián-Henares *et al.*, 2006). Caramelisation needs more severe conditions than Maillard reaction for degradation of sugars. In spite of different conditions for Maillard reaction and caramelisation to take place the reactions can occur simultaneously.

## 3.4. Sensory evaluation

Sensory evaluation is used to measure human responses to foods with different techniques to get important and useful information about for examples consumers' perception (Lawless & Heymann, 2010). The received information can e.g. be used by product developers and food scientists for evaluating sensory properties and characterisation of their products. Sensory evaluation is defined as a scientific method for analyse, evoke, measure and interpret responses to products under controlled conditions with the help of sight, smell, touch, taste and hearing. The tested samples are often labelled with random numbers and served in different orders for counterbalance of other judgements than the sensory experience.

Modern sensory evaluations are almost exclusively performed with panels with trained or untrained panellists depending on used sensory method (Lawless & Heymann, 2010). Three commonly used sensory methods, with different goals and participants, are discrimination, descriptive and affective tests. Discrimination tests are also called difference testing because the purpose is to evaluate if any difference exists between products.

Descriptive analyses are very comprehensive and informative methods and can quantify the perceived intensity of the sensory characteristics of a product (Lawless & Heymann, 2010). A panel for a descriptive test usually consists of selected and trained people to get objective descriptions of products. Scaling is a sensory method that forms the basis of descriptive analysis. Scaling involves application of numbers to quantify the sensory judgement of perceived intensity or degree of liking or disliking of products. Through the numbering, sensory evaluation data becomes a quantitative science subject and statistical analysis can be performed. Therefore, scaling can be used to show differences and degrees of difference between products. A widely used technique for intensity scaling is allowing the panellists to make a mark or slash on a horizontal line to indicate intensity or amount. The slashes are then measured from one end of the scale, usually from the end considered “lower”, where the distances represent the tested samples intensity or amount. Increasing distance numbers represent increasing flavour intensity. The samples can be ranked from little flavour to much flavour and show the intensity order among different flavours. Affective tests are in contrast to descriptive tests not very informative because the tests quantify the degree of liking or disliking of products and are often used for consumer evaluation.

# 4. MATERIAL AND METHODS

## 4.1. Material

Six wheat and three rye bran samples were included in the analysis. The samples had previously been heat-treated in two different ways at three temperatures (Table 2). One treatment was precooking where the bran samples were treated first with heat and moisture and then dried and roasted. The other treatment included drying and roasting (uncooked). The three different temperatures are called low, medium and high, and all temperatures were above 100°C. The analyses also included two untreated samples of wheat and rye bran as references.

Table 2. The different wheat and rye bran samples treatments; precooked or uncooked, and heating temperatures; low, medium or high

| Treatment and temperature | Sample | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Wheat bran | x | x | x | x | x | x |
| Rye bran | x | x | | | | x |
| Precooked | x | x | x | | | |
| Uncooked | | | | x | x | x |
| Low temp. | x | | | x | | |
| Medium temp. | | x | | | x | |
| High temp. | | | x | | | x* |

*The rye bran sample was treated at a higher temperature than the wheat bran sample.

All bran samples were analysed for dietary fibre components (sugar residues, uronic acid, Klason lignin and β-glucan), and the soluble and insoluble dietary fibre were analysed separately. All samples were also analysed for particle size distribution with a test sieve. A sensory analysis, with an untrained panel, was performed with the wheat bran samples 1, 2, 4 and 5. A rancid wheat bran sample and an untreated wheat bran samples were used as references during the sensory analysis.

## 4.2. Methods

### 4.2.1. Dietary fibre analysis

Representative samples were milled (Retsch, Haan, Germany) before the analysis to pass a 0,5 mm screen and all analyses were performed in duplicates. The results are reported on a dry matter basis, determined by oven-drying the bran samples at 105°C for 16 h (AACC method 44- 15A, 2000). The ash content was determined according to AOAC (1984) by placing approximately 2 g of sample in a muffle furnace for 3 hours at 600 °C and weighing after cooling in desiccator. The dietary fibre analysis was performed according to the Uppsala method (AOAC- NMKL methods no. 162, 1998) with some modifications according to Andersson *et al.* (1999) in order to analyse soluble and insoluble dietary fibres separately. The definition of dietary fibre is the sum of amylase-resistant polysaccharides and Klason lignin (AOAC- NMKL methods no. 162, 1998). The content of arabinoxylan was calculated as the sum of arabinose and xylose residues taking into account that some of the arabinose residues are present in arabinogalactan (arabinoxylan = arabinose - (galactose $^{x}$ 0.69) + xylose), (Loosveld *et al.*, 1997). The content of cellulose was calculated as the content of total glucose minus the content of β-glucan.

In the Uppsala method, free sugars and starch are removed with treatment of α-amylase and amyloglucosidase and soluble fibres are precipitated with 80 % ethanol. The analysis is thereafter followed by acid hydrolysis of soluble and insoluble dietary fibres separately to release neutral polysaccharide residues (Theander *et al.*, 1994). The polysaccharide residues are determined as alditol acetates by gas-liquid chromatography. The non-carbohydrate fraction of dietary fibre named Klason lignin (acid-insoluble material) is determined

gravimetrically and uronic acids residues in the acid hydrolysates are determined colorimetrically (Theander *et al.*, 1994; AOAC- NMKL methods no. 162, 1998).

The bran samples (250 mg) were incubated in 35 ml test tubes with α-amylase and amyloglucosidase in 15,0 ml acetate buffer to remove starch. After incubation all tubes were centrifuged to separate the insoluble and soluble fibres, where the pellet contained insoluble fibre and the supernatant contained soluble fibre. The supernatant was collected in a 25 ml volumetric flask while the pellet was washed with 5,0 ml acetate buffer and centrifuged again. The second supernatant was pooled with the first one. After dilution to 25,0 ml, 5,0 ml of the supernatant was transferred to a new test tube. 80 % ethanol was added to precipitate and form a pellet of the soluble dietary fibres.

The two pellets, soluble and insoluble dietary fibres, were after the centrifugations dried over night in 40°C and then hydrolysed with sulphuric acid in an autoclave. The hydrolysates of the insoluble fibres were washed through glass-fritted crucibles. The hydrolysates (insoluble fibres) were then diluted to 100 ml where 1 ml of each solution were prepared for determination of neutral sugars as alditol acetates by gas chromatographic (GC) by derivatisation (reduction and acetylation). The soluble fibres were not filtered but diluted to 10 ml and then treated as the insoluble fibres in the derivatisation step. The hydrolysates (250 µl) were also used to detect the content of uronic acids colorimetrically with a spectrophotometer for both soluble and insoluble dietary fibres.

The residues that stacked in the glass filters were washed, dried over night in 106°C and weighed after cooling in desiccator (W1). To determine Klason lignin the glass filters were ashed in a muffle furnace for 1 hour at 500°C and weighed after cooling in desiccator (W2). Content of Klason lignin is determined as the loss in weight after ashing (W1-W2).

### 4.2.2. Beta-glucan

The content of β-glucan in all samples were analysed with a Megazyme kit K-BGLU, AOAC method 32-32 (Megazyme, Bray, Ireland, 2006). Milled samples were used (100 mg) and first incubated with sodium phosphate buffer in order to suspend and hydrate the samples. After a further incubation with the enzyme lichenase, sodium acetate buffer was added and the samples were centrifuged. Aliquots of the supernatant were then dispensed into three test tubes (100 µl/ tube), whereof two of the test tubes were completely hydrolysed to glucose with β-glucoidase while the third was used as a blank. All samples were in the last step incubated with glucose oxidase/peroxidise reagent to be able to assay the content of D-glucose and thereby β-glucan content with a spectrophotometer. The two samples which were treated with β-glucoidase were corrected with the blank for free D-glucose in the samples.

### 4.2.3. Sensory analysis

The wheat bran samples 1, 2, 4 and 5 (Table 2) were evaluated in a sensory test to determine the flavour intensity between the samples regarding predefined flavours (rancid, bitter, roasted, sweet, total and aftertaste). The sensory analysis was held at SLU with mainly students as participants who could sign up voluntarily. The sensory test was performed

according to a line scaling test (Lawless & Heymann, 2010) and in total 19 persons participated. The panellist marked with a cross on a 9 cm horizontal scale, where the cross represented the tested samples intensity regarding each one of the predefined flavours compared to the other tested samples. See Appendix 1 for the instructions and formulary used for the sensory test (zero was the lowest intensity score whereas nine was the highest).

The wheat bran samples were tested as they were (raw) with no further treatment. The test was initiated with a practise where the panellists tested wheat bran sample number 2 and 5 (Table 2), untreated wheat bran and one wheat bran sample with a rancid taste, but without knowing anything about the samples. The practise was ended with a discussion where opportunity was given to discuss the tested samples and if they could feel any differences between the samples regarding the different predefined flavours. They were also asked if they could say which of the sample that was rancid, but nothing was told about the samples that were included in the test such as the different treatments and temperatures. The test panellists performed the same test twice, but with different codes (three-digits). The panellists received the samples in small plastic glasses with different codes which were organized according to a special code list and serving order. They tested the samples with a little spoon and during the test they had access to cold water and wheat wafers to get rid of any remaining aftertaste.

The results were then analysed according to a descriptive, line scaling test where the marked crosses on the horizontal scale were measured. The distance in cm from the left end named "low" represented the tested samples intensity and was evaluated statistically with analysis of variance (ANOVA, General linear model).

### 4.2.4. Sieve analysis

The analysis of the particle size was performed with a Sieving Machine (Retsch, AS 200 control) and included sieve sizes were 75 µm, 150 µm, 250 µm, 425 µm, 600 µm and 1 mm. Approximately 50 g of each sample were placed in the sieving machine in 10 sec intervals under 7 min with the amplitude 1,30 mm/"g". After every run the sieves were weighed and corrected for the weight of the sieve.

### 4.2.5. Statistical analysis

Statistical analyses to study the effect of pre-treatment and temperature on content of dietary fibre constituents and on different flavours in wheat bran samples were performed by analysis of variance (ANOVA, General linear model) using Minitab 16 Statistical Software (Minitab Inc., State College, PA, USA). P-values $< 0.05$ were considered significant and mean values are reported.

# 5. RESULTS & DISCUSSION

Heat treated wheat and rye bran were analysed in order to determine the dietary fibre content and composition, soluble and insoluble dietary fibre were analysed separately.

## 5.1. Total dietary fibre

TDF ranged between 41.3 and 44.8 % for the wheat bran samples (untreated 42.5 %), (Table 3). The wheat bran samples heat treated at low and medium temperature differed significantly from the bran sample heat treated at the highest temperature ($p < 0.001$) regarding TDF (Table 4). The wheat bran samples also differed significantly from each other regarding the pre-treatments ($p < 0.001$), (Table 5). This means that the treatments and temperatures affected the content of TDF in the different samples. According to the results in this thesis the dietary fibre content decreased with increasing temperature and the uncooked samples had a higher content than the precooked samples (Table 4 and 5). For the rye bran samples TDF ranged between 43.7 and 46.6 % (untreated 43.0 %), (Table 3). Kamal-Eldin *et al.* (2009) reported TDF contents for untreated rye bran around 44 % and for wheat bran 53 %. Theander *et al.* (1992) reported 37-42 % TDF content for wheat bran and Craeyveld *et al.* (2009) reported 46 % TDF content for wheat bran. Dietary fibre content can differ due to different variety, processing and used dietary fibre analysis method (Kamal-Eldin *et al.*, 2009; Elleuch *et al.*, 2011).

The decrease of TDF with increased temperature can be due to fragmentation of polysaccharides because of increased thermal heating and/or precooking process which also Ralet *et al.* (1990) and Siljeström *et al.* (1986) reported. These fragments of polysaccharides may not precipitate during treatment with 80 % ethanol in the dietary fibre analysis (AOAC-NMKL methods no. 162, 1998). It is only polysaccharides that precipitate during treatment with ethanol that are detected while smaller fragments and monosaccharides are discarded. Theander *et al.* (1994) established that varying amount (0.7-5.6 %) of TDF can be lost because of different solubility properties of polysaccharides in 80 % ethanol in the dietary fibre analysis.

The contents of xylose, mannose, galactose, glucose and uronic acid residues from total, soluble and insoluble dietary fibres, as well as arabinoxylan, β-glucan and cellulose in the heat-treated bran samples were quite similar to the results determined for the untreated bran samples of wheat and rye (Table 3, 6 and 7). The precooking and roasting process caused no significant effect on the previously named dietary fibre constituents. The content of β-glucan in the rye bran samples was almost twice as high as the content in the wheat bran samples, Kamal-Eldin *et al.* (2009) reported similar results (Table 3).

The content of arabinose residues from TDF differed significantly between the wheat bran samples regarding both temperature ($p = 0.002$) and treatment ($p = 0.001$), (Table 4 and 5). The content decreased with increasing temperature and uncooked samples had a higher content than precooked. The decrease of arabinose can depend on arabinose sensitivity for thermal treatment; the bounds are cleaved and arabinose residues are lost during the dietary fibre analysis because they are too small to precipitate when treated with ethanol (Siljeström

*et al.*, 1986; Theander *et al.*, 1992). This could also be the reason for the decrease of xylose and arabinoxylan with increasing temperature, even though the decreases are not statistical significant (Table 3).

The slight increased content of ash in some treated samples compared to the untreated wheat and rye bran can be due to incomplete ashing (Table 3). The time for ashing (2 h) was probably too short for complete ashing because of formed complexes during the heat treatment that are hard to break down (Esposito *et al.*, 2005). Heat treatment can lead to formation of protein polysaccharides complex due to Maillard reaction. These complexes are very resistant to enzymatic degradation which leads to a reduction of released soluble material by amylase and other enzymes used in the dietary fibre analysis. Therefore it is possible that these complexes contributed to an incomplete ashing in this trial.

The slight increased content of Klason lignin in some pre-treated samples can at least partly be explained by occurred Maillard reaction during the heat treatment (Siljeström *et al.*, 1986), (Table 3). In this trial the content of Klason lignin increased most distinct for the rye sample number 6 which can be due to the more intense heat treatment than the other bran samples (Table 2 and 3). In addition to lignin, Klason lignin contains components such as cutins, tannins and Maillard products from thermal processing (Theander *et al.*, 1994). The Maillard products formed during the heat process are not according to the definition dietary fibre but it behaves as dietary fibres, resistant for digestion and can therefore be included in the term dietary fibre (Esposito *et al.*, 2005; Theander *et al.*, 1992).

Table 3. Content (% DM) of ash, TDF, TDF polysaccharide residues, Klason lignin, and total cellulose, arabinoxylan and β-glucan in wheat bran (WB) and rye bran (RB) samples, precooked (pre) or uncooked (un) and treated at different temperatures (low, medium or high)

| | | | TDF (% of DM) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Treatment/ Temperature | Ash | TDF[3] | Ara[4] | Xyl[5] | Man[6] | Gal[7] | Glc[8] | KL[9] | UA[10] | Ax[11] | β-glucan | Cel[12] |
| WB ref.[1] | | 4.7 | 42.5 | 8.4 | 15.0 | 0.6 | 0.8 | 10.9 | 5.0 | 1.9 | 22.8 | 2.6 | 8.3 |
| WB 1 | Pre/Low | 5.1 | 43.1 | 8.4 | 15.3 | 0.7 | 0.8 | 11.0 | 5.3 | 1.7 | 23.2 | 2.6 | 8.4 |
| WB 2 | Pre/Medium | 5.2 | 42.8 | 8.3 | 15.1 | 0.6 | 0.8 | 10.8 | 5.4 | 1.8 | 22.8 | 2.7 | 8.1 |
| WB 3 | Pre/High | 5.4 | 41.3 | 8.0 | 14.9 | 0.6 | 0.7 | 10.8 | 4.4 | 1.8 | 22.4 | 2.7 | 8.1 |
| WB 4 | Un/Low | 5.2 | 44.8 | 8.8 | 15.7 | 0.7 | 0.8 | 11.5 | 5.4 | 1.9 | 23.9 | 2.7 | 8.8 |
| WB 5 | Un/Medium | 5.2 | 44.6 | 8.7 | 15.7 | 0.7 | 0.8 | 11.4 | 5.6 | 1.8 | 23.9 | 2.7 | 8.7 |
| WB 6 | Un/High | 5.1 | 43.0 | 8.4 | 14.9 | 0.7 | 0.9 | 11.0 | 5.3 | 1.8 | 22.7 | 2.8 | 8.2 |
| RB ref.[2] | | 4.3 | 43.0 | 8.0 | 16.2 | 0.6 | 1.1 | 11.1 | 5.0 | 1.1 | 23.5 | 5.7 | 5.4 |
| RB 1 | Pre/Low | 4.7 | 45.6 | 8.4 | 17.0 | 0.7 | 1.1 | 11.6 | 5.8 | 1.1 | 24.7 | 5.8 | 5.8 |
| RB 2 | Pre/Medium | 4.7 | 43.7 | 8.2 | 16.6 | 0.7 | 1.0 | 11.2 | 4.9 | 1.1 | 24.1 | 5.7 | 5.5 |
| RB 6 | Un/High | 4.9 | 46.6 | 8.3 | 17.0 | 0.7 | 1.1 | 11.8 | 6.8 | 1.0 | 24.5 | 5.6 | 6.2 |

[1]Wheat bran reference, [2]Rye bran reference, [3]Total dietary fibre, [4]Arabinose, [5]Xylose, [6]Mannose, [7]Galactose, [8]Glucose, [9]Klason lignin, [10]Uronic acid, [11]Arabinoxylan (arabinoxylan = arabinose - (galactose $^{x}$ 0.69) + xylose), (Loosveld et al., 1997), [12]Cellulose

Table 4. Mean content (% of DM) of total, insoluble and soluble dietary fibre, TDF polysaccharide residues, Klason lignin, arabinoxylan, β-glucan and cellulose in wheat bran treated at low, medium or high temperature (without any regards to treatment). Different letters after the mean values indicates significant differences between the temperatures

| Temperature | TDF[1] | Ins. DF[2] | Sol. DF[3] | Ara[4] | Xyl[5] | Man[6] | Gal[7] | Glc[8] | KL[9] | Ua[10] | Ax[11] | β-glucan | Cel[12] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 43.9a | 42.0a | 1.9a | 8.6a | 15.5a | 0.7a | 0.8a | 11.3a | 5.3a | 1.8a | 23.5a | 2.6a | 8.6a |
| Medium | 43.7a | 41.8b | 2.0a | 8.5b | 15.4a | 0.7a | 0.8a | 11.1a | 5.5a | 1.8a | 23.3a | 2.7a | 8.4a |
| High | 42.1b | 40.0c | 2.1a | 8.2c | 14.9a | 0.6a | 0.8a | 10.9a | 4.9a | 1.8a | 22.6a | 2.7a | 8.2a |

[1]Total dietary fibre, [2]Total insoluble dietary fibre, [3]Total soluble dietary fibre, [4]Arabinose, [5]Xylose, [6]Mannose, [7]Galactose, [8]Glucose, [9]Klason lignin, [10]Uronic acid, [11]Arabinoxylan, [12]Cellulose

Table 5. Mean content (% of DM) of total, insoluble and soluble dietary fibre, TDF polysaccharide residues, Klason lignin, arabinoxylan, β-glucan and cellulose in wheat bran that were either precooked or uncooked (without any regard to temperature). Different letters after the mean values indicates significant differences between the different treatments

| Treatment | TDF[1] | Ins. DF[2] | Sol. DF[3] | Ara[4] | Xyl[5] | Man[6] | Gal[7] | Glc[8] | KL[9] | Ua[10] | Ax[11] | β-glucan | Cel[12] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uncooked | 44.1a | 42.1a | 2.1a | 8.6a | 15.4a | 0.7a | 0.8a | 11.3a | 5.4a | 1.8a | 23.5a | 2.7a | 8.6a |
| Precooked | 42.4b | 40.4b | 1.9a | 8.2b | 15.1a | 0.6a | 0.8a | 10.9a | 5.0a | 1.8a | 22.8a | 2.7a | 8.2a |

[1]Total dietary fibre, [2]Total insoluble dietary fibre, [3]Total soluble dietary fibre, [4]Arabinose, [5] Xylose, [6]Mannose, [7]Galactose, [8]Glucose, [9]Klason lignin, [10]Uronic acid, [11]Arabinoxylan, [12]Cellulose

## 5.2. Insoluble dietary fibre

Total insoluble dietary fibre ranged between 39.1 and 42.8 % for the wheat bran samples (untreated 40.6 %), (Table 6). For the rye bran samples total insoluble dietary fibre ranged between 39.8 and 42.8 % (untreated 39.4 %), (Table 6). There was a significant difference between the wheat bran samples in content of total insoluble dietary fibre, regarding both temperature ($p < 0.001$) and the pre-treatment ($p < 0.001$), (Table 4 and 5). The content of insoluble dietary fibre decreased with increasing temperature particularly for the wheat bran samples. However, the pre-treated bran samples, except from wheat bran sample 3, contained a slight higher content of insoluble dietary fibre than the untreated wheat and rye bran (Table 6). The uncooked wheat bran samples had a higher content of insoluble dietary fibre than the precooked (Table 5).

It was believed that the content of insoluble dietary fibre and especially the content of glucose residues from the insoluble part of the fibre would have increased, especially for precooked samples because of the formation of resistant starch during the process which has been reported from extrusion processing (Esposito *et al.*, 2005). In this trial it seems that no resistant starch was formed since the content of glucose residues from the insoluble part did not increase considerably much and the contents are almost the same as the untreated wheat and rye bran (Table 6). On the other hand resistant starch could actually have been formed during the pre-treatment, but then broken down during the roasting. Some of the samples, like wheat bran sample number 4 and 5, have a slight increased content of glucose from the insoluble part compared to untreated wheat bran (Table 6).

Table 6. Content (% DM) of ash, insoluble dietary fibre, insoluble dietary fibre polysaccharide residues, Klason lignin, arabinoxylan and β-glucan in wheat bran (WB) and rye bran (RB) samples, precooked (pre) or uncooked (un) and treated at different temperatures (low, medium or high)

| | | Insoluble dietary fibre (% of DM) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Treatment/ Temperature | Ins DF[3] | Ara[4] | Xyl[5] | Man[6] | Gal[7] | Glc[8] | UA[9] | KL[9] | Ax[10] |
| WB ref.[1] | | 40.6 | 8.0 | 14.3 | 0.6 | 0.7 | 10.5 | 1.7 | 5.0 | 21.8 |
| WB 1 | Pre/Low | 41.2 | 8.0 | 14.5 | 0.6 | 0.7 | 10.6 | 1.6 | 5.3 | 22.1 |
| WB 2 | Pre/Medium | 41.0 | 7.9 | 14.4 | 0.6 | 0.7 | 10.5 | 1.6 | 5.4 | 21.8 |
| WB 3 | Pre/High | 39.1 | 7.6 | 14.1 | 0.6 | 0.6 | 10.4 | 1.6 | 4.4 | 21.2 |
| WB 4 | Un/Low | 42.8 | 8.4 | 14.9 | 0.6 | 0.7 | 11.2 | 1.7 | 5.4 | 22.9 |
| WB 5 | Un/Medium | 42.6 | 8.2 | 14.9 | 0.6 | 0.6 | 11.0 | 1.6 | 5.6 | 22.7 |
| WB 6 | Un/High | 40.8 | 8.0 | 14.1 | 0.6 | 0.7 | 10.5 | 1.6 | 5.3 | 21.6 |
| RB ref.[2] | | 39.4 | 7.2 | 14.6 | 0.6 | 1.0 | 10.2 | 0.9 | 5.0 | 21.1 |
| RB 1 | Pre/Low | 42.0 | 7.6 | 15.4 | 0.6 | 1.0 | 10.7 | 0.9 | 5.8 | 22.3 |
| RB 2 | Pre/Medium | 39.8 | 7.3 | 14.8 | 0.6 | 0.9 | 10.3 | 0.9 | 4.9 | 21.5 |
| RB 6 | Un/High | 42.8 | 7.6 | 15.4 | 0.6 | 1.0 | 10.7 | 0.7 | 6.8 | 22.2 |

[1]Wheat bran reference, [2]Rye bran reference, [3]Insoluble dietary fibre, [4]Arabinose, [5]Xylose, [6]Mannose, [7]Galactose, [8]Glucose, [9]Uronic acid, [10]Arabinoxylan

## 5.3. Soluble dietary fibre

Total soluble dietary fibre in the wheat bran samples ranged between 1.8 and 2.2 % (untreated 1.9 %), (Table 7). For the rye bran samples it ranged between 3.6 and 3.9 % (untreated 3.6 %), (Table 7). The hypothesis for this experiment was an increase of the soluble dietary fibre due to the heat treatment because of previously reported results on extrusion cooking (Elleuch *et al.*, 2011; Esposito *et al.*, 2005). The content of soluble dietary fibre in this experiment did not change significantly compared to the reference samples including both wheat and rye (Table 7). Probably more mechanically treatment is needed during the processing than in the process in this experiment, as in extrusion cooking where rupture of glycosidic bonds in polysaccharides can occur leading to oligosaccharides that can increase the soluble dietary fibre content (Esposito *et al.*, 2005).

Table 7. Content (% DM) of ash, soluble dietary fibre, soluble dietary fibre polysaccharide residues and arabinoxylan in wheat bran (WB) and rye bran (RB) samples, precooked (pre) or uncooked (un) and treated at different temperatures (low, medium or high)

| | | Soluble dietary fibre (% of DM) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample | Treatment/ Temperature | Sol. DF[3] | Ara[4] | Xyl[5] | Man[6] | Gal[7] | Glc[8] | UA[9] | Ax[10] |
| WB ref.[1] | | 1.9 | 0.4 | 0.7 | 0.0 | 0.2 | 0.4 | 0.2 | 1.0 |
| WB 1 | Pre/Low | 1.9 | 0.4 | 0.7 | 0.1 | 0.1 | 0.4 | 0.2 | 1.1 |
| WB 2 | Pre/Medium | 1.8 | 0.4 | 0.7 | 0.0 | 0.1 | 0.4 | 0.2 | 1.1 |
| WB 3 | Pre/High | 2.1 | 0.5 | 0.9 | 0.0 | 0.1 | 0.4 | 0.3 | 1.2 |
| WB 4 | Un/Low | 2.0 | 0.4 | 0.8 | 0.1 | 0.1 | 0.4 | 0.2 | 1.1 |
| WB 5 | Un/Medium | 2.1 | 0.5 | 0.8 | 0.1 | 0.1 | 0.4 | 0.2 | 1.2 |
| WB 6 | Un/High | 2.2 | 0.4 | 0.8 | 0.0 | 0.1 | 0.5 | 0.3 | 1.2 |
| RB ref.[2] | | 3.6 | 0.8 | 1.6 | 0.1 | 0.1 | 0.9 | 0.2 | 2.3 |
| RB 1 | Pre/Low | 3.6 | 0.8 | 1.6 | 0.1 | 0.1 | 0.9 | 0.2 | 2.3 |
| RB 2 | Pre/Medium | 3.9 | 0.9 | 1.8 | 0.0 | 0.1 | 0.9 | 0.2 | 2.6 |
| RB 6 | Un/High | 3.8 | 0.7 | 1.6 | 0.1 | 0.1 | 1.1 | 0.3 | 2.2 |

[1]Wheat bran reference, [2]Rye bran reference, [3]Soluble dietary fibre, [4]Arabinose, [5]Xylose, [6]Mannose, [7]Galactose, [8]Glucose, [9]Uronic acid, [10]Arabinoxylan

## 5.4. Sensory analysis

The sensory analysis was held at SLU with mainly students as participants. They were asked to evaluate the intensity of four wheat bran samples (1, 2, 4 and 5) on a 9 cm horizontal scale regarding the flavours rancid, bitter, roasted, sweet, total and aftertaste (zero was the lowest intensity score whereas nine was the highest), see Appendix 1 for instructions and formulary.

The results indicated that there were significant differences between the samples for roasted flavour, regarding both temperature ($p = 0.007$) and pre-treatment ($p < 0.001$), (Table 8 and 9). The wheat bran samples that were precooked had a more roasted flavour than the samples that were uncooked. The wheat bran samples that were heat treated at the medium temperature had a more roasted flavour than the samples that were heat treated at the lowest temperature. The roasted flavour can be due to occurred Maillard reaction and caramelisation during the process (Kroh, 1994). The panellists may have been affected of the tested samples colours during the test which could have affected the evaluation. Fogliano *et al.* (1999) wrote that in gluten-glucose systems more colour is produced when the samples are treated under wet conditions than under dry conditions, at all temperatures. This could be the case for the bran samples in this trial too, since the precooked samples had a more intense brown colour compared to the uncooked samples judge by the eyes.

A significant difference between the wheat bran samples was found for sweet flavour, regarding the pre-treatments ($p < 0.001$), (Table 8 and 9). The uncooked samples had a sweeter flavour than the precooked samples. The panellists thought that the flavour rancid was hard to evaluate but there was a significantly difference between pre- and uncooked samples ($p < 0.001$) where the precooked had a less rancid flavour than the uncooked (Table

9). When it comes to the total flavour there was an indication of that higher roasting temperature leads to a more intense total flavour (Table 8).

Whole grain can have a bitter taste, especially the bran, since bitter tasting compounds are concentrated in the outer layers of the grain. In this trial the intensities were however rather low for the both pre-treatments and temperatures, around 3-3.5 (Table 8 and 9), (Heiniö *et al.*, 2008; Jensen *et al.*, 2011). It would have been interesting to include also untreated wheat bran in the sensory evaluation for further evaluation of the bitter flavour and aftertaste, since the scores for aftertaste also were rather low, around 3.5 (Table 8 and 9).

There was now significantly difference between the two sessions which indicates that the panellists did not guess during performed tests, but it can also indicate that the variation was so large that the results turns out better than they really are (Table 10). The used sensory method, line scaling, is not adapted for untrained panellists so a more accurate sensory analysis need to be performed with a trained panel to be able to take further conclusions about the samples.

Table 8. Mean values for the predefined flavours after performed sensory test regarding low or medium treating temperature. Different letters after the mean values indicates a significant difference between the temperatures

| Temperature | Rancid flavour | Bitter flavour | Roasted flavour | Sweet flavour | Aftertaste | Total flavour |
|---|---|---|---|---|---|---|
| Low | 2.8a | 3.5a | 3.4b | 3.5a | 3.6a | 3.7a |
| Medium | 2.8a | 3.2a | 4.4a | 4.1a | 3.3a | 4.5a |

Table 9. Mean values for the predefined flavours after performed sensory test regarding uncooked and precooked. Different letters after the mean values indicates a significant difference between the treatments

| Treatment | Rancid flavour | Bitter flavour | Roasted flavour | Sweet flavour | Aftertaste | Total flavour |
|---|---|---|---|---|---|---|
| Uncooked | 3.7a | 3.6a | 3.0b | 5.1a | 3.7a | 4.2a |
| Precooked | 1.9b | 3.1a | 4.8a | 2.6b | 3.2a | 4.0a |

Table 10. Mean values for the different flavours between the two sessions. Different letters after the mean values indicates a significant difference between the sessions

| Session | Rancid flavour | Bitter flavour | Roasted flavour | Sweet flavour | Aftertaste | Total flavour |
|---|---|---|---|---|---|---|
| Session 1 | 2.8a | 3.4a | 4.0a | 3.9a | 3.4a | 4.0a |
| Session 2 | 2.8a | 3.3a | 3.7a | 3.7a | 3.5a | 4.2a |

## 5.5. Particle size

Generally, rye bran has smaller particle size than wheat bran which was verified in this trial for both treated and untreated samples (Table 11), and may depend on that the rye bran peripheral tissues are more friable and the endosperm is stronger adhered (Kamal-Eldin *et al.*, 2009). The precooked wheat bran samples had in general a larger particle size than the uncooked and also larger than the untreated wheat bran samples (Table 11). In contrast to the wheat bran samples the treated rye bran samples, both precooked and uncooked, had almost the same particle size as the untreated rye bran sample.

Ferguson & Harris (1997) and Noort *et al.* (2010) reported that wheat bran´s water-holding capacity increases with increased particle size and that particle smaller than 212 µm held a very small amount of water. A theory for this trial is that the wheat bran particles absorbed water and stacked together during the precooking process which formed larger aggregates. Whereas the rye bran particles were so small that the water absorption was reduced and they could not stick together as the wheat bran particles and form larger aggregates.

Noort *et al.* (2010) reported that the water absorption increased during dough mixing when a part of the flour was replaced with wheat bran and that coarse bran had least negative effect on the loaf volume during bread-making. De Kock *et al.* (1999) reported the same results that coarse wheat bran had the least negative effect on loaf volume and also that heat treated wheat bran affected the loaf volume less negative than untreated wheat bran. The opposite results have also been reported, that reduced particle size of the bran reduced the negative effects during bread making (Lai *et al.*, 1989). The different reported results can be due to variation in definition of bran, variation in composition and physical properties and also different bread baking procedures (Noort *et al.*, 2010).

Table 11. The allocation of the wheat bran (WB) and rye bran (RB) samples particle size reported in percent

| | Sieve size | | | | | |
|---|---|---|---|---|---|---|
| Sample | < 150 µm | < 250 µm | < 425 µm | < 600 µm | < 1 mm | > 1 mm |
| WB ref.[1] | 4.2 | 10.0 | 26.3 | 19.0 | 19.5 | 20.4 |
| WB 1 | 3.7 | 7.3 | 18.4 | 17.7 | 33.2 | 20.3 |
| WB 2 | 3.8 | 8.1 | 19.1 | 18.1 | 32.3 | 19.1 |
| WB 3 | 4.6 | 9.6 | 21.0 | 18.9 | 29.8 | 16.9 |
| WB 4 | 2.0 | 7.7 | 32.7 | 22.5 | 25.2 | 10.7 |
| WB 5 | 1.9 | 14.5 | 29.6 | 16.8 | 23.2 | 15.0 |
| WB 6 | 4.5 | 14.8 | 24.1 | 16.0 | 21.1 | 16.1 |
| RB ref.[2] | 15.5 | 53.5 | 28.0 | 2.1 | 0.5 | 0.0 |
| RB 1 | 16.5 | 52.5 | 24.8 | 4.0 | 3.0 | 0.6 |
| RB 2 | 17.8 | 54.2 | 23.4 | 3.4 | 2.4 | 0.4 |
| RB 6 | 21.9 | 57.9 | 20.3 | 1.6 | 0.4 | 0.1 |

[1]Wheat bran reference, [2]Rye bran reference

## 6. CONCLUSION

The results in this thesis showed that the dietary fibre content decreased with increasing temperature which can be due to fragmentation of polysaccharides because of increased thermal heating and/or precooking process. It was also shown that the uncooked wheat bran samples had a higher content than the precooked bran samples. The insoluble dietary fibre content decreased with increasing temperature, significantly for the wheat bran samples. The uncooked wheat bran samples had a higher content of insoluble dietary fibre than the precooked. The pre-treated samples had a slight increased content of insoluble dietary fibre compared to the untreated wheat and rye bran. The soluble dietary fibre content was not affected by heat treatment in either wheat bran or rye bran.

The wheat bran samples that were precooked had a more roasted flavour than the samples that were uncooked. The wheat bran samples that were heat treated at the medium temperature had a more roasted flavour than the samples that were heat treated at the lowest temperature. The uncooked samples had a sweeter flavour and the precooked wheat bran samples had a less rancid flavour than the uncooked. It would have been interesting to include untreated wheat bran in the sensory evaluation for further evaluation of the bitter flavour since the intensity scores were rather low. Conclusions should be drawn with caution because line scaling is not adapted for untrained panellists.

The precooking process in this trial can be used to get a more roasted and less rancid flavour in wheat bran compared to only dry roasting. But if the purpose is to increase the content of soluble dietary fibre because of the reported health effect, another process should be used. Wheat bran can though increase faecal bulk and relieve constipation because of the high content of insoluble dietary fibre which also is a good health effect. The determination of the particle size allocation showed that especially precooked wheat bran samples had the highest particle size allocation of the analysed samples.

## 7. ACKNOWLEDGEMENTS

I will first like to say thanks to my supervisors; Annica Andersson and Helena Fredriksson for all help and support with my thesis. Thank you Gunnel Fransson for all help with the laboratory work, I will carry with me a lot of new knowledge. Anette Jonsäll, thank you for all help and support with the sensory part and thanks to all panellists that participated in the sensory test (especially Jenny Eriksson for the extra help). Last but not least would I like to thanks for the enormous support from Kim and my family.

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# 7. APPENDIX 1

## Välkommen till detta sensoriktest av vetekli!

Läs NOGA i genom detta papper innan Ni börjar med provsmakningen och fråga om något är oklart.

Smaka varje prov var för sig, skölj med vatten och ta vid behov en bit smörgåsrån mellan proven. Om Ni inte vill svälja det smakade provet går det bra att spotta ut det i den vita muggen. Bedöm de angivna smakerna, markera med ett kryss (skriv provets nummer ovanför krysset) på axeln som Ni tycker representerar det testade provet. Alltså ett kryss för varje prov på axeln. Ni kan inte placera två prov vid samma intensitet på axlarna, alla prover måste särskiljas.

Vid egenskapen totalsmak rangordna alla proverna efter den totala smakintensiteten.
Lämna gärna övriga kommentarer om de testade proverna!

Var god fyll i följande.

Placeringsnummer: Omgång:

Datum:

Var god och lämna in formuläret efter genomfört test!
Tack för ditt deltagande!

Matilda Johansson

## Intensitetsbedömning av vetekli

Härsken smak

lite _____ mycket

Besk smak

lite _____ mycket

Rostad smak

lite _____ mycket

Söt smak

lite _____ mycket

Bismak

lite _____ mycket

Totalsmak

lite _____ mycket

Övriga kommentarer: _____

_____

_____

_____