EVALUATION OF CHEMICAL COMPOSITION OF BIOLOGICALLY ACTIVATED DRIED RYE GRAINS

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Abstract

Cereal products are the important part of human diet, because those contain high amount of proteins, carbohydrates, B group vitamins and dietary fibre. Germinated seeds, grain and grain germs have been used in food for long time with the purpose to improve bread nutritive value.

The albumin content in rye grain composition is smaller, while maintenance of essential amino acids is by 1.5 times higher (lysine and threonine) compared with wheat grain. The biggest part of rye grain albumin dissolves in water and low-concentration salt dilutions. The increase of glutenin amount promotes strengthening of gluten. The amount of riboflavin and vitamin E in rye grain is higher.

The research was accomplished on grains of rye (variety 'Puhovchanka') harvested in Latvia in 2007. The grains were biologically activated in order to achieve the maximum biological value, and then dried in several conditions with a purpose to prolong grain storage time, to facilitate technological processes than to use such grains in wheat bread technology for increasing wheat bread nutritive value.

Results of our experiments shove that the optimal drying parameters of biologically activated rye grains are temperature +60±3 ºC and time approximately three hours. The content of vitamin E decrease in biologically activated rye grain during drying 1.2 times, of vitamin C – 1.3 times, of vitamin niacin – 1.8 times. The changes of albumen, fat, dietary fibre and Ca content in biologically activated rye grain during drying are not relevant. Increase content of oleic, linoleic, cys-11-eucosan, eruc and α-linolenic acids 1.5 times during grain drying process. The content of total aminoacids was lower comparing with initial grain aminoacids composition.

Key words: drying, biological activation, rye grains

Introduction

Rye – the Latin name is *Secale cereale* – is still generally regarded as the typical rye bread cereal. Nevertheless, there is a continuous decline in rye consumption. In the case of this bread cereal, too, it is chiefly winter rye that is used in bread. Although over 90% of the world's rye is growing in Europe, the cereal is by no means a uniform product. The main growing areas and breeding centres are in eastern, central and northern Europe, although rye is also grown and bred in North America, Australia and other regions (Popper *et al.*, 2006).

Rye's nutritional characteristics are similar to the other cereal grains, however rye is higher than wheat in fiber, vitamin E, riboflavin, folacin and pantothenic acid. And unusual for a cereal grain, rye contains twice as much of the amino acid, lysine as wheat. This is especially significant because lysine's the limiting amino acid in wheat and most other cereal grains which necessitates food mixing to develop a complete protein. This isn't a problem with rye as eating rye by itself gives you a well rounded protein. Rye's high fiber content, higher than the wheat, also aids in fighting heart disease (Bushuk, 2001; Rye, 2008[1]).

Although rye does have some gluten, it doesn't contain enough to make good bread and must be used with other high gluten flours. Because of this, rye bread is generally heavier than wheat bread and has a darker color, a reflection of the grain it comes from. The more wheat flour is used, the lighter and milder the bread. Pumpernickel is one of the breads on the rye heavy side of this spectrum, prized by many for its rich, dark brown color and strong flavor.

Gluten is the main component characterizing dough quality. Gluten is a strong hydrolyzed gel, which mainly consists of albumen and carbohydrates, fats and minerals. The amount of gluten components depends on the variety of grain, flour type, preparing stage, and dough mixing and rinsing time.

Wet gluten of wheat grain consists of *gliadins* and *glutenins* (their ratio is 1:1), rye grain – of *gliadins* and *glutenins* (their ratio is 2:1), *barley* – of *prolamine*, *glutenins* and *hordeins* fractions. *Gliadins* decrease dough mixing time, whereas *glutenins* – increases it (Казаков, Кретович, 1989; Ruža, 2001; Казаков, Карпиленко, 2005; Rye, 2008[1]).

[1] Rye. 2008. Source: http://waltonfeed.com/self/rye.html, resource used on 28.01.2008.

The activity of enzymes increases during germination (biological activation): endohydrolase enzymes (α; β-amylases), proteolytic enzymes, diphenoloxsydase, and catalyse were activated. Stability of gluten depends on the amount of formed *disulfide* bonds *(-S-S-)* and *disulfide* bonds correlation with *sulfhydryl* group *(-SH-)* (Казаков, Кретович, 1989; Hugh Cornell *et al.*, 1998).

Optimal grain biological activation parameters are: relative air humidity – 80±2%, temperature – +34±1 °C, time – 24 hours. Gluten is not found in activated rye grains. Intense biochemical processes occur during the grain activation time, as a result grain biological value increases – the content of vitamins B_2, E and niacin, total sugar, dietary fibre and glycosamin increase; vitamin C is synthesized, and the content of irreplaceable amino acids is increased during the process of protein hydrolysis. Rye grains were biologically activated with the purpose to add such grain to wheat dough and to increase biological value of wheat bread. Biologically activated grain application in white bread technology is a new direction. As results of previous experiments show, the wheat bread with biologically activated grain additive had a higher biological value: higher content of vitamin B_2, niacin, E and C, dietary fibre, irreplaceable amino acid, total protein, total sugar, and glycosamin comparing with the test bread sample (Rakcejeva, 2006; Rakcejeva, Skudra, 2006; Rakcejeva *et al.*, 2007).

As practice show, the application of biologically activated rye grain in wheat bread production technology is very difficult and laborious process, because it is necessary to use biologically activated grains in bread production technology immediately; it is not possible to store such grains longer then six to eight hours, as a result the irreversible biochemical reactions will occur. The technology of rye grain drying will be developed for optimizing bread production technological process.

Drying process of biologically activated rye grains is not the same that malt production technology. In the malt production technology the grain germination time is from seven to nine days. For the bread production it is very long time for grain activation, because the gluten quality becomes unsatisfactory and it is not possible to produce high quality bread with such grain additive. In malt production technology, the temperature of germinated grain drying is from +80 to +85 °C and drying time is approximately to one day (Техноло–гия…, 2008[1]). We suppose that such temperature will be high for preserving of maximal quantity of vitamins in grains.

The aim of the current research work was set as follows – to study the changes of chemical composition of biologically activated rye grains during drying.

The following **objectives** are advanced to achieve the set aim:

- to determine experimentally the optimal parameters for biologically activated rye grain drying – temperature, and drying time;
- to investigate the changes of chemical composition of grain during the drying process.

Materials and Methods

For the research the following materials were used: rye grain (variety *Puhovchanka*), harvested in Latvia in 2007, drinking water for grain rinsing and steeping in compliance with Regulations No. 235 of the Cabinet of the Republic of Latvia „Compulsory Requirements for Harmlessness of Drinking Water", 2003[2].

Grain was washed (H_2O t=+20±1 °C) and wetted (H_2O t=+20±1 °C, τ=24±1 h). Grain biological activation was performed in the climatic chamber at temperatures (t) +35±1 °C at constant relative air humidity (φ) of 80±1% for up to 24 hours (τ).

The drying of biologically activated rye grain was accrued in thermo chamber on bolter with diameter d_b=0.185 m, the diameter of holes d_h=0.002 m, the square of bolter was S_b=0.030 m^2

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[1]Технология производства пива. 2008. Source: http://www.beermarket.ru/beer/technology.htm, resource used on 23.01.2008.

[2] Dzeramā ūdens obligātās nekaitīguma un kvalitātes prasības, monitoringa un kontroles kārtība. 2003. Source: http://www.likumi.lv/doc.php?id=75442, resource used on 29.01.2008.

with loading capacity S=6.700 kg m^{-2}. Grain was dried till constant moisture content 13.78±0.50% for storage. The parameters of grain drying process were: t=+60±3 °C, τ=2.75 h; t=+70±3 ºC, τ=1.92 h; t=+80±3 °C, τ=1,60 h and t=+90±3 ºC, τ=1.40 h.
For determination of the chemical parameters changes in biologically activated rye grains during drying, standard methods were used:

Grain moisture (%) was determined under the standard method *LVS 272*.

Total protein content (%) was determined under the standard method *ISO 5983*.

Fat content (%) was determined under the standard method *ISO 6492*.

Wood-fibre content (%) was determined under the standard method *ISO 5498*.

Vitamin niacin content (mg kg^{-1}) was determined under the standard method *AOAC 961.14*.

Vitamin E content (mg kg^{-1}) was determined under the standard method *AOAC 971.30*.

Vitamin C content (mg kg^{-1}) was determined under the standard method *AOAC 985.33*.

The content of amino acids (g 100 g^{-1}) was determined under the standard method *AOAC 985.28*.

Content of Ca (%) was determined under the standard method *ISO 6490/2*.

The content of fatty acids (% of total fatty acids) – extract of biologically activated hull-less oats / wheat bread was analysed with GC-FID. GC conditions: column DB–WAX (30 m×0.32 mm×0.25 μm), carrier gas: nitrogen, constant flow rate 1.2 ml min^{-1}, temperature program: +60 °C (1 min), +10 °C (1 min), +250 °C (10 min), injector: +230 °C, split 1:1, detector: +280 °C. The samples were prepared as follows: a mix of hexane and acetones was added to 5 g of a homogenised sample; after extraction, 100 mg of fats were used for the analysis; cyclehexane and H_2SO_4 in methanol were added to the sample, the reaction was completed at a temperature +60 °C for 14–16 h; followed by cooling and centrifuging.
The testing included three reiterations.

Results and Discussion

Dynamics of absolute moisture content. The changes of absolute moisture content in biologically activated rye grain during drying process depending on temperature are shoved on Figure 1. As results of our experiments shove, decreases of moisture content are more intensive if the drying temperature is higher then +60±2 °C.

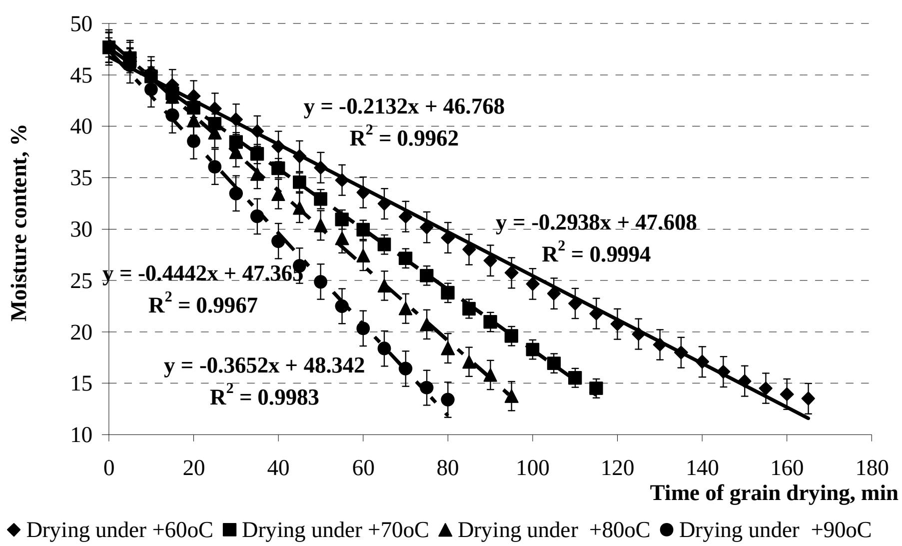

Figure 1. Dynamics of moisture content in biologically activated rye grain during drying

Dynamics of vitamin content. One of the tasks of our research was to found the optimal grain drying parameters, with the purpose maximally maintain quantity of vitamins in grains. In biologically activated rye grain the decreases of vitamins E, C and niacin was established. In unactivated rye grain content of vitamin E is 27.0 mg kg^{-1}, vitamin C – 0.0 mg kg^{-1} and niacin –54.0 mg kg^{-1}. As a control sample the rye grain biologically activated for 24±1 h was used in the research. The changes of vitamin content are showed in Table 1.

The results of our research prove, that the optimal drying parameters for biologically activated rye grain will be as follows: the temperature t=+60±3 ºC and the time τ=2.75h, because the changes of vitamin content are not so considerable; the decreases of vitamin E are ~1.2 times, vitamin C–~1.3 times and niacin–~1.8 times. Therefore, the biologically activated rye grains dried at temperature t=+60±3 ºC for τ=2.75h were use for future experiments.

Table 1

Changes of vitamins C, E and niacin content during grain drying, mg kg^{-1}

Vitamin	Changes of vitamin content				
	0	t=+60±3 ºC τ=2.75 h	t=+70±3 ºC τ=1.92 h	t=+80±3 ºC τ=1.60 h	t=+90±3 ºC τ=1.40 h
E	32.5	27.5	27.8	25.4	23.6
C	42.8	33.6	29.8	25.1	19.8
Niacin	66.7	37.5	33.3	32.5	30.1

Dynamics of total protein, fat and wood-fibre content. Activity of enzyme threacetilglycerolipase and lipoxygenase increase during the grain biological activation to 24 hours, as a result the changes of *fat* content are not so relevant, the content of fat increase from 1.37% to 1.4% in dry matter. Such changes will be explained with fat synthesise in grain shells during biological activation. During the biologically activated rye grain drying process at temperature +60±3 ºC and time 2.75 hours the content of fat is not changed.

Total albumen content could not increase during the grain biological activation, because the albumens are splited under the influence on proteolytic enzymes. As a result the content of albumins decreases from 11.0% to 10.53% in rye grains during biological activation to 24 h. The changes of total albumen content during drying process are not so relevant: the decreases were observed from 10.53% to 10.42%.

The content of wood - fibre increases from 2.80% to 3.73% during the rye grain activation time. It will be explained with amylolytic enzyme activity; as a result the cellulose and hemicellulose will be splited. The decrease of wood - fibre content during drying process was determined as not relevant (from 3.73% to 2.69% in dry matter).

Ca content. The increases of Ca content during rye grain biological activation were not so relevant: from 0.05% to 0.07%. Content of Ca during grain drying time was not changed.

Dynamics of fatty acid composition. The increase of oleic, linoleic, cys-11-eucosan, eruc and α-linolenic acids content during grain drying process was observed by 1.5 times. Such changes will be explained with the fat synthesise in grain shells during biological activation and not so high drying temperature which could not negative influence on grain chemical composition.

Dynamics of amino acids composition. The content of total amino acids decreases from 11.6% to 5.94% in dry matter during rye grain biological activation time. It could be explained with albumen splitting under the influence on proteolytic enzymes. During the drying process of biologically activated rye grain the increases of total content of amino acids was determined (from 5.94% to 7.15% in dry matter). Such changes will be explained with intensive biological process accruing in rye grain during first drying period, as a result the amino acids synthesize.

Conclusion

1. Optimal drying parameters of biologically activated rye grain are: temperature +60±3 ºC and drying time approximately three hours.
2. The content of vitamin E in biologically activated rye grain during drying decreases ~1.2 times, vitamin C – ~1.3 times, niacin – ~1.8 times.
3. The changes of albumen, fat, wood - fiber in biologically activated rye grain during drying are not relevant.
4. The increases of oleic, linoleic, cys-11-eucosan, eruct and α-linolenic acid content at the grain drying process is 1.5 times.
5. During the biologically activated rye grain drying process the increases of total amino acid content was determined (from 5.94% to 7.15% in dry matter).

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