

## QUALITY CHANGES OF NATURALLY FERMENTED KVASS DURING PRODUCTION STAGES

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### Abstract

Commercially available beverages sold as kvass are kvass drinks and malt extract drinks, made by diluting grain extract concentrates with water and adding colourings, different flavours and artificial sweeteners. Kvass quality parameters are defined by the Regulation No 926/2010 *Quality and classification requirements for kvass and kvass (malt) beverage* of the Cabinet of Ministers of the Republic of Latvia. Naturally fermented kvass is made from rye bread rusks without additional additives. The aim of this research was to assess the quality changes of naturally fermented kvass during production stages. Experiments were carried out at the Latvia University of Agriculture Department of Food Technology. Dry matter (refractometer, ISO 6496), active acidity (LVS EN ISO 10523:2012) and sensory properties (25 panellists; line scale ISO 4121:2003) were analysed in kvass samples during production stages. During fermentation stage of naturally fermented kvass, pH drops from 4.08 to 3.77 and in later production stages pH is between 3.82 and 3.88, pH levels do not exceed the index values of the Regulation of the Cabinet of Ministers. Relative dry matter content reduced from 5.96% to 4.94%. Sensory evaluation showed that the intensity of flavour, aroma and acidity was most pronounced in kvass sample C (total production time 156 h), however, colour was most pronounced in kvass sample A (total production time 36 h). Longer maturation process aids in the formation of more robust flavour as well as yeast and protein residue.

**Keywords:** kvass, dry matter, active acidity, sensory evaluation.

### Introduction

Kvass is a non-alcoholic beverage that can be used without restriction, its effects on the human body is similar to kefir. This is due to lactic acid which is formed by lactic acid bacteria (Costa et al., 2013). Kvass has beneficial effects on the digestive tract (Feik et al., 2010), furthermore energy value of naturally fermented kvass is only 25 kcal (105 kJ) per 100 mL (Costa et al., 2013). Kvass has thirst soothing and diuretic properties.

Fermented bread kvass has the positive qualities of beer, as well as minerals and vitamins. It contains more than 30 minerals and trace elements. Kvass contains such minerals as copper, phosphorus, potassium, zinc, iron, and fluorine and B vitamins – thiamine, riboflavin, niacin and folic acid (Zariņš, 1991); the content of thiamine (B<sub>1</sub>) in naturally fermented kvass is up to 0.04 mg per 100 mL (Покровский, 1976). There are no fat, cholesterol and nitrates in kvass. Most of the beneficial substances come from the raw materials used in naturally fermented kvass production – rye bread and malt.

Kvass is very low in sodium, so it promotes the excretion of fluid and it can recommend instead of other soft drinks for people who want to lower their blood pressure with food restrictions (Рудольф, 1982). Commercially available beverages sold as kvass are kvass drinks and malt extract drinks, made by diluting grain extract concentrates with water and adding colourings, preservatives, different flavours and artificial sweeteners. The most commonly used preservatives in soft drink production are benzoic acid, sorbic acid and sodium benzoate (Дотарецкий, 1990). Regulation No 926/2010 of Cabinet of Ministers of the Republic of Latvia indicates that it is allowed to use these raw materials if they comply with the requirements set in food laws and regulations for kvass production: spring water, drinking water, fruit juice and

puree, vegetable juice and puree, fruit juice concentrate, sugar, kvass mash concentrate, bread rusks, cereals, malt and grain products, raw plant extracts, kvass concentrate, carbon dioxide, compressed bakers' yeast or cultured yeast, honey, sweeteners and flavourings (except in the production of kvass), food additives.

Maximum cleanliness and hygiene conditions associated with good manufacturing practice must be provided during kvass production therefore stainless steel tanks are used (Bidzāne, 2000).

Water quality affects the formation of kvass sensory indicators. Kvass consistency is better if softer water is used. Elevated sulphate content in the water causes kvass to taste bitter, silicates interfere with the fermentation process and causes sludge, chlorides lead to unpleasantly sweet taste, iron and manganese affect kvass colour and foaming (Hugenholtz, 2013).

Malt for kvass production is usually obtained from spring barley, which has low levels of protein (8–11%) and higher levels of starch which contains the necessary sugars for fermentation. Germination of grains activates the break down starch and proteins during mash cooking (Sacher, 2013), thus obtaining necessary nutrients for yeasts and lactic acid bacteria.

Rye bread rusks which are the basic raw material in naturally fermented kvass production have a strong flavour and sour taste. Rye bread rusks are obtained by drying sliced or diced rye bread.

Bread yeast *Saccharomyces cerevisiae* is used for kvass production; yeast cells cause intense ethanol fermentation during anaerobic fermentation forming alcohol and carbon dioxide. To control fermentation and avoid formation of too much alcohol, oxygen is supplied during this process (Birch et al., 2013).

Active lactic acid bacteria growth takes place simultaneously with yeast cell growth during mash fermentation; lactic acid bacteria produce lactic acid.

Bread kvass made from pure cultures of lactic acid bacteria and yeasts is clearer and has increased resilience. Yeast and lactic acid bacteria that give refreshing taste and aroma are most commonly used. (Dlusskaya et al., 2008) Malt extract and bread fermentation process provides proteins, sugars, organic acids and vitamins.

Usually, preservatives which extend shelf life are added or kvass pasteurization is used. These processes shorten production time and costs, and also impact such sensory properties as taste and smell, as well as biologically active compounds. Naturally fermented kvass is made without preservatives and is not pasteurized, thus saving the maximum quantity of vitamins and minerals, as well as the flavour and aroma.

Before the production of a new type of kvass it is necessary to define sensory scores, which can significantly affect consumer beverage choices. Therefore the aim of this research was to assess the quality changes of naturally fermented kvass during production stages.

### Materials and Methods

All analyses were completed at Microbiology Research laboratory, laboratory of Sensory analyses and laboratory of Bread technology at Latvia University of Agriculture.

#### Kvass production

For the bread kvass production the following materials were used: rye bread rusks (Ltd *Liepkalni*), baker's yeast *Saccharomyces cerevisiae* (Sp.z.o.o. *Lallemand*), lactic acid bacteria *Leuconostoc mesentericus* (Ltd Chr. Hansen), beet sugar (Ltd *Dansukker*) and dark malt (Ltd *Liepkalni*).

To prepare 1 litre of kvass mash, 200 g of rye bread rusks and 2 g dark malt were soaked in 2 litres of hot water ( $78 \pm 2$  °C). Bread rusks were left to soak for 3 hours, then the water-bread rusk suspension was filtered (300 microns) and the liquid fraction was cooled down and used in further kvass production stages.

1 g baker's yeast, 2 units of lactic acid starter and 30 % of the estimated quantity of sugar were added to 1 litre of kvass mash. The total quantity of sugar for kvass production is 30 g; therefore 10 g of sugar were added prior to fermentation. The fermentation of kvass mash took 9 hours at  $27 \pm 1$  °C.

After fermentation kvass was placed in a refrigeration chamber to cool down to  $3 \pm 1$  °C. After cooling, the yeasts were filtered (5 microns) and the remaining sugar was added (blending). Kvass was matured for 12 hours at  $6 \pm 1$  °C and then it was ready for drinking (total production time 25 hours).

Afterwards kvass was filled in 0.5L plastic bottles and stored for 156 h in total, in order to complete physicochemical and sensory analysis. Technological process of naturally fermented kvass production is given in Figure 1. Shelf life of naturally fermented kvass is  $125 \pm 5$  hours (about 5 days).

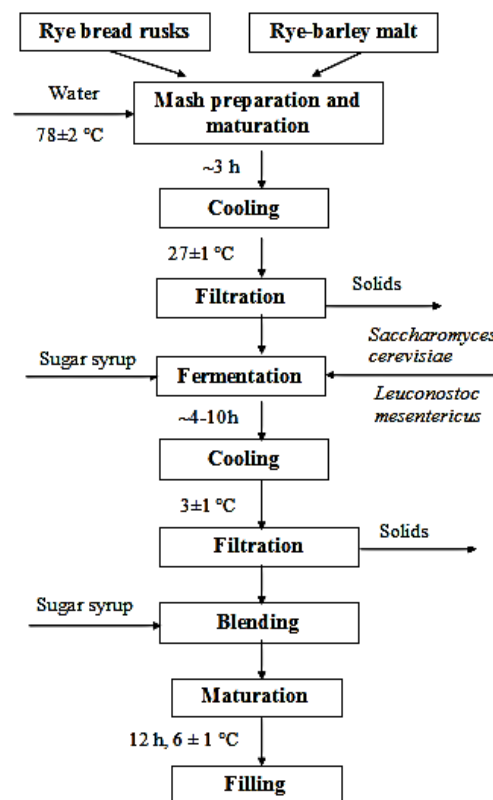


Figure 1. Technological process of naturally fermented kvass production

#### Physicochemical analyses

The Regulation No 926/2010 defines such kvass quality parameters:

- 1) dry matter content – 3.0 to 14.0 percent by weight,
- 2) acidity – 2.0 to 3.5, expressed as mL of 1N NaOH per 100 mL.

Active acidity (pH) and dry matter content was determined in kvass during 8 production stages (Table 1). Active acidity (pH) was determined according to the standard (AACC 02-31) and dry matter was determined with table refractometer according to the standard ISO 6496).

#### Microbiological analyses

Lactic acid bacteria were determined in kvass during 8 production stages (Table 1) according to the standard LVS ISO 15214:1998.

#### Sensory analyses

Kvass samples were evaluated sensory by 25 trained panellists (36% men and 64% women), average age 21 years.

Each panellist was served 3 samples of kvass in a randomized serving sequence: kvass stored for 11 h (sample A, total production time 36 h), kvass stored for 59 h (sample B, total production time 84 h), and kvass stored for 131 h (sample C, total production time 156 h). Line scale was used to evaluate the intensity of kvass sensory properties (aroma, flavour, acidity, and colour) (ISO 4121:2003). Kvass samples for sensory

evaluation were chosen according to organoleptic evaluation by research funder.

Table 1

Stages of kvass production process		
Stage	Materials and technological process	Time, h
S <sub>0</sub>	Rye bread rusks, before soaking	0
S <sub>1</sub>	Kvass after fermentation	12
S <sub>2</sub>	Kvass after blending	13
S <sub>3</sub>	Kvass after maturation	36
S <sub>4</sub>	Kvass during storage	60
S <sub>5</sub>	Kvass during storage	84
S <sub>6</sub>	Kvass during storage	132
S <sub>7</sub>	Kvass during storage	156

### Data analyses

The obtained data processing was performed with the Microsoft Excel 13 for Windows; arithmetic mean, standard deviation and standard error were calculated (Arhipova et al., 1999). For data cross-comparison ANOVA, Regression and other statistical calculation functions were used. Both t-test and F-test were used in order to assess the significance of changes and inter-comparison of the obtained data. For the interpretation of the results it is assumed that  $\alpha=0.05$  with 95% confidence (Næs et al., 2011).

### Results and Discussion

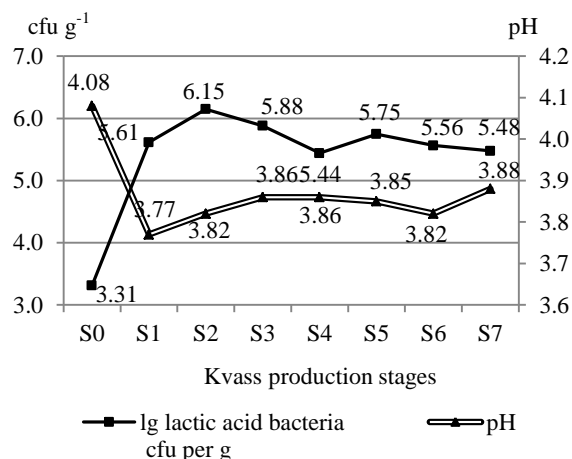
The changes detected in pH during kvass production stages are given in Figure 2.

The numerical value of pH decreased slightly during kvass fermentation; the initial pH was 4.08 and pH after fermentation was 3.77. During the rest stages of kvass production pH stabilized and was around pH 3.85. Compared to the indexed values of the Regulation No 926/2010, pH value of laboratory produced kvass corresponded to the regulatory scale (experimentally determined conversion factor approximately 1.8). pH value did not decrease to interval lower limit value (2.0 mL 1 N NaOH) in any of the controlled production stages; at the end a trend in pH increase was observed. The increase of pH in kvass at the end of production stages could be explained by the formation of new substances because yeast and lactic acid bacteria cells gradually die.

A strong, negative correlation ( $r=-0.92$ ) was observed between pH and lactic acid bacteria count changes in kvass. Correlation is significant ( $p<0.05$ ) primarily during the first three stages of kvass production (Lidums, 2011).

During later stages, at the onset of lactic culture gradual degradation and stabilization of pH, correlation is weak and negative ( $r= -0.11$ ). As pH is the logarithm of  $H^+$  ion concentration, correlation is compared to the logarithmic values of lactic acid bacteria count. A moderate, negative correlation ( $r= -0.50$ ) was observed

using pairwise correlation calculation between pH and the absolute number of lactic acid bacteria.



**Figure 2. Changes in pH and lactic acid bacteria count during kvass production stages**

S<sub>0</sub> – rye bread rusks, before soaking, S<sub>1</sub> – kvass after fermentation, S<sub>2</sub> – kvass after blending, S<sub>3</sub> – kvass after maturation, S<sub>4</sub>, S<sub>5</sub>, S<sub>6</sub>, S<sub>7</sub> – kvass during storage

During kvass production stages dry matter content (%) experienced a slight decrease at the expense of volatile fermentation product formation (mainly alcohol). At times a rise in dry matter content can be observed at the expense of increased fermentative microorganism total cell count.

Decrease in dry matter content was found after intensive fermentation stage (S<sub>1</sub>). Relative dry matter content changed from 5.96% to 4.94%. Decrease in the intensity of fermentation caused sedimentation of some substances that were not fully included in the test sample. In later stages of kvass production significant changes on dry matter content were not observed ( $p>0.05$ ).

The changes in indicator value were characterized by this polynomial division:

$$y = 0.00005x^2 - 0.0148x + 6.0285 \quad (1),$$

where  $y$  – the dry matter content (%) after a certain time,  $x$  – fermentation, h.

The process is characterized by regression  $R^2 = 0.99$ . The first right-hand number in the division (1) is a very low figure, so it can be dropped and the calculations performed with a linear response without significant mistakes:

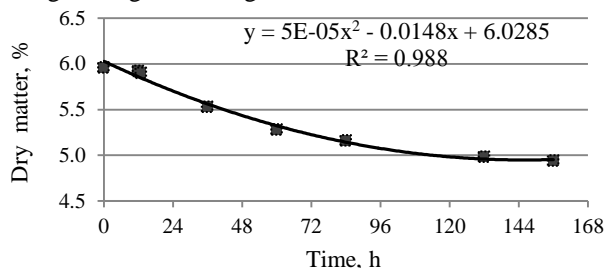
$$y = -0.015x + S_0 \quad (2),$$

where  $y$  – the dry matter content, %;  $x$  – fermentation, h;  $S_0$  – initial dry matter content, %.

It should be noted that the decrease in dry matter content affects physical as well as chemical and biogenic elements, so for each particular set of circumstances of kvass production stages a calculation formula must be found. In general form it looks like this:

$$\text{Dry matter (\%)} = -k \times (\text{hours}) + \text{initial dry matter (\%)} \quad (3),$$

where  $k$  – coefficient of proportionality, determined with control measurements.  
Changes in dry matter content during kvass production stages are given in Figure 3.

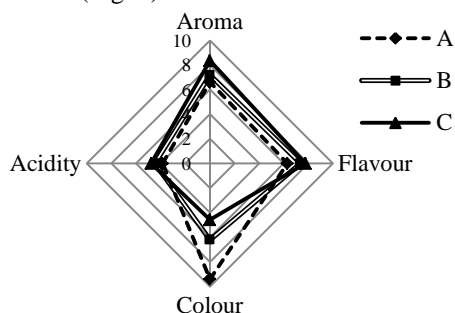


**Figure 3. Changes in dry matter content (%) during kvass production stages**

Dry matter content decreased during kvass fermentation, as most of the dry ingredients and sugar were used for yeast and lactic acid bacteria development.

Since in kvass production normative documents no strict parameters have been set for acidity (affects flavour) and dry matter (affects clarity), solely the recommended value intervals, many versions and combinations (market brands) of kvass quality and sensory properties are possible.

The intensity of sensory properties of three kvass samples with different storage (total production) times was evaluated (Fig. 4).



**Figure 4. The intensity of kvass sensory properties**

The results show that the intensity of aroma was most pronounced in kvass sample C (total production time 156 h) and the least pronounced in kvass sample A (total production time 36 h) ( $p=0.0230$ ). This is due to the fact that further maturation happens during storage and longer storage time aids in stronger aroma forming. Flavour intensity was most pronounced in sample C ( $p=0.0430$ ), this is due to the fact that further maturation happens during storage and as in the case of aroma, longer storage time also aids in stronger flavour forming. Kvass sample A, which was stored for the shortest time, was rated as having the most intense colour ( $p=0.008$ ). Further maturation aid in the formation of sludge, yeast and protein residue which gives a hazy, muddy colour; the intensity of colour in sample C was the least pronounced.

Samples C and B (total production time 84 h) were rated as having the most pronounced acidity.

Because of further maturation happening during storage, yeasts left in kvass continue to ferment remaining sugars, resulting in increased acidity.

### Conclusions

During production stages, changes in active acidity range from pH 3.77 to pH 4.08. Relative dry matter content reduced from 5.96% to 4.94%.

Sensory evaluation showed that the intensity of flavour, aroma and acidity was most pronounced in kvass sample C (total production time 156 h), however, colour was most pronounced in kvass sample A (total production time 36 h). Longer maturation process aids in the formation of more robust flavour as well as yeast and protein residue.

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