CHARACTERISTICS OF DRY NATURALLY FERMENTED KVASS OBTAINED BY SPRAY DRYING

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Abstract
Kvass is an aromatic soft drink which in a form of powder could be used in dairy or bakery products, or sugar confectionary to expand the diversity of flavours. Spray drying is one of the techniques used for producing powders; however, liquids with high sugar content become sticky during drying process and need additional drying aids to increase glass transition temperature and improve powder stability. The aim of this research was to evaluate the characteristics of dry naturally fermented kvass. Maltodextrin was used in 50, 40 and 25% quantity to kvass dry matter in order to aid the spray drying of naturally fermented non-pasteurised, non-filtered bread kvass. Spray drying of 8 l naturally fermented kvass returned approximately 500 g dry naturally fermented kvass powder with a light brown colour, a pronounced aroma of rye bread and moisture content of 7 ± 0.1%. Microstructure analysis of the spray dried naturally fermented kvass showed irregularly spherical shaped particles, having many shrinkages, breakages and dents on the surface in general. Total viable microorganism count in dry naturally fermented kvass powder was within the recommended levels, traces of lactic acid bacteria were found in all samples. The presence of *Bacillus amyloliquefaciens* was established in dry naturally fermented kvass powders, with possible contamination from spray dryer.
Key words: dry kvass, naturally fermented kvass, maltodextrin, spray drying, microbiological contamination, microstructure.

Introduction

Kvass is a soft drink produced by fermenting kvass mash with yeast, with alcohol content under 1.2% alc/vol and dry matter of 8 – 12%, mainly from sugars (Lidums *et al*., 2015). Kvass is an aromatic drink which in a form of powder could be used in dairy or bakery products, or sugar confectionary to expand the diversity of flavours.

Similar to juice powders which have many benefits and economic potentials over their liquid counterparts such as reduced volume or weight, reduced packaging, easier handling and transportation, and much longer shelf life, dry naturally fermented kvass could be a valuable contribution compared to liquid kvass. Besides, juice powder physical state provides a stable, natural, and easily dosable ingredient, which generally finds usage in many foods and pharmaceutical products such as flavouring and colouring agents (Shrestha *et al*., 2007; Goula & Adamopoulos, 2010).

Drying is widely used to extend the shelf life of food products; the decrease in moisture content causes the reduction of the mass, volume, enzymatic and microbial activity (Kaya *et al*., 2007). Spray drying is one of the techniques used for producing powders from liquid solutions and suspensions. The spray-drying technique is 30–50 times cheaper than freeze drying (Gharsallaoui *et al*., 2007). Spray drying is the transformation of feed from a liquid or slurry form to a dry powder. The feed is atomized into a chamber where the resulting spray mixes with hot gas, which evaporates the liquid component of the spray leaving dried particles (Goula & Adamopoulos, 2010). The products to be spray dried can be categorized into two major groups: non-sticky and sticky products. Sticky products are generally difficult to spray dry. During the drying process they may remain as syrup or stick on the dryer wall, or form unwanted agglomerates in the dryer chamber and conveying system (Bhandari & Howes, 2005). The problem of powder stickiness is mainly due to the low glass transition temperature of the low molecular weight sugars present in such products as sucrose, glucose and fructose (Roos *et al*., 1996; Oberoi & Sogi, 2015).

For example, more than 90% of solids in fruit juices are low molecular weight sugars and organic acids which attribute to the sticky behaviour. Sugar content in kvass is lower than in fruit juices; however, it is still too high to dry them under normal conditions (Goula & Adamopoulos, 2010; Oberoi & Sogi, 2015). To overcome the stickiness problem, various methods that are able to produce free-flowing fruit juice powder have been suggested: using an adjunct or a carrier agent (maltodextrin, gum, starch or gelatin) as an additive in the feed material during spray drying (Saénz *et al*., 2009). The addition of high molecular weight additives to the product before atomizing is a widely used alternative that increases glass transition temperature and improves product stability (Tonon *et al*., 2011). Maltodextrins are generally produced from starch by partial hydrolysis, consisting of β-D-glucose units linked mainly by glycosidic bonds (1 → 4) conneced in chains of variable length (Hobbs, 2009; Nurhadi *et al*., 2016). Maltodextrins are classified as a GRAS (generally recognised as safe) ingredient (Hobbs, 2009).

Microbiological criteria have been used internationally for many years as a means of assessing the safety and suitability of foods (CAC, 2013). Since

there are not microbiological criteria developed for dry naturally fermented kvass, it could be compared to juice powder. As juice powder has a low water activity that does not support growth of mesophilic aerobic microorganisms, expected levels of these microorganisms would be low in juice powder; they serve as an indicator of general contamination. Centre for Food Safety (2014) recommends maximum standard plate count at 10^4 CFU g^{-1} for satisfactory and 10^4 - $<10^6$ CFU g^{-1} for borderline quality of powdered foods (e.g., soup and drink powder, milk powder), also suggesting *Enterobacteriaceae* count below 10^2 CFU g^{-1} (10^2 - $<10^4$ for borderline quality). The aim of this research was to evaluate the characteristics of dry naturally fermented kvass.

Materials and Methods

Experimental design

Experiments were carried out at Institute of Process Engineering and Equipment, Faculty of Food Sciences, The University of Warmia and Mazury in Olsztyn, Poland during September to November 2015 and at the Department of Food Technology, Latvia University of Agriculture during December 2015. The object of the research was dry naturally fermented kvass. Ltd Liepkalni naturally fermented non-pasteurised, non-filtered bread kvass 'Liepzeme' was used to produce dry naturally fermented kvass at Institute of Process Engineering and Equipment, The University of Warmia and Mazury in Olsztyn, Poland. Dry naturally fermented kvass particle microstructure was analysed at Institute of Process Engineering and Equipment, while microbiological analyses were performed at the Department of Food Technology, Latvia University of Agriculture.

Spray drying conditions of dry naturally fermented kvass

Experiments were performed using a pilot plant spray dryer at a drying rate of 12.3 kg of water h^{-1}. Feeding solution of 1 litre was prepared by dissolving ~70 g maltodextrin in 100 ml kvass, and then it was mixed with the rest of kvass to dry matter content 14%. Kvass was atomized from a rotary atomizer (disk speed 11 000 rpm) into a vertical co-current drying chamber 1.8 m in diameter and with a height of 2.3 m. The inlet and outlet air temperatures were in 170 °C and 103 °C, respectively. Temperature inside the drying chamber was 75 – 80 °C, but the temperature of the feed mixture was 20 °C. The feed flow rate was fixed at 15 kg h^{-1}. Product flow rate and temperature inside the dryer were controlled throughout procedure, as temperature in the most important parameter in spray drying of kvass. Dried kvass samples were collected from the cyclone separator and after cooling to room temperature packaged in vacuum in laminated PE/PA pouches and stored in dark until further analysis.

Three dry naturally fermented kvass samples were investigated with drying aid (added as quantity to kvass dry matter):

- ✓ sample A (kvass 50% and maltodextrin 50%);
- ✓ sample B (kvass 60% and maltodextrin 40%);
- ✓ sample C (kvass 75% and maltodextrin 25%).

Dry naturally fermented kvass particle microstructure

Dry naturally fermented kvass particles were analysed by scanning electron microscope (XL-30, Philips, Amsterdam, The Netherlands). Dry naturally fermented kvass sample was attached to a double sided adhesive tape on SEM stubs, coated with 3 – 5 mA palladium under vacuum and examined with a scanning electron microscope at 3000 kV and magnification of 200× and 400×.

Microbiological analyses

Preparation of test samples, initial suspension and decimal dilutions for microbiological examination was carried out according to ISO 6887-1:1999. 90 ml 0.85% sterile saline was added to 10 g sample of dry naturally fermented kvass in a stomacher bag; then, the sample was homogenized with a stomacher BagMixer400 (Interscience, USA) for 10 seconds. Serial dilutions in 0.85% sterile saline were pour-plated in triplicate for determination of aerobic and facultative anaerobic, mesophilic bacteria (hereafter referred to as TPC – total plate count) on Plate Count agar (Ref. 01-161, Scharlau, incubation at 30 °C for 72 h, LVS EN ISO 4833-1:2014), for lactic acid bacteria on MRS agar (Ref. Ref. 01-135, Scharlau, incubation at 37 °C for 48 h, LVS ISO 15214:1998) and for *Enterobacteriaceae* on Violet Red Bile agar with Glucose (Ref. 01-295, Scharlau, incubation at 37 °C for 24 h, ISO 21528-2:2004 A).

After incubation, the colonies were counted using automated colony counter aCOLyte (Topac Inc., USA) and reported as colony forming units (CFU).

Identification of microorganisms in dry naturally fermented kvass was carried out by cultivating selected colonies on Plate Count agar using streak plate method. Gram staining was performed followed by catalase test. Identification of bacterial species was completed by the API (analytical profile index) biochemical test system using API 50 CHB kit (bioMérieux, France) which is intended for the identification of *Bacillus* and related genera.

Data analysis

The obtained data processing was performed with the Microsoft Excel 13 for Windows; mean values and standard deviations were calculated.

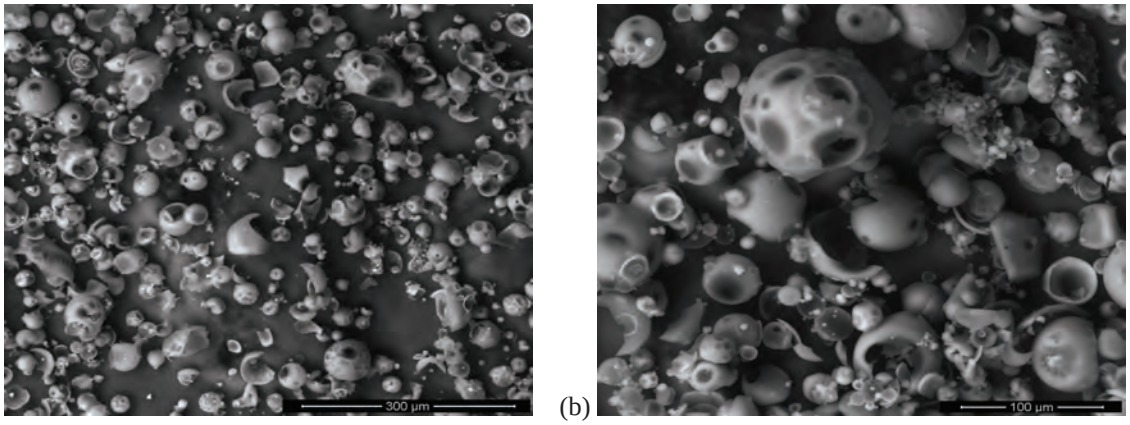

Figure 1. Micrographs of 50% dry naturally fermented kvass particles at magnifications of (a) 200×, (b) 400×. HFV: 746 µm (200×) and 373 µm (400×); det: DualBSD; temperature: 24.9 °C.

Results and Discussion

Spray drying process of dry naturally fermented kvass

Preliminary spray drying was carried out using 100% kvass from 30 l kegs. The resulting product was caramelised hard brown kvass crystals with a very pleasant and pronounced kvass aroma. Therefore, similar to juice spray drying, maltodextrin was used as a drying aid in order to obtain dry naturally fermented kvass. The first experiment was completed with 50% maltodextrin addition (quantity to kvass dry matter) according to Islam *et al*. (2016), where higher concentration of orange juice: maltodextrin (50:50) was investigated compared to Shrestha *et al*. (2007) and Goula and Adamopoulos (2010). Maltodextrin proportion was later reduced to 40% and 25%, in order to obtain dry naturally fermented kvass with less maltodextrin addition. Lower amount of maltodextrin (below 25%) gave a sticky syrup that started crystallising.

Spray drying of 8 L naturally fermented kvass returned approximately 500 g dry naturally fermented kvass. The resulting product was dry naturally fermented kvass with pronounced aroma of rye bread and light brown colour. Moisture content of dry naturally fermented kvass was 7 ± 0.1%.

Optimal technological parameters during spray drying, as well as the best drying method are still being researched, in order to reduce the added drying aid (or drying aid mixture) to minimum.

Dry naturally fermented kvass particle microstructure

Microstructure analysis showed that spray-dried naturally fermented kvass had irregularly spherical shaped particles, having many shrinkages, breakages and dents on the surface in general (Fig. 1). The results agree with Fazaeli *et al*. (2012), in which orange juice powder produced with 50% maltodextrin addition had dented surfaces with wrinkles and deformation. Powder with higher amounts of maltodextrin (70%) had the smoothest surface with smaller spherical shapes and no shrinkage. The particle size distribution showed that spray-dried naturally fermented kvass particles ranged up to 112.205 µm.

Microflora of dry naturally fermented kvass

TPC levels in dry naturally fermented kvass were within the recommended levels by Centre for Food Safety (2014), EU Regulation No 2073/2005 does not define TPC for juice powders and similar products. Significant differences were not found in TPC levels of dry naturally fermented kvass samples; total viable microorganism count in 50% dry naturally fermented kvass (sample A) was 7.58×10^4 CFU g^{-1}, in 60% dry naturally fermented kvass (sample B) 7.62×10^4 CFU g^{-1} and in 75% dry naturally fermented kvass (sample C) – 7.8×10^4 CFU g^{-1}. *Enterobacteriaceae* count in all samples was $<10^2$ CFU g^{-1}. Traces of lactic acid bacteria (<20 CFU g^{-1}) were found in all samples.

Bacteria found in all dry naturally fermented kvass samples with similar morphological characteristics were investigated further. Gram staining proved them to be gram positive and catalase positive sporeforming bacteria of *Bacillus* spp. API biochemical identification established the presence of *Bacillus amyloliquefaciens*, with possible contamination of dry naturally fermented kvass from spray dryer (or handling equipment).

B. amyloliquefaciens and its closely related species are particularly known to be involved in ropy bread spoilage that is characterized by an unpleasant fruity odour followed by enzymatic degradation yielding soft, sticky and stringy bread crumb making the bread inedible (Valerio *et al*., 2012).

The possibility of using dry naturally fermented kvass for flavour enrichment of different products depends on the product treatment process after dry naturally fermented kvass addition. Enterobacteria,

which were found in dry naturally fermented kvass, are non-spore-forming bacteria, therefore, if the products with added dry naturally fermented kvass are subjected to thermal treatment, vegetative cells of unfavourable bacteria will be destroyed and pose no harm to consumer health.

Conclusions

1. Spray drying of 8 L naturally fermented kvass returned approximately 500 g dry naturally fermented kvass. The resulting product was light brown dry naturally fermented kvass with pronounced aroma of rye bread and moisture content of 7 ± 0.1%.
2. Microstructure analysis of the spray dried naturally fermented kvass showed irregularly spherical shaped particles, having many shrinkages, breakages and dents on the surface in general.
3. Microbiological contamination of dry naturally fermented kvass samples was within the recommended levels for powdered foods (TPC $<10^5$ CFU g^{-1}). *Enterobacteriaceae* count in all samples was $<10^2$ CFU g^{-1}. Traces of lactic acid bacteria (<20 CFU g^{-1}) were found in all samples. Spores of *B. amyloliquefaciens* were found in all dry naturally fermented kvass samples; possible source of these bacteria was spray dryer.
4. Research should be continued to evaluate the obtained dry naturally fermented kvass for flavour enrichment of different products.

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