Fermentation Studies on the Traditional Russian Drink "Sourish Shchi"

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ABSTRACT

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The fermentation process for the traditional Russian drink Sourish Shchi was investigated in order to better understand the original process, its flavour products and to investigate opportunities to improve the process. The six ingredients usually employed for the Sourish Shchi preparation (Shchi in Old Russian means "Six") were: three kinds of malt – barley, rye and wheat; one kind of flour – wheat or rye; buckwheat and honey. This wort, composed of malted and unmalted grains, was traditionally fermented with a mixed culture of bacteria and yeasts to achieve the desired sourness, alcohol and flavor. Laboratory fermentations were conducted using traditional recipes and the fermentation parameters were examined.

Key Words: Fermentation, mixed culture, Sourish Shchi, traditional Russian beverage, volatile components, wort.

INTRODUCTION

Sourish Shchi is an alcoholic drink that was popular in Russia during the 18th and 19th century. The origin of this traditional Russian beverage was most likely linked to the appearance of Champagne in Russia since it required champagne bottles and a second fermentation. The six components usually employed for the Sourish Shchi preparation (Shchi in Old Russian means "Six") were: three kinds of malt – barley, rye and wheat; one kind of flour – wheat or rye; buckwheat and honey.

The malted and unmalted grains were mashed separately using hot water and then the two were combined to produce the final wort. The wort was inoculated with the spontaneous microflora found on the grains, in the vessels and in the air. The naturally inoculated wort was kept in a warm place for 12 to 24 h and once the wort had begun to ferment, there was one more inoculation with a "special sour" culture (from the sediment of the vessel from the previous fermentation). After this final inoculation it was very important to monitor the "culmination" of the fermentation which was usually indicated by the thickness of the foam layer. When fermentation was almost complete the wort was cooled and the beverage bottled in champagne bottles. Traditionally to ensure that there was sufficient carbon dioxide, sugar syrup or honey was added just before bottling. History relates that these champagne type bottles were allowed to end ferment at very low temperatures. Bottles of Sourish Shchi often exploded due to the large internal CO_2 pressure[1]. Sourish Shchi differs from Russian Kvass and other beverages[3] in its sparkling nature due to the high CO_2 concentration, the frothiness and its resemblance to champagne in taste.

The purpose of these experiments was to investigate, using current analytical instrumentation, the Sourish Shchi wort fermentation. The course of the fermentation, wort parameters, and the inocula of baker's yeast, brewer's yeast, concentrated mixed culture of yeasts and lactic-acid bacteria (used for rye bread dough preparation) and spontaneous micro-organisms contained on the raw material, vessels and in air were examined.

MATERIALS AND METHODS

Wort preparation

A traditional wort was prepared using a mixture of light barley malt, non-fermented rye malt, wheat malt, wheat flour, buckwheat and honey in the proportions of 25:10:10:20:20:5% (w/w). Historically these proportions in the original beverage would vary by 10–20 per cent but for this experimental work the aforementioned concentrations were employed. The fermenter was a 5 L laboratory vessel. The wort for the Sourish Shchi was prepared in the traditional way i.e. mashing at 52°C; 15 min rest; temperature rise of 1°C/min to 60–62°C; 30 min rest; temperature rise to 70–75°C; 1 h rest. Wort was clarified using a laboratory centrifuge and the clear wort was boiled for 15 min to stabilise the colloid content and to pasteurise the liquid. Wort was cooled to 30°C before inoculation.

Organisms

The yeasts employed were from the Russian Collection of Industrial Micro-organisms (VKPM): *Saccharomyces cerevisiae* strain 14 is a baker's yeast strain and *Saccharomyces uvarum* (*carlsbergensis*) strain 143 is a brewer's strain. The "concentrated lactate sour" (CLS) culture was a commercial mixture of *Lactobacillus brevis* strain 11 and *Saccharomyces minor* strain "M-Kvasnaya" obtained from the Scientific Institute of Bread Process. This commercial "concentrated lactate sour" is normally used in rye bread production. The spontaneous sour inoculum used in the experiments included the microflora from the vessels, air and cereals. The majority consisted of wild and culture yeasts such as *Saccharomyces cerevisiae, carlsbergensis,* and *oviformis,* as well as *Torula* and *Candida.* The bacteria were identified only as *Lactobacilli.*

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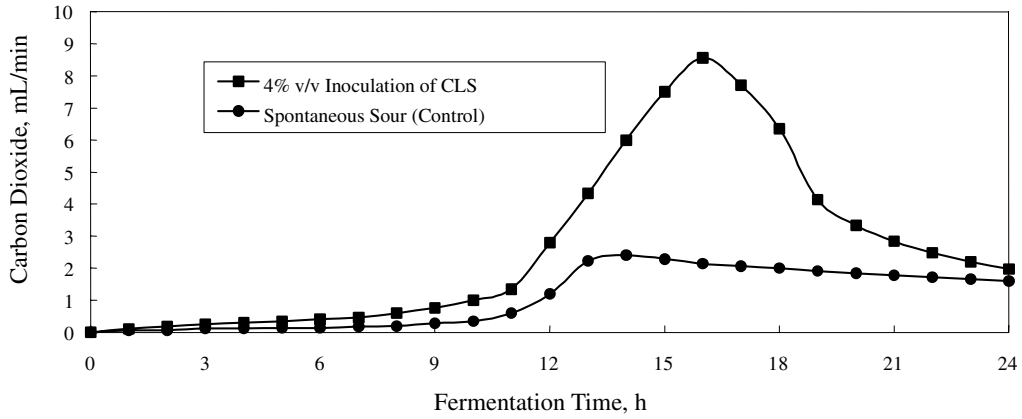

Fig. 1. Carbon dioxide production during fermentation.

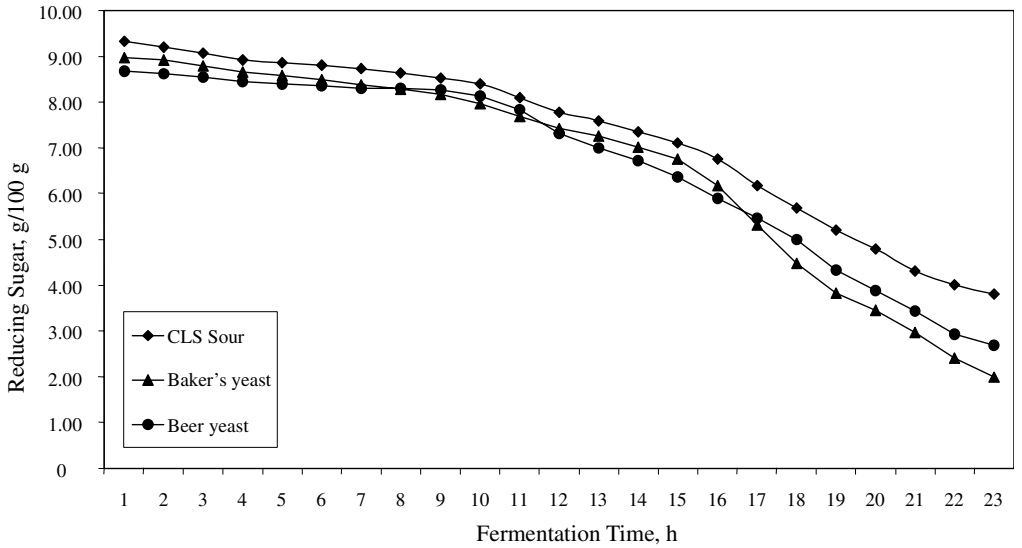

Fig. 2. Wort sugar utilization.

Fermentation conditions

A 2–4% (v/v) sample of CLS or liquid yeast was used to inoculate the vessel. For the "spontaneous sour" the vessel lid was left with open for 12 h at a temperature of 28–30°C and for the fermentation phase held at 28–30°C. When the main fermentation was complete the wort was cooled to 5–6°C, the yeast removed by sedimentation, and the liquid moved to a second aging vessel.

Analyses

Total sugar content and free amino nitrogen (FAN) in both the unfermented and fermented wort were assayed by the Bertrand and Pope & Stevens methods[2]. The content of dry substances in unfermented and fermented wort was assayed with a refractometer.

Volatile analysis

Volatile content in the product after fermentation was assayed using Gas Chromatography with hydrogen as a carrier-gas, a 5 m stainless steel column, PEG-400 and a temperature from 180 to 210°C. Total volatiles, acetaldehyde, ethyl acetate, propyl alcohol, isobutyl alcohol and isoamyl alcohol were assayed.

Table I. Experimental planning matrix and estimations.

Fermentation duration, h (X1)	Inoculum rate, % v/v (X2)	Ethanol concentration, % v/v (Y)
16	2	0.8275
72	2	1.1996
16	4	1.1834
72	4	2.3024

Carbon dioxide

The carbon dioxide accumulation during the beverage fermentation was measured using a water filled U-tube, connected to the fermentation vessel.

Experimental design

Experimental project design using a "Statgraphics Plus" packet was employed (Manugistics Inc., Rockville MD) to set up experiments to determine the relationships between alcohol accumulation (Y), fermentation duration (X1) and the quantity of the inoculum (X2) in the Sourish Shchi wort. A full factorial experiment (2^2) was selected, which permitted the evaluation of the interplay of the factors selected.

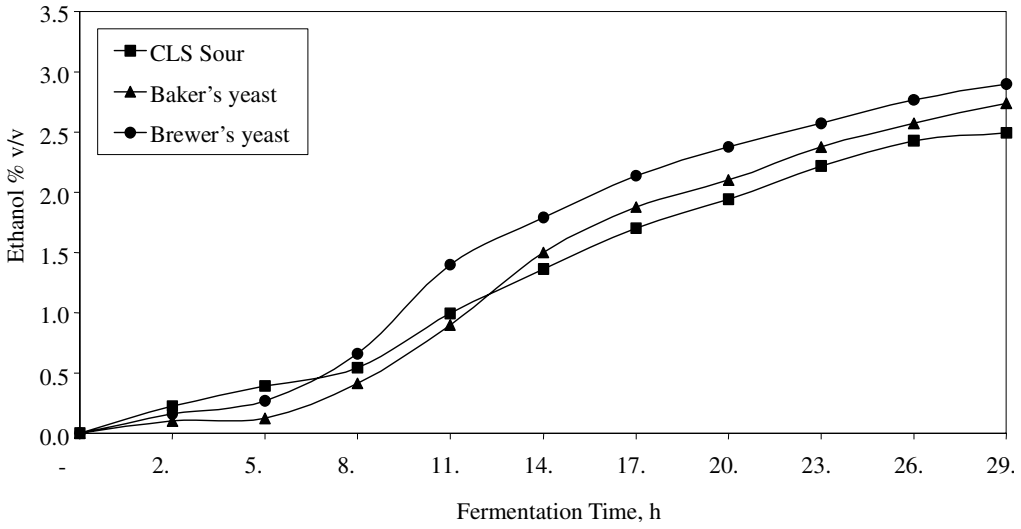

Fig. 3. Ethanol production.

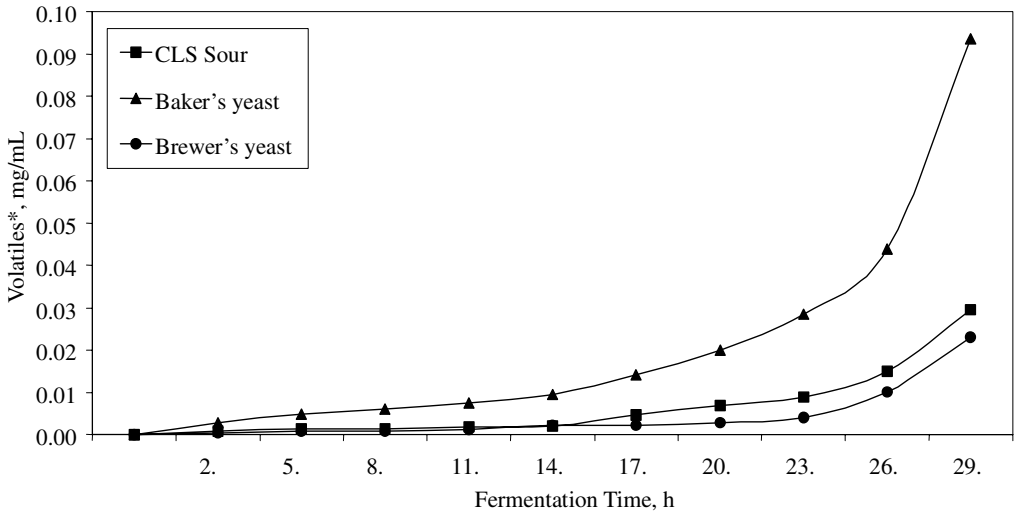

Fig. 4. Volatiles produced during fermentation. (*Sum of 5 volatiles, represented on Fig. 5.)

RESULTS AND DISCUSSION

Four experiments under the following parameters were conducted (see Table I). From the data interpretation a regression equation was obtained, which adequately depicted the process of alcohol accumulation in Sourish Shchi.

$$Y = 0.579 - 0.007 \cdot X1 + 0.070 \cdot X2 + 0.007 \cdot X1 \cdot X2$$

Analysing this equation with the use of "Statgraphics Plus", it was determined that the factor at X1 had the greatest statistical veracity (≫80%). This meant that in regard to alcohol accumulation in Sourish Shchi the time of fermentation had the greatest influence. The relationship between the accumulation of alcohol and the fermentation duration from this equation was linear.

The next phase of the investigation studied the course of wort fermentation with the use of a "concentrated lactate sour" and a "spontaneous sour culture" to determine which fermentation produced maximum carbon dioxide. The results are shown in Fig. 1. The wort fermentation rate by the "spontaneous sour culture" peaked and then levelled at 14 hours of fermentation whereas the wort fermented by the "concentrated lactate sour" peaked at 16 hours and then fell. The quantity of dissolved carbon dioxide was determined using a U-tube.

The third set of experiments examined the reduction in reducing sugar using three different micro-organisms (brewing yeast strain 143, baker's yeast strain 14 and the "concentrated lactate sour" from Scientific Institute of Bread Process (Fig. 2).

The unfermented wort had a dry substance content of 10.0 (± 0.5) g/100 mL, a maltose content of 7.0 (± 0.5) g/100 mL and an FAN content of 5 (± 1) mg/100 mL. The potential alcohol production is dependant on the sugar content of the wort and the initial reducing sugar content of the worts before fermentation was similar in all cases at ~9.0 (± 0.5) g/100 mL of wort.

Fig. 3 illustrates the alcohol accumulation during wort fermentation by the baker's yeast strain 14, the brewing strain 143 and the concentrated lactate sour. After fermentation the lowest maltose levels reached in the wort were those samples fermented by the brewer's and baker's yeast.

Fig. 5. Volatiles production at end of fermentation.

Within the first 8 h of fermentation the alcohol accumulation was low and similar in all three cases. Ethanol in fermented wort reached a maximum of 2.4% (± 0.2%) (v/v) for strain 143 and 2.1% for strain 14 and 1.9% for the "concentrated lactate sour" culture, the lowest alcohol producer.

Organoleptic testing of the fermented worts revealed essential differences in taste and odour between the worts fermented by the yeasts and the wort fermented by the "concentrated lactate sour" culture. The wort fermented by yeast on both taste and odour resembled a distiller's wort while the wort fermented by the "concentrated lactate sour" culture had the pleasant sweet-sour taste and odour reminiscent of the odour of rye bread.

The total quantity of volatiles accumulated after 24 h of wort fermentation was determined (Fig. 4) as well as the individual compounds (Fig. 5). From Fig. 4 it can be seen that few volatiles were produced in the first 8 h of wort fermentation, but the quantity increased in subsequent hours and by 29 h there was 0.094 mg/mL volatiles in the baker's yeast wort and 0.030 and 0.023 mg/mL in the brewer's yeast and "concentrated lactate sour" culture respectively.

Table II. Sourish Shchi beverage physico-chemical parameters.

Parameters	Sourish Shchi with spontaneous sour	Sourish Shchi with CLS sour
Initial wort concentration, %	9.5–10.0	9.5–10.0
Ethanol, % v/v	2.5–3.0	2.5–3.0
Acidity, mL 0.1 M NaOH on 100 mL of beverage	22.1–22.5	22.1–22.5
Color, mL 0.1 M iodine on 100 mL of distilled water	2.4–2.6	2.4–2.6
Acetaldehyde, µg/mL	4.8	3.8
Ethyl acetate, µg/mL	2.1	1.5
Propyl alcohol, µg/mL	18.9	5.9
Isobutyl alcohol, µg/mL	10.9	3.4
Isoamyl alcohol, µg/mL	42.0	13.1

The volatiles (acetaldehyde, ethyl acetate, propyl alcohol, isobutyl alcohol and isoamyl alcohol were measured using gas chromatography. Each of these volatiles can significantly influence organoleptic parameters.

In the wort fermented by the baker's yeast 0.047 mg/mL of propyl alcohol and 0.035 mg/mL of isoamyl alcohol accumulated at a level much higher than in the other two fermentations. An unpleasant flavour and odour in the wort fermented by the brewer's yeast was observed and this was probably due to compounds not assayed with this method.

For traditional tasting Sourish Shchi the use of "concentrated lactate sour" culture was expedient over "spontaneous sour fermentation" and this was confirmed by the physico-chemical and organoleptic beverage parameters (Table II).

CONCLUSIONS

The optimum fermentation time for Sourish Shchi wort was 20–25 h. This allowed sufficient accumulation of CO_2 and produced alcohol in the range of 2.0–2.5% (v/v), and the correct flavour volatiles associated with the product. An inoculation rate of 4% (v/v) was superior to 2% (v/v). Optimal organoleptic parameters for this traditional drink were obtained when the yeast-lactobacillus mixture found in the "concentrated lactate sour" culture was utilized. This work is the first report on the qualitative and quantitative analysis of a Sourish Shchi wort fermentation.

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