

NOVEL MALT-BASED BEVERAGES

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ABSTRACT

Consumer awareness for the negative impact of malnutrition has grown in the last years. Consumers are looking for new products with natural ingredients and health beneficial attributes. This paper shows a new concept for the production of non-alcoholic fermented beverages based on malted cereals and pseudocereals. Some possibilities to produce novel beverages are shown, as well as a new tasting scheme and the analysis of stale flavour compounds in these beverages. With some modification of well known processes in the brewing industry it is possible to design and produce innovative malt-based drinks. The sensory evaluation of the beverages has to be adjusted to their different ingredients particularly fruit juices and flavours. The chromatographic analysis of stale flavour compounds can be carried out according to the methods used for beer.

Keywords: *arabinoxylan, flavour stability, fructan, innovative beverage, lactic acid fermentation*

INTRODUCTION

In recent years a number of novel, innovative beverages have been launched. Due to growing consumer awareness of the negative impact of malnutrition in western countries novel drinks based on natural raw materials have attracted a growing interest. Malted grains and natural fruit juices are especially suitable for the production of such beverages as they are generally considered as positive and healthy food ingredients. A huge variety of malted cereals, barley being the most commonly known, wheat, spelt wheat, rye, oats, triticale and others may be used. Also rice and corn and some pseudocereals such as buckwheat, quinoa or amaranth can be utilised and are of special interest as they are gluten-free and their products can be consumed by people suffering from celiac disease. One possible approach to the production of new beverages is the use of lactic acid fermentation.

The demand for natural food and beverage products through health-conscious consumers is increasing. In addition to natural ingredients consumers are especially interested in health-beneficial bioactive compounds. As most diets in the western world lack a sufficient supply of dietary fibres, these and plant polyphenols, which can act antioxidative and thus anti-carcinogenic, are the most promising functional substances. Examples for dietary fibres in malt-based beverages are arabinoxylans and fructans. The amount of water-soluble arabinoxylans particularly can significantly be increased through the malting process¹. Beta-glucans from malted grain belong as well to the dietary fibre fraction. But due to viscosity increasing properties beta-glucans are problematic in the wort production process.

Arabinoxylans are a part of the naturally occurring dietary fibres in the plant kingdom. The chemical structure of arabinoxylan is based on a chain of linear $\beta(1-4)$ -D-xylopyranose units, which can be substituted with α -L-arabinofuranose in the O-2 or the O-3 position or both². Arabinoxylans in the cell wall are partly cross-linked by diferulic acid bridges and possibly other condensation products of ferulic acid³, which may complicate their solubilisation. The content of water-extractable arabinoxylan (WEAX) increases during the germination in the malting process, as the cell walls are being degraded¹. The solubility of arabinoxylan also increases with a higher degree of arabinose substitution.

Among plant carbohydrates, arabinoxylans are non-digestible ingredients, *i.e.* are not degraded or absorbed in the stomach or in the small intestine and reach the colon intact⁴. Here they are fermented to a large extent, especially the water-extractable part, by the large bowel microflora to lactic acid and short chain fatty acids (SCFA). These can be absorbed and metabolised by the host. Associated with this is the probiotic effect of soluble dietary fibre, which has been shown to result in enhanced concentrations of probiotics such as *Lactobacilli* and *Bifidobacteria* in the colon lumen⁵. SCFA like propionate, butyrate or lactate are the end products of probiotic carbohydrate fermentation. They are used as an energy source by the colonic epithelial cells⁶, as well as having a beneficial effect on human liver cells. Butyrate is an important factor in maintaining normal function in colonocytes and a protective agent against colon cancer⁷. By decreasing the pH of the colon contents SCFA also prevents the growth of pathogenic bacteria⁶. The lower pH in the colon in combination with the SCFA significantly increases the mineral absorption, especially of calcium and magnesium from the gut. The calcium absorption decreases when people are ageing. Therefore the relative increase in absorption induced by soluble dietary fibre becomes more important for older population groups especially those suffering from osteoporosis⁸.

Fructans are β -D-linked polymers of fructose. Approximately 15% of higher plants store fructans⁹. Fructans can be stored in plants in high concentrations as an alternative to starch. The substrate of fructan biosynthesis is sucrose. Chemically, cereal fructans are a linear carbohydrate material consisting mainly, if not exclusively, of $\beta(2-1)$ -fructosyl-fructose linkages. A starting α -D-glucose moiety is mostly present but not necessary⁸. Plant fructans generally show a degree of polymerisation (DP) less than 50, although some have been shown to exceed 200¹⁰. Fructans are divided into inulin, fructooligosaccharides (FOS) and neosugars. Long-chained polymers with a DP greater than 30, are referred to as inulin. FOS have a DP of up to 10, and FOS with a DP of 3–5 are called neosugars¹¹. These oligosaccharides are food products with interesting nutritional properties. The extent of resistance to enzymatic reactions occurring in the upper part of the gastrointestinal tract allows fructans to become colonic nutrients, as some bacterial species express specific hydrolases and are able to convert these sugars into short-chain fatty acids and/or gases by fermenting them¹².

For the production of beverages rich in polyphenols buckwheat, a pseudocereal is a very promising grain. The dominant polyphenol in buckwheat is rutin and buckwheat can be described as an excellent dietary source of rutin^{13,14}. Due to their high content of flavonoids, buckwheat products are associated with a health-beneficial nutrition^{15,16}. The high rutin levels found in buckwheat raw material can additionally be increased significantly by the malting process.

Rutin has a gastro-protective effect¹⁷. In human lymphocytes rutin displayed protective effects against DNA damage^{18,19}. It is a protective agent against carcinogenesis²⁰. Due to its antioxidative, anti-inflammatory and anti-hypertensive properties rutin is of increasing interest for the food industry²¹.

The production of novel beverages is of interest for the world-wide brewing industry. The beer consumption in many countries worldwide is decreasing. In Germany the average annual decrease is between 1.0 and 2.3%²². At the same time due to tight traffic alcohol regulations the sales of non-alcoholic beer have increased by about 2.0% per year²³. In the future novel malt-based beverages could be of interest for breweries. The existing brewery equipment can be used and over capacities can be found in nearly all the leading breweries. One example for the success of such beverages is the product Bionade[®]. The sales of Bionade[®] increased from 2.310 hectolitres in 1997 to 66.000 hectolitres in 2007²⁴.

If such beverages are being produced, the impact of process technology such as pasteurisation and ageing on the resulting product aroma and flavour, are of particular interest. In order to guarantee a stable product quality, the changes in aroma and flavour have to be known to the producer. For over 50 years research has been done on the origins of staling flavours in beer. Thirty years ago Dalglish proposed a model of sensory changes in beer flavour during ageing. It showed an increase in sweet notes and an increase in ribes aroma and later the formation of the so-called cardboard flavour²⁵. In recent years, sweet aroma components have been frequently discussed. These flavour components are primarily carbonyl compounds, such as Strecker aldehydes, products of lipid oxidation and Maillard products²⁶.

MATERIALS and METHODS

Lactic acid fermentation

In order to have standardised wort for lactic acid fermentations, unhopped malt extract (Weyermann, Germany) was used. The extract was diluted with boiling distilled water to an original gravity of 7%. Boiling water was used to ensure a maximum microbiological safety. Other sterilisation methods like autoclaving were not suitable because of their negative impact on the resulting flavour. The fermentations were performed using *Lactobacillus spp.* at 50°C for 3 days. After fermentation the resulting pH-values, the amount of lactic acid and the osmolality of the fermented wort were measured.

Analysis of the fermented product

Osmolality was measured by the determination of freezing point depression. The cryoscopy analysis was done using a Cryostar (Funke-Gerber, Germany). The pH-value was measured with a commercial pH meter according to MEBAK 2.14²⁷. Lactic acid concentration was determined by titration MEBAK 1.10.3²⁸. Original gravity was analysed by a density meter (Anton-Paar, Austria) according to MEBAK 2.10.6.1²⁷.

Beverage production

The obtained fermentation product was mixed with concentrated grapefruit and peach juice (Döhler, Germany) and the appropriate flavour extracts (Döhler, Germany). The osmolality of the beverages was adjusted to 290 mosmol/kg by mixing the fermented wort with the fruit components and distilled water. Thus the resulting beverages were isotonic. The fresh samples were stored at 4°C. Pasteurisation was done in a heated water bath at 65°C for 70 minutes.

Ageing of the beverages was simulated by one day shaking at room temperature followed by storage at 40°C for five days. This process corresponds to a natural ageing of about three to four months²⁹.

Tasting

Sensory evaluation was done by a panel of ten tasters. The tasted attributes were acidity, sweetness, ratio, malty flavour, honey like flavour, fruity flavour, malty aroma, honey like aroma, fruity aroma, astringency, freshness, oxidation and stale flavour. All attributes were rated from 0 to 5 whereas 0 meant no sensory impression. The stale flavour was rated according to the scheme introduced by Eichhorn³⁰. A fresh product is rated with 1. The maximum value for this attribute is 4.

Analysis of aroma components

The volatile compounds were concentrated through steam distillation and extracted with dichlormethane. Afterwards the solvent phase was analysed using the institute method developed by the GC-laboratory at the Lehrstuhl für Technologie der Brauerei I in Weihenstephan based on gas chromatography with a flame ionisation detector (GC-FID)³¹.

Volatile compounds were characterised by Narziß *et al* using GC-MS³².

RESULTS AND DISCUSSION

Osmolality of different beverages

Over 100 different beverages were analysed with regard to their osmolality. The results for some are shown in **Table I**. Beverages with an osmolality of less than 246 mosmol/kg are considered as hypotonic; beverages with an osmolality of more than 334 mosmol/kg are considered as hypertonic beverages. The range inbetween is called isotonic. Isotonic beverages have nearly the same osmolality as human blood (290 mosmol/kg). A fast water resorption from the gut is guaranteed because the osmotic pressure of the beverage is the same as in blood. The solutes in isotonic beverages lead to a fast gastric emptying.

TABLE I		
Osmolality of different commercial available beverages		
Beverage		Osmolality [mosmol/kg]
Hypotonic	Tap water	8,1
	Cola light	36,6
	Sport grapefruit	56,6
	Water + X beverage	188,3
	Cherry sportdrink	220,4
	Non-alcoholic lager (dealcoholized)	231,7
	Non-alcoholic wheat beer (dealcoholized)	236,2
Isotonic	Sportdrink peach	296,0
	Milk 1,5 % fat	298,7
	Grapefruit-lemondrink	300,2
	Sportdrink apple-cherry-lemon	304,1
	Non-alcoholic lager (stopped fermentation)	309,6
	Fitnessdrink grapefruit-lemon	318,5
	Iced tea	322,6
	Grapefruitshandy	323,9
Hypertonic	Sparkling apple juice	379,2
	Cola	569,0
	ACE juice	576,7
	Orangejuice	656,5
	Shandy	738,7
	Colashandy	1001,4
	Pils style beer	1009,7
	Wheatbeer	1142,4

Lactic acid fermentation

The pH-values correlated excellently with the amount of lactic acid produced by the *lactobacilli*. However, if the original gravity of the fermented wort changed, the pH-value could not be used as a suitable indicator for the produced amount of lactic acid. The changed buffer capacity resulted in higher levels of lactic acid at the same pH-values. Only the fermentation process could be monitored by the pH-value. All investigated *lactobacilli* stopped fermentation at a pH of 3.0. Exemplary, the fermentation process with *lactobacillus amylovorus* is shown in **Fig. 1**. The freezing point depression always correlated with the amount of lactic acid measured by titration. This correlation was independent of the original gravity at the beginning of the fermentation process (**Fig. 2**).

The results of this work show that cryoscopy is a good analytical tool to analyse the amount of lactic acid in the fermentation process. The advantage of this method compared with the sole pH-value is the independency from the original gravity of the fermented wort used for the fermentation process.

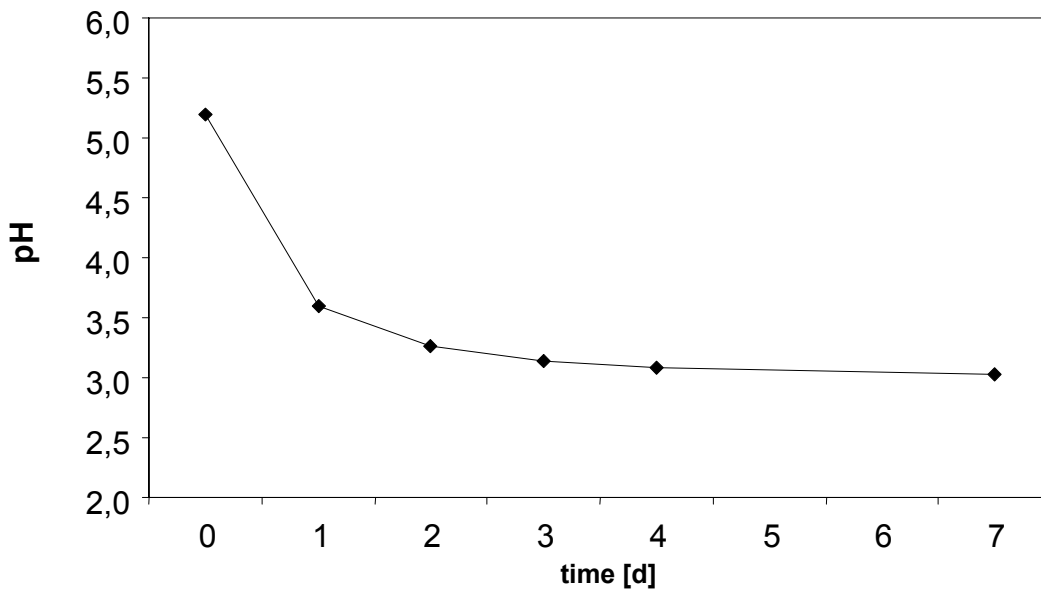


Fig. 1 pH decrease during lactic acid fermentation

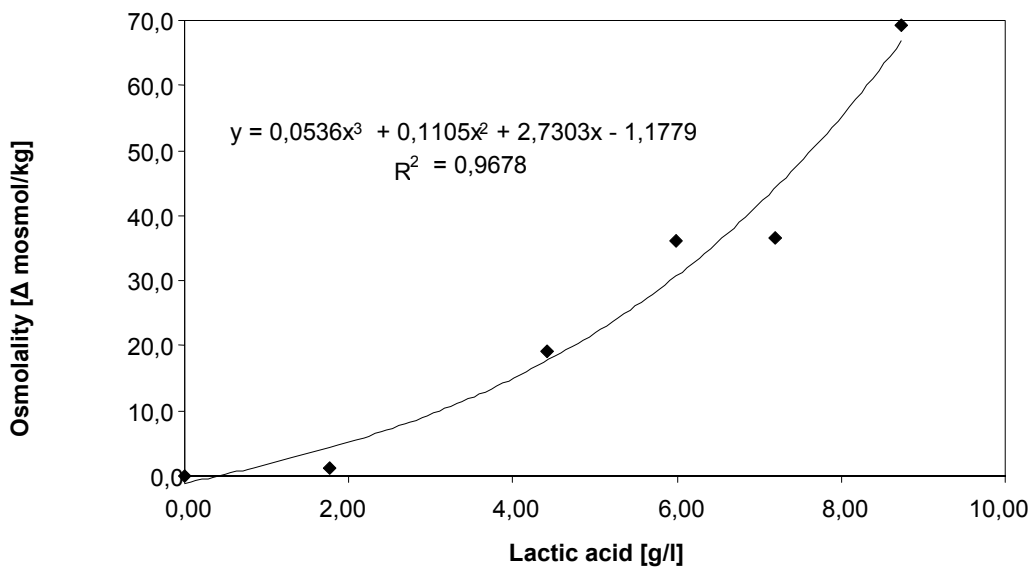


Fig. 2 Correlation between lactic acid and osmolality during fermentation

Tasting results

The results of the sensory evaluation of the two produced beverages and of the fermented wort are shown in **Tables II-IV**. In all three samples the ratio decreased after pasteurisation and simulated ageing. Oxidation and stale flavours increased. In contradiction to beer, no increase in malty and honey like, sweet aroma or flavour could be observed. The grapefruit and peach aroma faded in both beverages. The influence of the pasteurisation process on the analysed samples was similar to the effect of the simulated ageing process. In the production of such beverages that have at least to be

pasteurised to guarantee a sufficient microbial safety, the used amount of aroma extract should be adjusted accordingly.

TABLE II			
Tasting results of the fermented wort			
Attribute	Fresh sample	Pasteurised sample	Forced aged sample
Acidity	3.4	3.4	2.9
Sweetness	1.7	1.7	2.1
Ratio	3.1	2.4	2.4
Malty aroma	2.4	2.1	2.5
Honeylike aroma	3.0	2.3	2.4
Fruity aroma	1.3	1.1	0.9
Malty flavour	2.1	2.1	2.1
Honeylike flavour	2.5	2.2	2.3
Fruity flavour	1.0	1.3	0.9
Astringency	1.6	1.5	1.2
Freshness	2.3	2.4	1.8
Oxidation	0	1.0	1.5
Stale flavor	1.1	1.4	2.1

TABLE III			
Tasting results of the grapefruit beverage			
Attribute	Fresh sample	Pasteurised sample	Forced aged sample
Acidity	3.2	3.3	3.3
Sweetness	1.8	1.9	1.8
Ratio	2.8	2.4	1.9
Malty aroma	0.3	0.4	0.7
Honeylike aroma	0.8	1.1	1.2
Fruity aroma	3.3	2.9	2.2
Malty flavour	0.3	0.4	0.9
Honeylike flavour	0.8	0.9	1.1
Fruity flavour	2.1	2.5	2.3
Astringency	2.1	1.9	1.9
Freshness	2.4	1.6	1.1
Oxidation	0.2	0.4	0.8
Stale flavor	1.2	1.4	1.9

TABLE IV			
Tasting results of the peach drink			
Attribute	Fresh sample	Pasteurised sample	Forced aged sample
Acidity	2.1	2.3	2.8
Sweetness	3.2	2.7	2.3
Ratio	3.4	3.4	3.2
Malty aroma	0.6	0.9	1.4
Honeylike aroma	1.6	1.7	1.6
Fruity aroma	3.9	3.3	2.8
Malty flavour	0.8	0.9	1.0
Honeylike flavour	1.7	1.4	1.4
Fruity flavour	3.4	3.3	2.3
Astringency	0.6	0.7	1.3
Freshness	2.3	2.2	2.1
Oxidation	0.1	0.6	1.2
Stale flavor	1.1	1.4	1.8

Pasteurisation and ageing had no significant influence on the flavour of the grapefruit drink. The refreshing abilities of this beverage decreased. The peach flavour was not affected through the pasteurisation process but significant losses occurred during ageing. The refreshing ability of the peach drink was not affected by time and temperature.

Aroma analysis

The results of the GC analysis are shown in **Tables V-VII**. **Table VIII** shows the values for a commercial lager beer from Germany.

TABLE V			
Stale aroma compounds in the fermented wort			
Stale aroma compound [$\mu\text{g/L}$]	Fresh sample	Pasteurised sample	Forced aged sample
2-methylbutanal	14	19	27
3-methylbutanal	23	26	48
2-furfural	235	315	698
benzaldehyde	11	13	20
2-phenylethanal	24	45	81
phenylacetaldehyd	0.0	2.5	0.0
γ -nonalactone	3.7	2.4	3.6

TABLE VI			
Stale aroma compounds in the grapefruit drink			
Stale aroma compound [$\mu\text{g/L}$]	Fresh sample	Pasteurised sample	Forced aged sample
2-methylbutanal	4.0	5.9	6.7
3-methylbutanal	4.3	6.3	7.1
2-furfural	270	349	550
benzaldehyde	4.9	6.6	5.7
2-phenylethanal	7.1	12.0	13.0
phenylacetaldehyd	7.8	7.9	8.0
γ -nonalactone	2.0	2.6	1.5

TABLE VII			
Stale aroma compounds in the peach drink			
Stale aroma compound [$\mu\text{g/L}$]	Fresh sample	Pasteurised sample	Forced aged sample
2-methylbutanal	5.9	7.5	11.0
3-methylbutanal	1.6	2.9	2.2
2-furfural	166	335	626
benzaldehyde	56	70	73
2-phenylethanal	3.1	4.9	3.1
phenylacetaldehyd	13	12	11
γ -nonalactone	2.8	2.6	3.0

TABLE VIII		
Stale aroma compounds in beer samples		
Stale aroma compound [$\mu\text{g/L}$]	Fresh sample	Forced aged sample
2-methylbutanal	not evaluable	not evaluable
3-methylbutanal	6.4	12
2-furfural	n.e.	101
benzaldehyde	1.1	1.3
2-phenylethanal	6.3	13
phenylacetaldehyd	1.6	1.8
γ -nonalactone	26	37

The data shows that the well-known analysis established for beer is suitable for novel malt-based beverages. If the tables are compared with each other it can be concluded that each fruit adjunct has its own characteristic aroma compounds. High amounts of benzaldehyde (almond like aroma and flavour) can be found in peach. Grapefruit on the other hand shows high levels of 2-furfural (almond like, fruity). Phenylacetaldehyd (honey like) is a flavour compound that was found in all analysed fruit components but not in the fermented wort. The highest levels of phenylacetaldehyd (800µg/L) were found in pineapple juice.

CONCLUSION

This work shows a possible approach for the production of a novel malt-based beverage. Sensory evaluation and GC analysis to describe aroma and flavour stability of these drinks have been presented. Alternative drinks based on malted cereals and pseudocereals offer the opportunity to increase brewery plant utilisation. For the health-conscious consumer such innovative natural products are of great interest and offer a huge potential in the future.

ACKNOWLEDGEMENT

This work was supported by the Fond InBev-Baillet Latour.

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