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Sensory quality evaluation of whey-based beverages

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Summary

Whey as a by-product of the cheese industry is a source of biological and functional valuable proteins. The aim of this research was to evaluate the commercial potential of whey-based dairy beverages containing a definite amount of semi-skimmed milk addition. The purpose of this paper was to improve the whey flavour via its fermentation by commercial yogurt starter cultures, and via 25 % and 50 % of milk addition. The course of fermentation was monitored by pH and titratable acidity changes. The sensory profile of non-fermented and fermented drinks was assessed using unstructured graphical scales. No significant differences in acidity were found between the samples which were fermented for 3 or 4 hours, but a significant difference was found between samples of whey drinks without milk and samples with milk addition. Fermentation by yoghurt culture did not bring statistically significant improvement of the whey drink organoleptic properties, while the addition of milk was the most important factor influencing not only the total sensory quality of the whey drinks but also their flavour, appearance, colour, viscosity and homogeneity.

Key words: whey drinks, fermentation, yoghurt starter culture, acidity, sensory analysis

Introduction

Whey is a by-product of the cheese industry which was often disposed as waste in the past, causing high environmental contamination. Considerable efforts have been made over the past years to find new outlets for whey utilization and to reduce environmental pollution (González-Martínez et al., 2002; Douaud, 2007; Jeličić et al., 2008). Whey and its protein concentrates are used as ingredients in the food industry mainly due to their foaming and emulsifying properties (Hall and Iglesias, 1997; Ji and Hauque, 2003; Jovanović et al., 2005) and nutritional and biological attributes (Mistry et al., 1996; Smithers et al., 1996; Kenny et al., 2001; Carunchia Whetstine et al., 2005; Herceg et al., 2008; Akpinar-Bayizit et al., 2009). The main biological activities of whey proteins are suggested to include cancer prevention, increase of glutathione levels, antimicrobial function and increase of satiety response (Valli and Trail, 2005; Madureira et al., 2007).

There has been recently a widespread increase in consumption of lactic beverages, such as drinking yoghurt, fermented milk products and milk-like drinks of which whey-based beverages constitute an emerging segment of non-conventional dairy products. These products require sensory, physical and chemical characterization for quality control and product development (Gallardo-Escamilla et al., 2007). From the consumer's point of view, lactic beverages should be, visually and in textural terms, as homogeneous as milk. Texture and mouthfeel are

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often matched to those found in traditional equivalents in this type of products, (Jack et al., 1995). Due to the low total solid content of liquid whey (approximately 6 %, by weight), the mouthfeel of whey-based beverages is poor and watery in comparison with fermented milk, thus requiring either the use of exopolysaccharide-producing starter cultures or the addition of hydrocolloids (Ryder, 1980; Sienkiewicz and Riedel, 1990). Whey has also an unappealing taste, a relatively high lactose-glucose ratio and excessive acidity, especially if is acid whey. Therefore numerous procedures have been developed for improving its characteristics aiming to enable its direct utilization in human nutrition (Djurić et al., 2004). Manufacture of beverages through lactic fermentation can provide desirable sensory profiles and has already been considered an option to add value to whey (Salminen et al., 1991; Skudra et al., 1998; Pescuma et al., 2008). Whey fermentation by lactic acid bacteria (LAB) could decrease the high lactose content in whey, producing mainly lactic acid and other metabolites such as aroma compounds contributing to the flavour and texture and increasing carbohydrate solubility and sweetness of the end product (Mauriello et al., 2001). Fermented dairy products have a positive health image, which can be further enhanced by the addition of probiotic bacteria with therapeutic properties (Lourens-Hattingh and Viljoen, 2001). A few LAB species such as *Lactobacillus delbrüeckii* subsp. *bulgaricus* and *Streptococcus thermophilus* have been studied recently for their ability to degrade whey proteins in milk products (Morr and Foegeding, 1990; Bertrand-Harb et al., 2003).

The liquid whey was often used as a domestic animal feed because of its pure organoleptic properties. Due to the increasing interest in whey-based beverages, the high nutritional value of whey and the lack of data in the literature about fermented whey drinks with milk addition, the aim of this research was to improve the whey flavour via its fermentation and via milk addition. The scientific hypothesis was that organoleptic properties of whey are positively affected by its fermentation, by the time of fermentation and by the milk addition.

Materials and methods

The basic component of the whey drink blends was whey prepared in the laboratory from commercially available sweet cheese whey powder (Whey powder; proteins min. 11 %, fat max. 1 %, lactose min. 69.5 %; produced by Moravia Lacto a. s., Czech Rep.). Whey was reconstituted with distilled water to 10 % (w/v) final concentration in the ratio of 1:10 and the pH was 6.4. Some samples of reconstituted whey (RW) were mixed with pasteurised semi-skimmed milk obtained from the market (Semi-skimmed fresh milk; proteins 3.2 g/100 mL, lactose 4.6 g/100 mL, fat 1.5 g/100 mL, calcium 120 mg/100 mL; produced by Madeta a. s., Czech Rep.) in the rate of 25 % and 50 % of milk. All of these blends were heat treated at 80 °C for 15 min. One third of evaluated samples were without fermentation, second third of blends were fermented for 3 hours using the yoghurt starter culture and the last third of whey drinks were fermented by the same culture for 4 hours. Samples for fermentation were inoculated under aseptic conditions by the yoghurt thermophilic lactic acid bacteria starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrüeckii* subsp. *bulgaricus*. The yoghurt culture (Yoghurt Dried Culture) was purchased from Milcom a.s. Laktoflora®. It meets the fermented milk products requirement of 10^6 microorganisms per 1 g in the final product. This culture was chosen because it is widely used for fermented drink yoghurt beverages production. It also gives the final product desirable pleasant organoleptic properties via its hetero-fermentative way of fermentation. Samples of whey, whey with 25 % of milk and whey with 50 % of milk with yoghurt culture (inoculum 1 %) were incubated at 43 °C. After fermentation, the samples were cooled down to 4-6 °C. Heat treated samples without fermentation were directly stored at 4-6 °C. This way prepared whey drink blends were evaluated for their acidity and organoleptic properties. True acidity pH values were determined using a digital pH meter (pH 114, Snail Instruments), titratable acidity was measured by the titration method (ČSN 57 0529) using a standard solution of 0.25M sodium hydroxide and expressed in Soxhlet-Henkel units.

Table 1. Descriptors evaluated in sensory analysis and their scale orientation

Descriptor	Scale orientation	
	0 %	100 %
Appearance	very bad	excellent
Colour	rejectable	very pleasant
Odour	rejectable	very pleasant
Consistency	rejectable	very pleasant
Viscosity	very thin	very thick
Homogeneity	heterogeneous	homogeneous
Flavour	rejectable	very pleasant
Total quality	rejectable	very pleasant

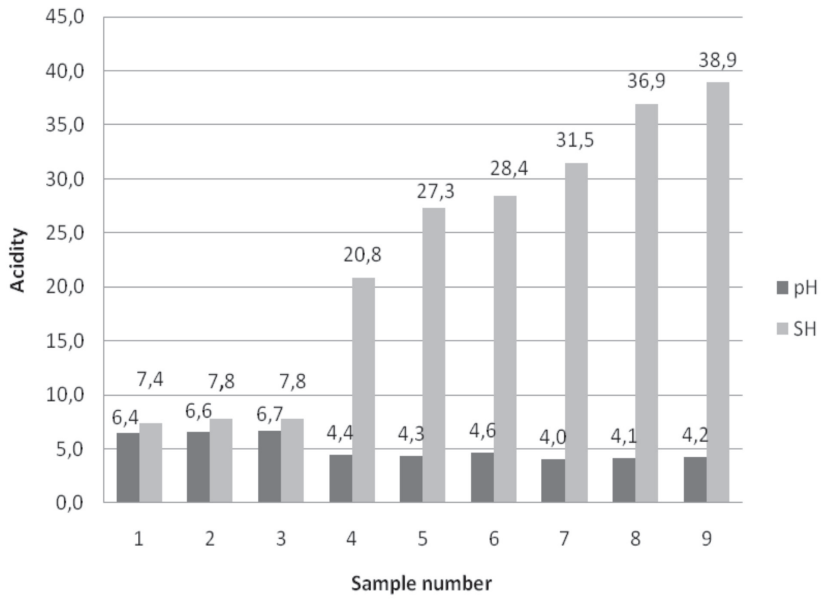
Table 2. Composition and fermentation conditions of whey drink blends

Sample number	Whey drink blend composition		Fermentation
	Whey (%)	Milk (%)	Time (h)
1	100	0	0
2	75	25	0
3	50	50	0
4	100	0	3
5	75	25	3
6	50	50	3
7	100	0	4
8	75	25	4
9	50	50	4

Table 3. Sensory profile results (in %) from whey drink samples evaluation

Descriptor	Sample number								
	1	2	3	4	5	6	7	8	9
Appearance	28±25	59±17	74±13	30±14	67±15	73±18	34±15	64±18	72±17
Colour	27±22	64±18	74±17	24±13	71±14	79±16	33±19	66±17	81±13
Odour	35±24	52±20	59±21	41±24	59±18	65±20	44±22	60±18	66±20
Consistency	35±27	60±21	68±17	42±25	59±23	66±26	44±20	59±19	71±18
Viscosity	14±10	36±18	43±24	19±15	45±19	61±18	19±14	41±18	62±25
Homogeneity	61±29	73±18	79±16	56±29	74±16	76±21	65±25	69±20	78±14
Flavour	37±27	60±22	76±17	18±12	36±20	58±20	32±21	52±25	68±21
Total quality	34±28	58±20	68±17	33±13	59±18	68±23	39±21	59±22	71±22

Scale orientation is given in Table 1; Sample numbers are according to Table 3



*Sample numbers are according to the Table 3

Figure 1. Acidity of whey drink samples

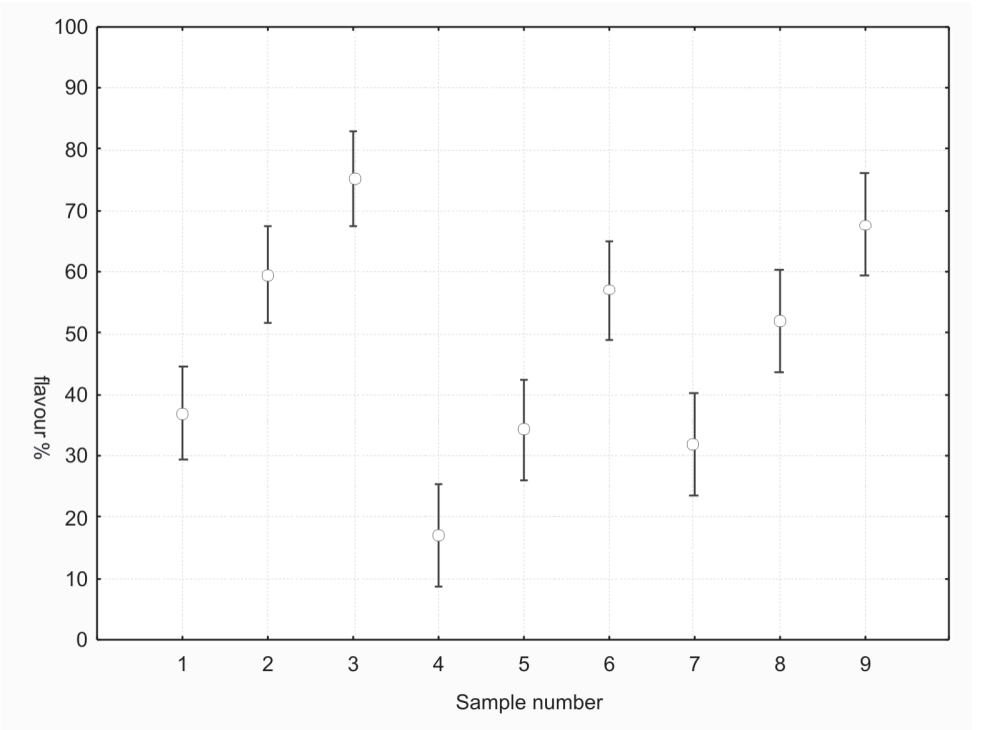
The sensory profile of the samples was evaluated after 1 day of cold stabilisation by the panel of 15 trained assessors (ISO 22935-1, ISO 8586-1) using a linear, graphical, unstructured, orientated scale (ISO 13299, ISO 6658, ISO 6564). The evaluated descriptors were selected according to the most frequent descriptors used for these kinds of food from the literature (Vojnović et al., 1993; Gallardo-Escamilla et al., 2005; Gallardo-Escamilla et al., 2007). Their list and the scales orientation are given in table I. All samples were coded using three-digit, randomly generated numbers and served cooled at 4 to 6 °C. The composition and fermentation conditions of nine evaluated samples are in table II. Sensory analysis of the whey drink samples was repeated three times (with three times whey based samples production).

The results were submitted to analysis of variance (F-test) and the means were compared using the Tukey test at the 95 % or 99 % level of significance ($a = 0.05$ or 0.01) using the software package Statistica for Windows version 8 (StatSoft Inc.). To determine correlation coefficients (r) between the data P-values <0.05 were regarded as statistically significant. Correlations were described as a weak ($|r| < 0.3$), moderate ($|r| = 0.3$ to 0.7) and strong ($|r| > 0.7$) (Elifson et al., 1990).

Results and discussion

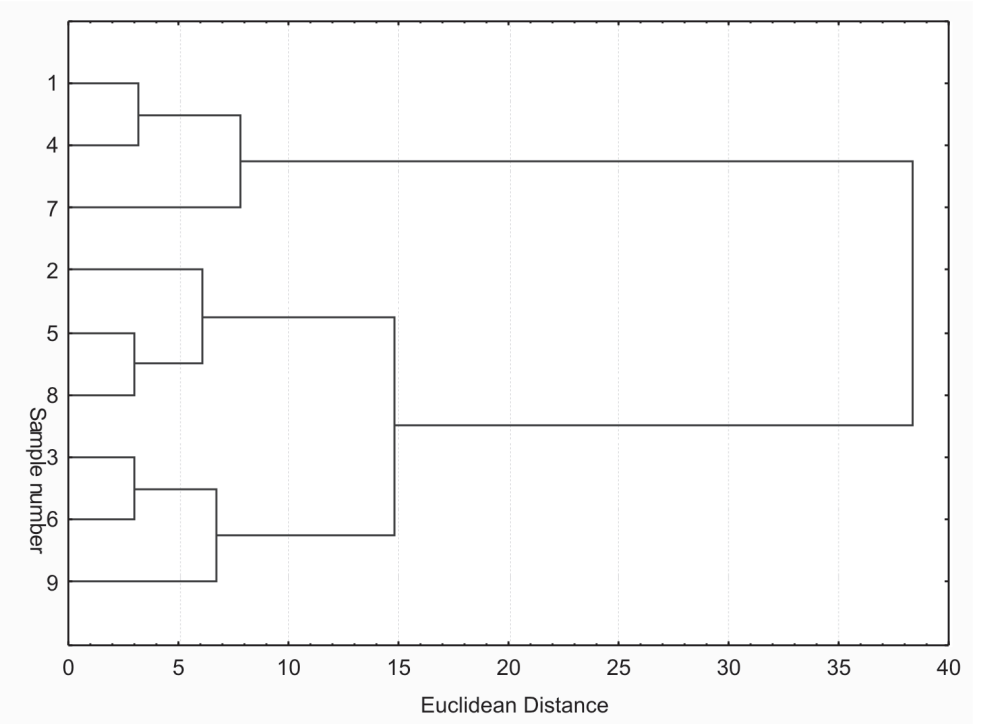
Results of the pH values and titratable acidity of the whey drink blends are presented in Figure 1. The pH value of non-fermented samples without the milk addition was 6.4 and titratable acidity of these samples was 7.4 SH on average. The pH values and titratable acidity of samples slightly changed after the addition of semi-skimmed milk. Due to the metabolic activity of LAB on proteins, sugars and lipids there were statistically significant differences in acidity between non-fermented and fermented samples ($p<0.01$). LAB contribute to food digestibility and preservation as well as the improvement of texture and sensory profile of the end product (Wood, 1997).

No significant differences ($p>0.05$) in acidity were found between the samples which were fermented 3 or 4 hours under the conditions of the method. This fermentation time corresponds with the recommended time for the used thermophilic culture (3-4 hours). On the other hand, a significant difference was found between samples of whey drinks without milk, samples with 25 % of milk ($p=0.025$) and samples with 50 % of milk ($p=0.032$).



*Sample numbers are according to the Table 2

Figure 2. Flavour of tested whey drink samples



*Sample numbers are according to the Table 2

Figure 3. Euclidean distance of whey drink samples according to the total quality

Comparing the acidity of the final product in relation to the milk addition, the lowest titratable acidity had samples without milk addition, followed by samples with 25 % of milk, and samples with 50 % of milk (Figure 1). It can be seen that milk addition accelerated the fermentation process of the whey drink based samples.

Results of the eight most important and variable organoleptic properties are presented in Table III. Values in Table 3 are expressed as average ± standard deviation. The total quality was considered as the most important characteristic of whey drink product where flavour has the main impact. There were statistically significant differences in flavour between the samples without and with milk addition as well as between the samples with 25 % and 50 % of milk (all p values were less than 0.001). The maximum value (the most pleasant sample) was reached by non-fermented drink No. 3 which contained 50 % of milk. The lowest score had sample No. 4, fermented for 3 hours without milk addition (Figure 2).

Using cluster analysis (Figure 3), the samples separated into three statistically significant different groups ($p<0.001$) according to their total quality (Euclidean distance 10). Group A contained samples without milk addition (No. 1, 4 and 7), group B included samples with 25 % of milk (No. 2, 5 and 8) and group C contained samples with 50 % of milk (No. 3, 6 and 9). Group C had the best total quality score while group A had the worst sensory evaluation. Despite that, the production of functional beverages via whey fermentation by lactic acid bacteria is an interesting utilization of whey (Pescuma et al., 2008). On the basis of these results it can be deduced that the effect of fermentation is not as important on the whey drink quality as the effect of milk addition. The more milk was added to the whey, the more statistically significant were the sensory analysis scores.

All the samples (non-fermented as well as fermented samples) were prepared under the same conditions and were treated at the same pasteurisation temperature. The low sensory score of pure whey-based samples (without milk addition) was probably mainly because of their watery and poor flavour. This could be affected by total solids and the fat content of liquid whey which is lower then in the case of milk. The addition of milk therefore positively contributed to the better taste, aroma and consistency of the samples.

Calculating the correlations of all monitored sensory characteristics statistically significant correlations were observed between the total quality of the whey drinks and appearance ($r=0.80$), flavour ($r=0.99$), colour ($r=0.79$), odour ($r=0.69$), consistency ($r=0.82$), viscosity ($r=0.69$) and homogeneity ($r=0.86$). The addition of milk affected appearance of the whey drinks. Samples without the milk had more unpleasant odours, worse flavours and appearance comparing to the samples with milk. Due to the opaque white colour of milk, its creamy consistency and higher content of total solids, mainly fat, the milk portion reasonably masked the whey off-flavour as well as its typical yellowish-green colour caused by the presence of vitamin B_2.

National consumer preferences could also play an important role in sensory analysis. There are not too many whey-based drink products in the Czech market and there is no tradition of drinking whey and whey-based beverages in the Czech Republic. These products are more widely available and accepted by people in countries such as Germany, Austria, and Switzerland where there is a longer tradition of whey consumption.

Conclusions

On the basis of the results it may be concluded that fermentation by yoghurt culture significantly affected the acidity of whey drink samples. According to the analysis of variance (F-test) it did not bring statistically significant ($p>0.05$) improvement of the whey-based beverages organoleptic properties because there were no significant differences in sensory properties between fermented and non-fermented samples. The addition of milk was the most important factor influencing not only the total quality of the whey drinks but also their flavour, appearance, colour, viscosity and homogeneity.

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Senzorska procjena kvalitete napitaka na bazi sirutke

Sažetak

Sirutka kao nusproizvod industrije sira izvor je biološki i funkcionalno vrijednih proteina. Cilj ovog istraživanja bio je procijeniti komercijalni potencijal napitaka na bazi sirutke koji sadrže određeni dodatak djelomično obranog mlijeka, odnosno poboljšati okus sirutke fermentacijom s komercijalnim jogurtnim starter kulturama, te dodatkom 25 % i 50 % mlijeka. Tijek fermentacije praćen je promjenom pH i titracijske kiselosti. Senzorski profil nefermentiranih i fermentiranih napitaka procijenjen je pomoću nestrukturirane grafičke skale. Nije bilo značajnih razlika u kiselosti između uzoraka koji su fermentirani 3 ili 4 sata, ali je utvrđena značajna razlika između uzoraka sirutke bez i s dodatkom mlijeka. Fermentacija s jogurtnim kulturama nije donijela statistički značajno poboljšanje organoleptičkih svojstava napitaka na bazi sirutke, a dodavanje mlijeka bio je najvažniji čimbenik koji je utjecao ne samo na ukupnu senzorsku kvalitetu sirutkinih napitaka, već i na njihov okus, izgled, boju, viskoznost i homogenost.

Ključne riječi: napici na bazi sirutke, fermentacija, jogurtna starter kultura, kiselost, senzorska analiza

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