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EVALUATION OF SELECTED PHYSICAL, CHEMICAL AND MICROBIOLOGICAL INDICATORS OF DRINKING WATER QUALITY USED IN THE BREWERY

[1]Veszelits Lakticová K., [1]Vargová M., [1]Sasáková N. and [2*]Zigo F.

[1]Department of the Public Veterinary Medicine and Animal Welfare, University of Veterinary Medicine and Pharmacy, Košice, Slovakia.

[2]Department of Animal Nutrition and Husbandry, University of Veterinary Medicine and Pharmacy, Košice, Slovakia.

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***Corresponding Author**
Zigo F.
Department of Animal Nutrition and Husbandry, University of Veterinary Medicine andPharmacy, Košice, Slovakia.

ABSTRACT

All food production sectors are characterized by specific risks that can endargen product quality. It is no different in brewing. In recent years, we have witnessed increased beer production and consumption. The popularity of this drink therefore places increasing demands on its quality. In brewing, water is one of the most important raw materials, because it directly affects the quality of beer and at the same time consumes the most of all raw materials. The water that comes into contact with the ingredients needed for beer production must be hygienically and bacteriologically safe. Many breweries underestimate water as a raw material and do not pay enough attention to its quality. Beer contains up to 95 % water, so it is very important that its properties meet the requirements for drinking water. Water in the operation of the brewery as one of the main raw materials is subject to strict controls from a chemical and hygienic point of view. In addition to the purity of beer, hardness, acidity and salt content in water also play an important role in beer production. All these attributes have a great influence on the final taste of the beer. Beer water should generally not contain alkali carbonates, chlorine, too much iron, manganese and nitrates. In our work, we evaluated the quality of water used in beer production based on physical, chemical and microbiological indicators in one of the monitored breweries. The obtained values from investigation of selected physical and chemical indicators of all examined drinking water samples correspond to all limits and maximum accepted limits in accordance with the Decree of the Ministry of Health of the

Slovak Republic No. 247/2017 Coll. Microbiological examination of the tested all drinking water samples showed that the quality is of a high level, because no microorganisms were detected during the monitoring, which would prove the presence of fecal contamination. The obtained results showed that the investigated water in beer production does not pose any risk to the quality of beer and the safety of its consumers, as well as meets the requirements for drinking water in the monitored brewery.

KEYWORDS: physical indicatiors, chemical indicators, microbiological indicators, drinking water, brewery.

INTRODUCTION

The food industry has high requirements for water quality from a microbiological point of view as well as its mineral composition.[1]

Nitrite, phenols, phosphates, ammonia, ammonium ions and sulphate must not be present in the water intended for the production of beverages. A higher content of iron and manganese in the water is also undesirable. The total water hardness should be in the range. The water used to make beer (wort) must be of drinking water quality. If the brewery uses its own water sources (from boreholes close to surface sources), it is necessary to treat it.

Beer is one of the most consumed beverages in the world and therefore it is becoming popular.[2]

The rich history of beer and brewing points to the great importance of drinking water quality as a raw material. People already knew at the time that the basis of good beer is quality, healthy and hygienically harmless drinking water.[3]

The basic raw materials for beer production are water, malt and hops.[4]

Water is the basic component of beer and significantly affects the taste of the final product. A large amount of water is consumed in the brewing industry[5], this consumption is one of the largest in the food industry.[6,7]

The WHO handbook states that most water-related health problems are the result of microbial contamination, but a significant number of serious health problems can also be caused by chemical contamination of drinking water.[8]

Smaller breweries use their own wells. The larger ones take water from public distribution systems and then adjust it as needed.

In medium-sized and large beer production plants, water is used from the public water supply, where its quality must be regularly monitored and the results of the evaluated indicators must comply with the set limits and maximum acceptable limits according to the Decree of the Ministry of Health of the Slovak Republic No. 247/2017 Coll.[9]

In beer production, the emphasis is currently on the durability and sensory stability of beer. It is stated that it is very difficult to achieve the stability of the internal state of food and also its unlimited durability in relation to the sensitivity of food products to the external environment.[10]

The work is focused on the evaluation of physical, chemical and microbiological indicators of drinking water quality used in brewery.

MATERIAL AND METHOD

The monitored and evaluated brewery belongs to the group of large plant (Figure 1, 2). The quality of the water used by the brewery to produce beer was assessed.

Figure 1: Beer brewing.

Figure 2: Bottle line.

Sterile glasses bottles (Figure 3) were used for the microbiological examination of the water, which is used for beer production in the evaluated plant, and clean sample boxes for the physical and chemical examination.

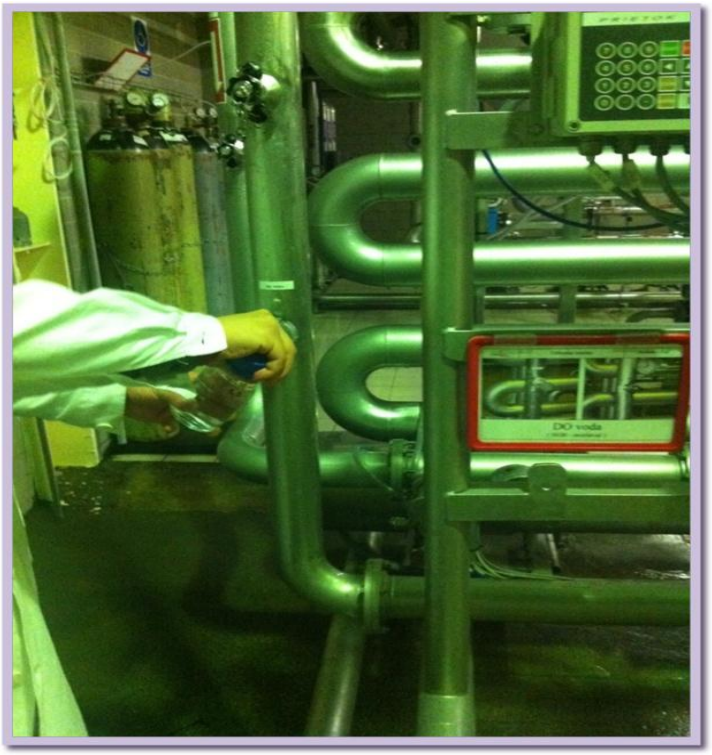

Figure 3: Water collection for microbiological examination.

In the evaluated brewery, they used drinking water to produce beer from a public water supply. The quality of this type of drinking water supply must be regularly monitored. Selected physical, chemical and microbiological indicators of examined water samples were determined in laboratory conditions (mash water, sparging water, degassing water). Mash water is used in process of beer making when malt is mixed with boiling water at a temperature of 40-50 °C. Sparging water is obtained by draining from the process of mixing malt with hot water. Degassing of liquids is required to reduce microbial growth and increase food usability.

The water used in the production of beer must have the character of drinking water. The health safety of drinking water is assessed and checked according to indicators of drinking water quality and their hygienic limits. Health-safe drinking water must meet the limits of drinking water quality indicators.

Selected physical and chemical indicators were determined according to the in the laboratory before microbiological examination. The odor of the drinking water sample was sensory checked and turbidity and coloration were visually assessed. The result of sensory tests was described verbally, while the evaluation scale was respected.

From the point of view of chemical examination of water, pH, nitrates, phosphates, chlorides, calcium and magnesium, iron, COD_{Mn} were determined in drinking water. Quantitative testing was performed in samples in which a qualitative test indicated the presence of these substances. The water was examined according to valid STN standards. The evaluation of microbiological indicators is important from the point of view of human and animal health.

From microbiological indicators, cultivable microorganisms at 22 ºC (CM22), cultivable microorganisms at 36 ºC (CM36), coliform bacteria and fecal coliform microorganisms were evaluated. The number of cultivable microorganisms was determined according to STN EN ISO 6222[11] by the pouring method in a 1 ml sample and by counting the colonies of the microorganisms after culturing on masopeptone agar at 22 °C for 72 hours and 36 °C after 48 hours. Coliform bacteria and *E. coli* were determined according to STN ISO 9308-1[12], a membrane filtration method after culturing on Endo Agar at 36 ° C and 43 °C for 24 hours. 100 ml of the examined water was used for filtration (public water supply). The results of the analyzed water are the average values from five analyzes of samples of the examined water.

RESULTS AND DISCUSSION

Table 1 presents selected physical indicators of the examined water, which was used for the production of beer in the brewery. The obtained results correspond to the limits in accordance with the Decree of the Ministry of Health of the Slovak Republic No. 247/2017 Coll.[9]

Table 1: Evaluated physical indicators of the investigated water.

Indicators	Mash water	Sparging water	Degassed water	Limit
Water reaction (pH)	7.15	7.22	6.0	6.5 – 9.5
Colour	5	5	5	20 mg/l
Turbidity	0.5	0.5	0.5	5 FNU (formzine unit)
Smell	Odorless	Odorless	Odorless	Odorless
Conductivity	1.02	1.0	1.5	125 mS/m

In the brewery, water is of great importance and influence on the quality of the final product.[13] The determination of microbiological indicators of drinking water is one of the basic criteria for water assessment. It is important for drinking water that it does not contain any pathogenic germs and that they do not enter the water source. Bacteriological findings are the best indicator of direct and indirect faecal contamination. Serious epidemics can also arise from ingesting water in which unwanted microflora has multiplied.

The results of the chemical examination of water are shown in table 2. Obtained values of the monitored chemical parameters corresponded to the limits for individual evaluated indicators as well as to the maximum acceptable limit for nitrates (50 mg/l) in accordance with the Decree of the Ministry of Health of the Slovak No. 247/2017 Coll.[9]

Water must meet physical as well as chemical and microbiological criteria.[14]

The iron was determined qualitatively in the examined water samples and the presence of iron was evaluated as negative.

Table 2: Evaluated chemical indicators of the investigated water.

Indicators	Mash water	Sparging water	Degassed water	Limit
COD_{MN}	0.12	0.2	0.12	3 mg/l
Nitrates	4.0	2.0	3.0	50 mg/l
Chlorides	11.0	9.0	10.0	250 mg/l
Calcium and	2.4	2.05	2.6	1.1 – 5 mmol/l

magnesium				
Iron	Negative	Negative	Negative	0.2 mg/l

In table 3 shows the microbiological results of the investigated water. In the case of drinking water mass supply, the limit for coliform microorganisms is 0 CFU/100 ml of and the maximum acceptable limit for *E.coli* is 0 CFU/100 ml. The microbiological investigation of the source of drinking water showed that ist quality is at high level, because it was reported a zero colony forming units (CFU) of the coliform bacteria and *E. coli*. Other evaluated microbiological indicators meet the requirements for the quality of drinking water, and therefore the water does not pose a risk to the health of the consumer of the final product.

Table 3: Microbiological indicators of investigated water.

Microbiological indicators	Mash water	Sparging water	Degassed water	Limit
Escherichia coli	0	0	0	0 CFU/100 ml
Coliform bacteria	0	0	0	0 CFU/100 ml
Cultivable microorganisms at 22 ºC	3	1	50	200 CFU/1 ml
Cultivable microorganisms at 36°C	0	0	30	50 CFU/1 ml

CONCLUSION

Water in the food industry undergoes quality changes during the technological process, but these changes should never be to such an extent that the water does not meet the necessary limits of its use for the given purpose. In the evaluated brewery, they used water to produce beer from the public water supply, where its quality must be regularly monitored. Based on our results from individual evaluations of selected physical, chemical and microbiological indicators of water quality, it can be stated that the water met the requirements and criteria for drinking water according to the Decree of the Ministry of Health of the Slovak Republic No. 247/2017 Coll. and does not pose a risk to the health of the consumer of the final product.

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