TECHNOLOGICAL QUALITY OF BIOFERMENTED WHITE CABBAGE, CULTIVAR FUTOŠKI

Biljana Cvetković[1*], Željko Bardić[1], Marija Jokanović[2], Jasna Mastilović[1]

[1]Institute for Food Technology, Novi Sad, Serbia
[2]Faculty of Technology, Novi Sad

UDC 66.039.7 : 635.34 : 543.645

Abstract: *In our country Futog is a region well known for the most quality cabbage. White cabbage, cultivar Futoški, as raw material has been used like grosery for salads and thermally treated meals during most of the year. In the winter cabbage can be put on biofermentation process and storaged like so cold „sauerkraut" White Futog's cabbage was fermented on a traditional way, by setting the cabbage heads into the fermentors and adding 6% salt solution. Fermentation process was runing for a 28 days on 15-18 ^{0}C, when adequate sensory and chemical carasteristics of fermented Futog's cabbage were achieved. The objective of this paper was to determine the technological quality and special properties of fermented Futog's cabbage. Chemical properties of Futog`s cabbage quality were determinated and statistically analyzed.*

Key words: *White cabbage, fermentation, sugar content, technological quality*

INTRODUCTION

White cabbage is consumed both raw and processed in different ways, e.g. stewed or fermented. Fermented cabbage known as sauerkraut is very popular also in Germany and Austria as its name, originating from German language, implies. However, it is also frequently consumed in the United States, Canada, and Russia, especially throughout the winter period, as a properly performed process guarantees good quality of the product during storage (Barbara Kusznierewicz et al. 2008). Cruciferous vegetables, such as cabbage, are among the most important dietary vegetables consumed in Poland and other Central European countries owing to their availability at local markets, low cost and consumer preference. It is estimated that in Poland the annual cultivation of cabbage constitutes about 30% of the total production of ground vegetables (Polish Central Statistical Office, 2006). Cabbage is a cruciferous vegetable, which is rich in minerals, vitamin C, dietary fibers, folates and especially phytochemicals (Kyung Young Yoon et al., 2006, Jagerstad et al., 2004, Rodriguez et al. 2006). In our country Futog is well known region where the best quality cabbage is cultivated. Futog's white cabage as raw material has been used like grousery for sa-

*Corresponding author:
e-mail: biljana.cvetkovic@fins.uns.ac.rs
Tel: +381 21 485 3806: Fax: +381 21 450725

lads and thermally treated meals during most of the year. In the winter cabbage can be subnaitted to biofermentation process and storaged like so cold „sauerkraut“ (Niketić-Aleksić, 1988). Fermented cabbage received a certificate as a product with geographic origin. Biofermentation is carried out with NaCl adition in water solution and adequate temperature in fermentation tanks area. Like most vegetable fermentations, sauerkraut fermentation is spontaneous and relies on a very small population of lactic acid bacteria (LAB), which are naturally present on fresh vegetables, for presservation. It is known that a succession of various lactic acid bacteria species and their metabolic activities are responsible for the quality and safety of these products (Breidt Lu Z. et al, 2003). The bacteria in the LAB genera are classified by their cell morphology and the fermentation pathway used to ferment glucose. There are widespread, their natural habitats are many plants and are also a part of gastrointestinal microflora. These bacteria have been found in traditional fermented food and used in food fermentation controlled processes.They are important to the food industry because of their ability to transform fermentable sugars into lactic acid, ethanol and other metabolites, which changes the characteristics of the product by lowering the pH and creating unfavorable conditions for the growth of potentially pathogenic microorganisms in both food products and the human intestinal microflora. They are divided into homofermentative, which produce lactic acid as principal metabolite, and heterofermentative, which also produce ethanol and carbon dioxide. Some lactic acid bacteria strains isolated from fermented foods have been used as probiotics due to their resistance to host gastrointestinal conditions, adhesion to host intestinal epithelium and the prevention of the growth or invasion of pathogenic bacteria into the animal intestine. The most important LAB are *Leuconostoc, Lactobacillus, Streptocccus* and *Pediococcus* (Yadira Rivera-Espinoza et al., 2008).

MATERIALS AND METHODS

In the experiment cabbage of six different producers from Futog's region was used. Cabbage was cultivated and fermented during 2007. In raw cabbage, sugar content was determined (Bylaw, SFRJ, 29/1983). Sugar content was measured at three points: on the top, in the middle , and inside the cabbage head, whereas fermentation process started with salt diffusion from out of coatings to cabbage's root. Fermentation lasted out for 28 days on 15-18 ^{0}C, when adequate sensory and chemical caracteristics of fermented Futog's cabbage are achieved. Parameters of quality was determinated at three different points (3-rd, 20-th, 28-th day of fermentation). According to the national legislations parameters which regulates the quality of biofermented vegetables are (Bylaw, SFRJ no 1/79): Overall acidity expressed as lactic acid, content of NaCl, pH value, potasium-sorbate content, evaporative acids expressed as acetic acid. Vitamin C also was determinated in the biofermented cabbage. Each value was measured in duplicate and presented as meant standard deviation. Standard deviation and correlation coefficient were determinate by using Microsoft Excel. For measuring of linear conection between two factors was taken corelation coefficient (r). By r value linear conections are determinated like strong or weak: Correlation coefficient ≤ 0.50, weakly significant linear correlation Correlation coefficient between 0.50-0.70, significant linear correlation Correlation coefficient between 0.70-0.90, very significant linear correlation (Vukadinović, 1981).

RESULTS AND DISCUSSION

Futog's white cabbage is, firstly, intended for biofermentation, because sugar content is appropriate for fermentation. The sugar content is significant because fermentation process is based on transformation of fermentable sugars into lactic acid by the microorganisms. According the Niketić, 1988, sugar content in cabbage prepared for fermentation should be at least 3% (Niketić-Aleksić G., 1988). Sugar content of three spots of cabbage head is shown in Table 1.

The process of cabbage fermentation is spontaneous and it is characterized by an initial heterofermentative stage, followed by a homofermentative stage. Heterofermentative *Leuconostoc mesenteroides* initiates the fermentation and quickly predominates the early stage of the fermentation because it is presentat an initially higher number and has a shorter generation time at 18 °C (the typical temperature of sauerkraut fermen-

tation) than most other epiphytic lactic acid bacteria. The quality characteristics of sauerkraut are largely dependent on the growth of this species. Between 3 and 7 days after the start of the fermentation, heterofermentative *Leuconostoc* species are usually succeeded by the more acid-tolerant homofermentative *Lactobacillus* spe-cies, due to the accumulation of lactic acid to 1% (wt/vol) or more and the decrease in pH below 4.5. *Lactobacillus plantarum* com-pletes the fermentation, with a final pH of approximately 3.5.

Table 1.
Averaged sugar content with standard devitiation in different parts of cabbage head

Sugar content in different parts of cabbage (%)	**average**	**STD**
top of the cabbage	3,22	0,72
middle of cabbage	3,4	0,75
inside of cabbage	3,55	0,75

*Correlation coefficient (r) was used as a measure of linear relation between two factors

.

The correct sequence of LAB species is essential in achieving a stable product with the typical flavor and aroma of sauerkraut. It is generally thought that microbial succession is largely due to the initial microbial load on cabbage, salt and acid concentrations, pH, and temperature (Breidt Lu Z. et al, 2003). Anaerobic lactic acid microorganisms like *Lactobacillus plantarum*, *Lactobacillus brevis*, *Bacterium cucumeris fermentati*, *Leuconostoc mesenteroides*, *Streptococcus faecalis, and Pediococcus cerevisiae* also takes part in the fermentation.

Overall acidity, pH value, and salt content are important parameters for the control of fermentation process. In Table 2, those parameters are shown in three different periods of fermentation of Futog's cabbage.

Table 2.
Overall acidity expressed as lactic acid, pH value and salt content during fermentation

Fermentation time in days	**Overall acidity expressed as lactic acid (%)**	**pH**	**NaCl content (%)**
3rd	0,090	5,38	4,088
20th	0,675	3,57	3,430
28th	0,905	3,32	3,430

Acidity is a major factor for the quality of fermented cabbage and verification of fermentation tendency. In the begining the change in pH value shows if fermentation goes to adequate direction. In further, increased pH value prevens of the pathogenic microorganisms development. Usually pH value of fermented Futog`s cabbage ranges over 3.5-3.8. Salt content has relevance in the fermentation process. Results of all chemical quality parameters of Futog`s fermented cabbage are shown in Table 3. Correlation coefficients of chemical parameters of Futog`s cabbage are calculated and shown in table 4. Linear relation between salt content and overall acids is very significant (r=0.7636), and between salt content and vitamin C is significant (r=0.6883) (Table 4).

There is significant linear relation between overall acids content expressed as lactic acid and vitamin C content (r=0,5531). Salt content has influence on chemical composition of fermented cabbage which is consistent with the conclusions of Niketić-Aleksić (1988).

Table 3.
Results and averaged values with standard deviation of chemical quality parameters of Futog`s fermented cabbage

Chemical parameters	Producers						Average values for Futog's cabbage quality parameters
	A	B	C	D	E	F	
Salt content (%)	0.16	0.86	2.92	2.68	2.97	2.89	2.08 ± 1,13
Overall acidity expressed as lactic acid (%)	0.54	0.44	0.72	0.72	0.63	0.89	0.66 ± 0,14
Potasium-sorbate content (%)	-	-	0.11	-	-	-	0.11
pH value	4.21	3.79	3.68	3.92	4.10	3.66	3.89 ± 0,21
Vitamin C content (mg %)	7.11	8.13	9.65	18.30	13.21	12.70	11.52 ± 3,76

Table 4.
Correlation coefficients of chemical parameters of fermented Futog`s cabbage

Parameter	Salt content (%)	Overall acids content expressed as lactic acid (%)	pH value	Vitamin C content (mg %)
Salt content (%)		0,7636**	-0,4649	0,6883*
Overall acids content expressed as lactic acid (%)	0,7636**		-0,4866	0,5531*
pH value	-0,4649	-0,4866		-0,0845
Vitamin C content (mg %)	0,6883*	0,5531*	-0,0845	

* Significant linear relation
** Very significant linear relation

CONCLUSIONS

Based on theoretical knowledgement and examination of chemical parameters, Futog`s cabbage should comply the following conditions and values of chemical quality parameters: NaCl content between 1,5-3.5%, overall acids expressed as lactic acid between 0.5-2%, pH value gradually decreasing in the falling down slowly in initial stadium of fermentation riching pH 4. The only preservative which is allowed to be used in the fermented cabbage production is potasium-sorbate at maximum concen-

tration of 0.13%. Linear relation between the salt content and overall acids is very significiant. There is significant linear relation between overall acids content expressed as lactic acid and vitamin C content. Salt content has great influence on the fermentation and chemical composition of fermented cabbage.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support from the Ministry of Science and Technological Development of the Republic of Serbia (Project TP-20066).

REFERENCES

1. Kusznierewicz, B., Smiechowska, A., Bartoszek, A., Namiesnik, J. (2008). The effect of heating and fermenting on antioxidant properties of white cabbage, *Food Chemistry 108,* 853-861.
2. Breidt, Lu Z. F., Plengvidhya, V., Fleming, H.P. (2003). Bacteriophage Ecology in Commercial Sauerkraut Fermentations, *Applied and Environmental Microbiology 69,* 3192-3202.Bylaw of quality of fruits and vegetables pro-ducts and pectins preparations, “Službeni list SFRJ“ br. 1/1979, 20/1982 and 74/1990.
3. Bylaw of taking samples methods and chemical and physical analysis for quality control of fruit and vegetable products, “Službeni list SFRJ“ br. 29/83.
4. Jagerstad, M., Jastrebova, J., Svensson, U. (2004). Folates in fermentedvegetables—a pilot study, Lebensm., *Wiss. u.-Technol. 37* 603–611.
5. Kyung, Y. Y., Woodams, E., Hang, Y.D. (2006). Production of probiotic cabbage juice by lactic acid bacteria, *Bioresource Technology 97,* 1427–1430.
6. Niketić-Aleksić, G. (1988). Fruit and vegetable technology, Beograd, Naučna knjiga.
7. Rodriguez, R., Jimenez, A., Fernandez, J., Guillen, R., Heredia, A. (2006). Dietary fibre from vegetable products as source of functional ingredients, *Trends in Food Science & Technology 17*, 3-15.
8. Vukadinović, S. (1981). Elements of mathematical statistics and probability theory, Beograd, Privredni pregled.
9. Espinoza, Y.R. & Gallardo-Navarro, Y. (2008). Non-dairy probiotic products, *Food Microbiology doi:10.1016/*j.fm.
10. Yu-Ping Sun, Cheng-Chun Chou, Roch-Chui Yu. (2008). Antioxidant activity of lacticfermented Chinese cabbage, *Food Chemistry, doi: 10.1016/j.foodchem*.