J. Int. Environmental Application & Science, Vol. 12(3): 197-203 (2017)

Evaluation of the Quality of Albanian Beer 'Stela' Packed in Pet

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Received July 12, 2017; Accepted September 26, 2017

Abstract: The aim of our study is to evaluate the quality of the beer in PET based on a strict control of physical and chemical parameters. Moreover, our aim is to compare it with the beer packed in glass bottle. The work for this study was performed in a well-known beer company in our country and abroad, and shows us the real possibilities in producing beer in PET.
Keywords*: PET, polyethylene, tetrafolate, migration, movement, gases*

Introduction

The packing of food products considers several factors related to the food safety, the ease of production and usage, the looks, the costs of the packages, the compliance to the laws and to official standards in place, production devices, and the ways of recycling after it has been used. Chemistry engineering plays the main role in designing and selecting the packing. It studies the chemical properties and the kinetics of packing components, as well as their interaction with the products and with the external environment. Mechanical engineering serves to keep the devices that are used to produce the packages of food products under control. Physics and mathematics are related to the mass, size, and structure of the packing (Hanlon, 1971). The model, outer shape, colour, labelling of the packages, and its closure should be selected in such a way that it makes the product compelling to the consumer, who is the main quality evaluator. Beside the attractiveness of the package, its weight, shape, and product consistency are other important factors that must be considered to make the consumer happy.

Nowadays, recyclable products are being considered more often than not, because they serve the reduction of environment pollution and the re-usage of the materials. The packing of food products is the interface of the product to the consumer and it makes the first impression in the market. In the case of plastic bottles its attributes that are related to the usability (not breakable, light, and re-closable) make it very easily transportable and consumable. Before the producer chooses to bring to market a product in a plastic bottle, it is necessary that he understands the philosophy and the acceptability of the consumer. In the case of wine, or other traditional food products, there are barriers when it comes to the perception of the product image and of the product quality when plastic packing is used. However, the society is quickly developing, for example the European market of beer is consolidated and the customers have established their own customs for the products in the market. To define the critical quality parameters, the following must be observed:

1. Penetration capability of the plastic material (mainly penetration of O_2 and CO_2)
2. Sensorial properties (mainly the shelf life of the product and external scent)
3. Instrumental analysis
4. Mechanical properties of the PET bottle (strength, change of shape and size caused by temperature, etc.)
5. Statistical models of instrumental and sensorial data. Models are created to establish correlations between the data produced by the experiments.

PET bottles of beer have distinct advantages when it comes to usage, cost, and recycling. Plastic packing is ideal mainly for drinks that are not very sensitive to O_2. PET bottles are relatively cheap; their weight is 1/7 of the equivalent glass bottle, are not breakable and can be used for selling large quantities of liquids (1-5 kg) (Mc Graw Hill, Inc., 1994). The main drawback of a PET bottle is that it can be penetrated by O_2 and CO_2. This is not very important for liquids or PET bottled water as it does not impact them much, but it is quite critical for beer. Penetration of gases not only decreases the shelf time of the products, especially for beer, but it changes its sensorial parameters as well. However,

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during the last years many efforts have been made to minimize the effect of this disadvantage of packing.

Materials and Methods

We have analysed 100 cases of 1.5 l PET bottled beer, in the period March 2015 – June 2015, in the laboratory of physics and chemistry at Stela factory and in the laboratory of Food Chemistry and Technology in the Industrial Chemistry Department in the Faculty of Natural Sciences, University of Tirana. The objective was to study the quality of PET bottled beer. We used physical – chemical methods and analytical methods, as defined in the standard set of methods of the European Brewery Commission, approved by Codex Alimentarius (Europian Brewing Chemist 1992). First, we performed the check of all the physical and chemical parameters of the beer, during one month, stored in several different temperatures and in several types of packages. We chose the storing temperatures of 20, 30, and 40 ºC. We chose packing of brown, green, and colourless PET for our experiments. We measured the values of pH, CO_2, O_2, air, bitterness, turbulence, apparent extract, and colour. We performed weekly checks.

Results and Discussions

In Table 1 we show the physical-chemical parameters that we monitored in the conditions of temperature of 20, 30, and 40 ºC.

Table 1. Dependency of physical and chemical properties on time in temperatures 20, 30, and 40 ºC

Time/Days	**1**	**8**	**15**	**22**	**29**
pH	4.23	4.2	4.21	4.21	4.21
CO_2	0.61	0.5	0.47	0.44	0.42
O_2	0.13	0.086	0.058	0.05	0.044
Air	12	15	10.5	11.5	10.5
Bitterness	20.05	19.68	20.2	20.4	20
Turbulence	1.19	1.17	0.615	0.65	0.59
Ex ap.	2.3	2.3	2.3	2.3	2.3
Colour	8	8.7	9.93	10.55	11.05
					T = 40 ^{0}C
pH	4.23	4.24	4.24	4.23	4.23
CO_2	0.6	0.53	0.51	0.5	0.44
O_2	0.118	0.07	0.058	0.05	0.046
air	12	9.8	13	10.3	12
Bitterness	20	18.88	20	18.7	17.8
Turbulence	1.2	0.98	0.8	0.56	0.59
Ex ap.	2.35	2.35	2.35	2.35	2.35
Colour	8	9.2	9.8	10	10.7
					T = 30 ^{0}C
pH	4.23	4.25	4.16	4.21	4.25
CO_2	0.61	0.59	0.57	0.56	0.54
O_2	0.116	0.108	0.101	0.07	0.07
air	12	16	8	12.8	5.8
Bitterness	20.1	20.2	18.3	18.1	18.3
Turbulence	1.2	0.85	0.67	0.58	1.16
Ex ap.	2.35	2.35	2.35	2.35	2.35
Colour	7.45	7.85	7.55	7.78	8.1
		T = 20 ^{0}C			

The table above shows very low the variance of pH values, despite the time of measurement and storing temperature. This means that the beer is highly stable. Seven days later we noticed that in temperatures of 30 and 40 ºC the values of acidity became stable. This is an indicator of the high stability of the readymade product. The high temperature is the responsible parameter for the increase of the acidy. This was noticed when the beer was stored in high temperatures beyond the storing period. O_2 is a component of internal reactions and that is why more O_2 participates in enzymatic biochemical reactions and less participates in chemical reactions. The increasing of the temperature

favours the enzymatic reactions such as polyphenol oxidation. It is important to point out that we noticed that the amount of O_2 becomes lower for all the values of the temperature that were studied.

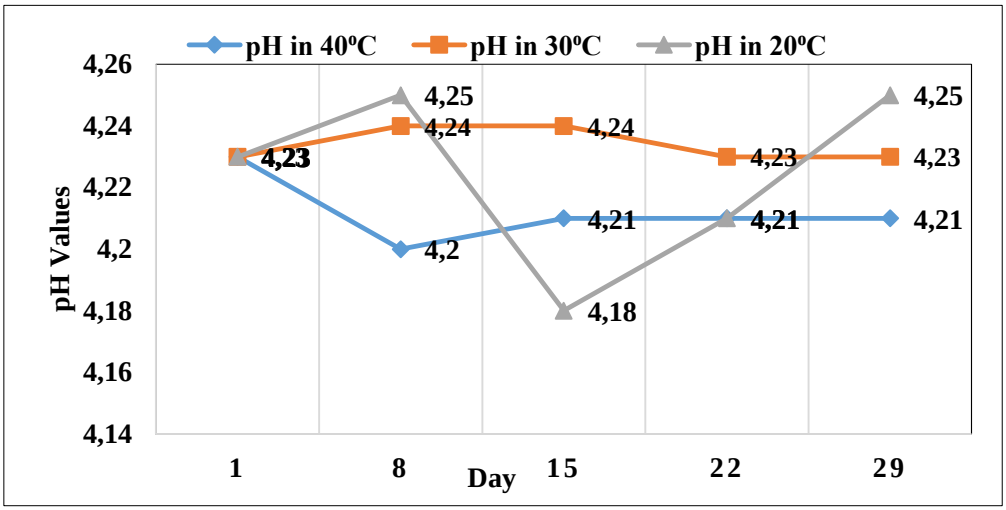

Figure 1. Dependency of pH on time

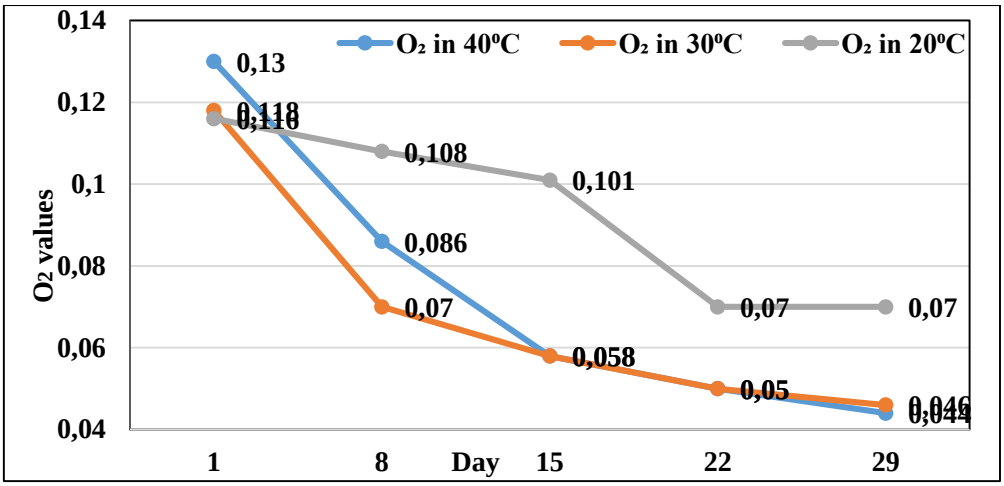

Figure 2. Dependency of O_2 on time

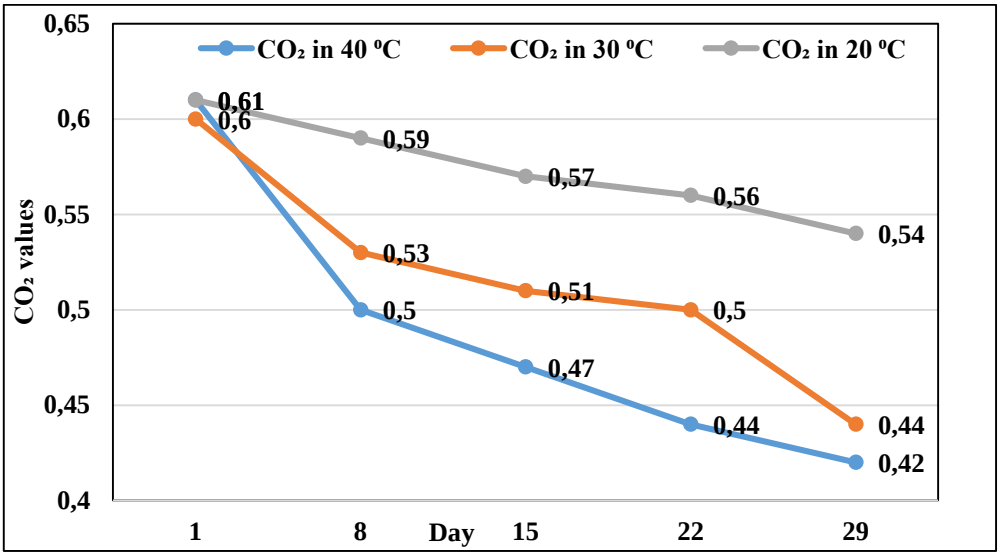

Figure 3. Dependency of CO_2 on time

The amount of CO_2 decreases slightly. The explanation for this slight decrease is mostly related to mechanics rather than to the chemical processes. The molecules of CO_2 migrate because of the intensification of their Brownian motion which is caused by the increase of the kinetic energy when the temperature is increased by 10 ºC. The results are shown in the graphics below.

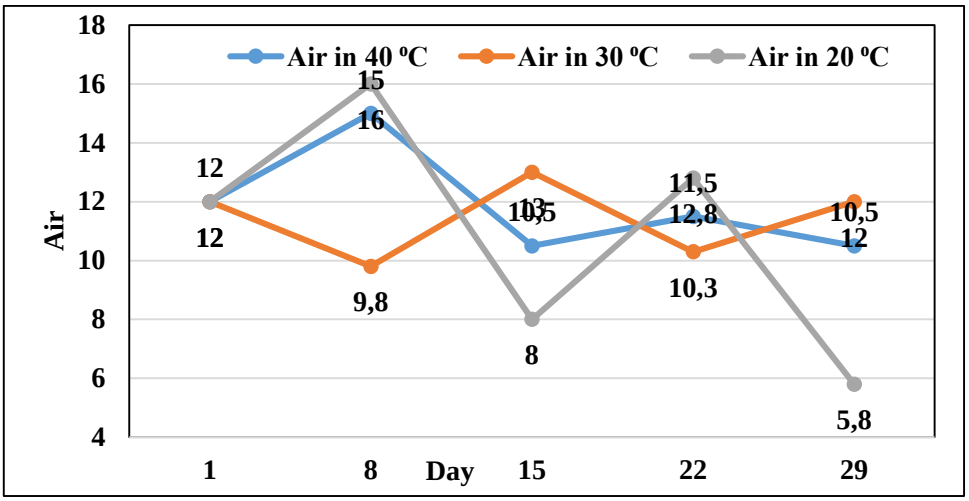

Figure 4. Dependency of air on time

The results we received on the dependency of air from time showed that we cannot come to definite conclusions, because the observed oscillations require an interpretation that is related also to the technological conditions.

The amount of bitter substances in the beginning and in the end of the observation period is almost the same. However, there have been noticed high amplitudes in the values. The time frame from day 20 to day 30 is considered suitable to build a detailed plan for controlling the amount of bitter substances. This is because there is no progress that can be easily interpreted theoretically. Variations are quite considerable, that is why this is a component of the experiment that needs further verifications. Bitterness can be discussed by referring to the results of the experiment shown in the graphic for temperature of 30 ºC in Figure 5.

We observed that the intensity of the turbulence decreases, and this is understandable because the turbulent substances of big molecular mass that are obtained by the oxidation of phenolic substances precipitate. Light increase of turbulence that was observed may be a coincidence or an experimental deviation. However, it must be clarified, mostly by analysing the random changes in the internal reactions. No changes in the turbulence are acceptable.

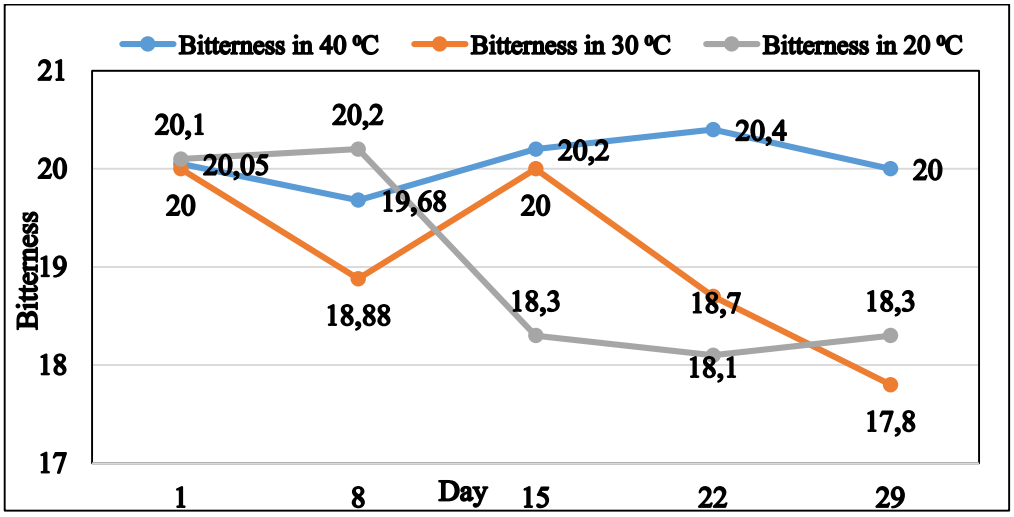

Figure 5. Dependency of bitterness on time

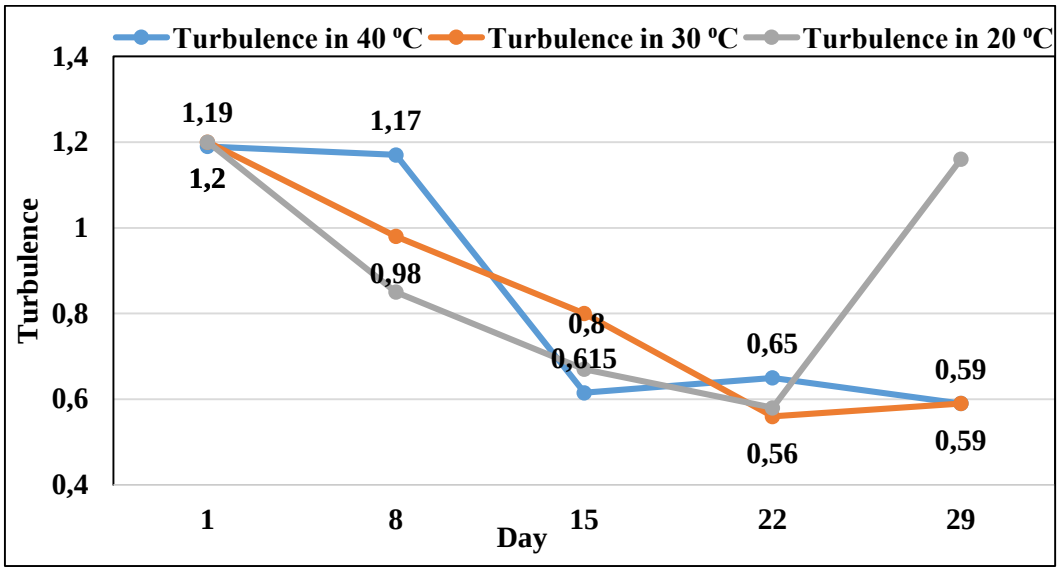

Figure 6. Dependency of turbulence on time

The apparent extract does not show changes and variations in the values and no considerable changes are expected during the observation period. The colour intensifies, the difference is not very big, however it is understandable if we consider the phenomenon of the dispersal of coloring substances (alcoholic phase). The values of the colour change uniformly and proportionally.

The values shown in the table below have been observed when the composition of the packing system has considerably changed and when there has been migration of the substances present in the alcoholic solution. Because of this, variances in the values are expected. The pH increases as the time passes and this is most probably because of the existing alkalinity of the contact point of the packing and the product. This is a new issue that has been identified when facing the bacterial load. The amount of CO_2 decreases significantly, and this is another evidence of the increased presence of microbiological problems (continuous microbiological monitoring is required). Turbulence increases and the new conditions do not favour the precipitation of the particles. The apparent extract follows the progress that has now been confirmed theoretically and experimentally.

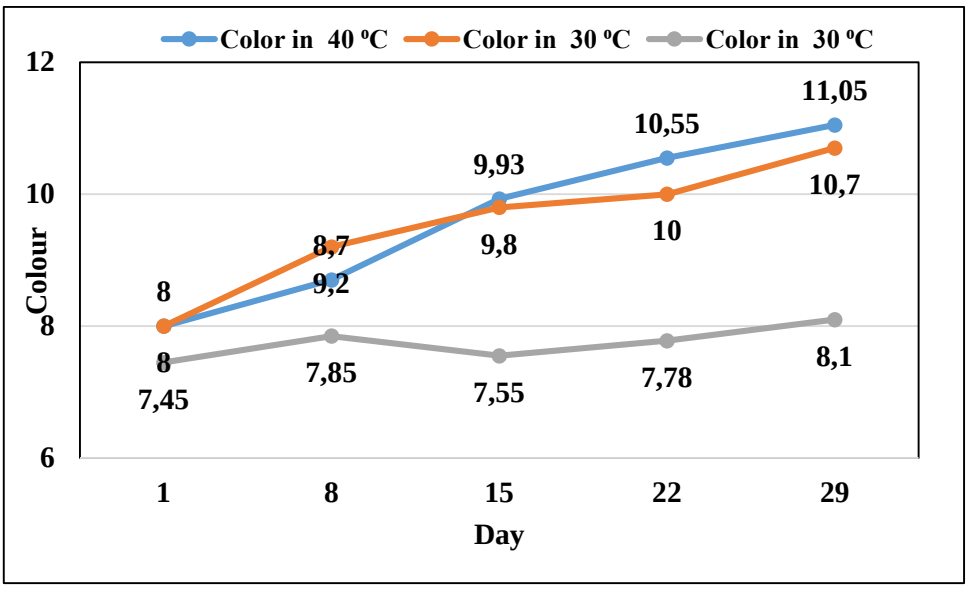

Figure 7. Dependency of colour on time

Table 2. The dependency of physical and chemical parameters on the PET color

time/days	**1**	**8**	**15**	**22**	**29**
pH	4.21	4.21	4.16	4.23	4.27
CO_2	0.61	0.59	0.57	0.56	0.54
O_2	0.13	0.086	0.058	0.05	0.044
air	12	16	8	12.8	5.8
bitterness	20.1	20.2	18.3	18.1	18.3
turbulence	1.2	0.85	0.67	0.58	1.16
Ex ap.	2.35	2.35	2.35	2.35	2.35
colour	7.45	7.85	7.55	7.78	8.1
Brown PET					
pH	4.23	4.23	4.16	4.21	4.25
CO_2	0.61	0.55	0.575	0.55	0.53
O_2	0.13	0.086	0.058	0.05	0.044
air	12	15.5	7	14.5	9
bitterness	20.05	21.75	21.15	17.1	18.5
turbulence	1.19	0.76	1.27	1.63	1.58
Ex ap.	2.3	2.3	2.3	2.3	2.3
colour	7.45	7.48	7.55	7.68	7.8
Green PET					
pH	4.23	4.25	4.16	4.21	4.25
CO_2	0.61	0.59	0.57	0.56	0.54
air	0.13	0.086	0.058	0.05	0.044
bitterness	12	16	8	12.5	5.3
turbulence	20.05	20.1	18.3	18.15	18.33
Ex ap.	1.19	0.85	0.67	0.53	1.11
colour	2.3	2.3	2.3	2.3	2.3
air	7.45	7.48	7.55	7.78	8.1
White PET					

Conclusions and Recommendations

As a conclusion of our study, we can say that the PET bottle should have the priority to be used in the case of mass consumption of the beer. This result is supported by the analytical monitoring of the degree of migration of components and their impact on the sensorial and physical-chemical parameters. All the physical-chemical indicators (gas, air, extract) are fully monitorable. The experiments performed for several storing temperatures suggest that storing must be on 20-30 ºC. Higher temperatures positively influence the turbulence by lowering it, but influence negatively other indicators. Thus, light turbulence is acceptable when the rest of the parameters is within the range of their expected values. The plastic packing does not influence the microbiological load of the final product. The variation in the bitterness of the final product must still be verified with respect to the combination polymer – bitter substances. We suggest to perform groups of experiments in plastic bottles of 330 and 500ml to be able to better understand the influence of the volume of the plastic bottle.

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