Quality of Canned Beef in Relation to Internal Corrosion of Plain Aluminium Cans

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The word "corrosion" means all transformations in which the metal passes from the elementary to the combined condition including reactions leading to the formation of a solid oxide film and other kinds of films as well as the reactions resulting in a compound dissolved in the corrosion medium (3). Corrosion phenomena are apparently complex in the canning industry, especially the internal corrosion of canned food products due to numerous veriables taking part in such processes. Finding out of the interrelations of packaging materials-product manufacturing practices-canned products is the item of permanent investigations which aim is to escape potent deleterious effects of materials on the quality of canned products that could be the limiting marketing factors especially for long-storage products (8).

Nowadays, in the world canning industry, aluminium use, as the food packaging material has significantly increased owing to its following properties: nontoxicity, good formability, low weight, good heat conductivity, odourlessness, testelessness, impermeability to gases, moisture, light and grease, good lacquerability, good printability and good recyclability (2, 10).

According to its position in the potential series of the metals, aluminium should be a very reactive metal. However, owing to its significant affinity to oxygen as well as to the ability of producing and regenerating the stable, adherent, water insoluble oxide film, aluminium is passivated and so shows to be more noble in relation to its electrochemical potential i.e., it is corrosion resistant to air, water and many other media (3). When the aluminium material is found in the conditions in which its oxide film is destroyed without regenerability, aluminium corrosion reactions develop (3). Probably such conditions are in the majority of canned food products. Therefore, many authors recommend only the use of varnished aluminium cans on purpose to obtain the satisfactory corrosion shelf-life of canned products (5, 6, 7, 8, 9).

Having in mind all above cited facts as well as the lack of literature data on interactions of food product-plain aluminium plate, in our work, we decided to investigate the rate of internal aluminium corrosion during heat treatment and storage of the product and its effect on the quality of processed beef products in plain aluminium cans.

MATERIALS AND METHODS

Experimental drawn cans (Ø 73 mm; 75 ml capacity) and conventional ends (Ø 73 mm) were produced at the Yugoslav can factory - "Saturnus", Ljubljana. Cans and ends were made of plain cold-rolled aluminium plate (0.25 mm thickness) deriving from pure aluminium - Al 99,5 (4) with the following impurities: silicon 0.1%, iron 0.34%, copper 0.01%, zinc 0.04%, titanium 0.02%. Aluminium plate was produced by the Yugoslav aluminium industry - "Impol" Slovenska Bistrica without additional heat and chemical treatments upon the performance of the cold-rolling operation. Metal surfaces were smooth, matt, grey silver and free from visible defects. By laboratory tests, no manufacturing defects were found.

Plain drawn aluminium cans were used in the production of three experimental canned beef products at the "Budimka" meat packing plant. In preparing meat for canning, connective tissue and fatty one were trimmed from beef butt cuts and beef was cut in cubes of dimension 20x20 mm.

In the "A" experimental canned beef series-canned beef goulash-ingredients were the following: unblanched beef, beef bone soup, lard, tallow, flour, onion, tomato concentrate, paprika, common salt (2.5%), pepper, celery, carrot and laurel leaf. The relation of meat to liquid part of can content was 1:1.

In the production of the canned beef of the "B" experimental series, 2.5% common salt was added to unblanched beef cubes.

the "C" experimental series, can content were unblanched beef cubes cured by 2.5% common salt and 0.02% trites.

ned beef products of the "A", "B" and "C" series were simultaneously processed in the retort at 118-120^{o}C r 30 minutes and pressure cooled.

llowing the production, canned beef products were kept in the unconditioned room (temperature variations nged 15-23^{o}C and relative humidity - 66-82%). Products were sampled for testing: prior to processing, llowing heat treatment; after 30, 90 and 180 storage days. The quality of canned beef products of each perimental series and experimental group was tested on 10 samples.

ganoleptic evaluation of products was performed by 3 experts having the task to check samples with off-organoleptic properties of samples and the kind of the defect. The only imperfection that should not be gistered was the excessive saltiness; salt was intentionally added in the higher quantity (2.5%) on pur-se of producing the higher corrosion rate.

n content pH was determined by direct pH-meter (Radiometer, Denmark).

uminium quantitative analysis was performed by the spectrophotometric method with aluminon (1).

n tightness was evaluated by means of the data on double-seam quality and indicator test (6).

SULTS AND DISCUSSION

mediately following the production of canned beef products, it was found that outside can surface appearan-e of all samples changed from matt, grey silver to the uniform, matt, white one. It is probably the conse-uence of the formation of mixed oxide-hydroxide film during the heat treatment of the products. It is to e pointed out, however, that above mentioned corrosion changes had not caused the unacceptable outside ppearance of canned products. In the same time, internal can surfaces of samples from all experimental

ble 1. Aluminium quantity and pH of can contents in different periods of production and storage of canned beef products

Canned beef series	Testing of can content		Canned beef testing period I	II	III	IV	V
A	Aluminium (mg/kg)	$\bar{x}$	8,26	8,47	26,35	34,69	54,15
		max	10,00	10,50	31,24	41,01	62,75
		min	6,96	6,75	20,41	27,38	42,55
	pH		5,50	5,45	5,70	5,75	5,90
B	Aluminium (mg/kg)	$\bar{x}$	5,06	5,34	12,00	17,92	22,03
		max	6,78	7,23	16,03	20,60	25,50
		min	3,92	4,41	10,24	15,73	19,98
	pH		6,00	6,00	6,00	6,15	6,15
C	Aluminium (mg/kg)	$\bar{x}$	5,16	4,99	15,93	18,55	24,64
		max	6,37	7,74	18,20	22,35	28,11
		min	4,18	4,01	10,97	17,61	20,70
	pH		6,10	6,00	6,00	6,10	6,20

Explanations: A - canned beef goulash; B - canned salted beef; C - canned cured beef; canned beef testing period: I - prior to product processing; II - immediately following product processing; III - after 30 day storage of product; IV - after 90 day storage of product and V - after 180 day storage of product; $\bar{x}$ - mean value for aluminium content in 10 samples.

series of canned products had the apparent unhomogeneous appearance - matt, grey silver spots intermingled with bright, silver spots; internal end surfaces were completely matt, grey silver in all experimental series except in A series (canned beef goulash) in which inside end appearance was similar to the can one.

During storage, the outside appearance of cans remained unchanged. Already after 30 day storage of canned beef products at room temperature, it was found out that internal can surfaces and end ones had obtained the uniform, bright, silver appearance and so it was kept up to the termination of testings - 180 days. In no case the pitting corrosion was produced i.e., the can corrosion was of the superficial type.

The changes of internal can surfaces showed that already during the heat treatment of canned beef products, internal can corrosion reactions were directed towards the destruction of the oxide film and in the course of 30 day storage of all tested canned beef products, they succeeded to destroy it completely. So aluminium plate has lost the protection against the corrosion processes. Such statement was proved by checking the aluminium content in canned beef products of all experimental series during the production and the storage.

In the Table 1, there are data on aluminium contents in canned beef goulash, salted beef and cured beef prior and after heat treatment of the products as well as in the course of their storage. It can be seen that there was no significant rise in aluminium quantities in can contents during the heat treatment of all tested products. The highest rate of internal aluminium corrosion of all canned beef products was recorded in the course of the first 30 days of storage. During the subsequent storage of the products, the internal corrosion proceeded but in the reduced rate. The corrosivity of canned beef products could be differentiated in the storage period. Canned beef goulash showed the highest degree of corrosivity. Namely, the aluminium content in the canned beef goulash stored 30 days at room temperature was approximately the same as in the canned cured beef stored in the same conditions for 180 days. Although canned cured beef showed the higher aggressiveness than canned salted beef all through the corrosion testing period, the differentiation of one from other was not so significant as in the case of canned beef goulash in relation to other canned beef products. In the internal corrosion processes in canned beef products of A, B and C experimental series, the constant factors were the following: kind, construction and quality of cans and ends, meat and common salt as ingredients of canned beef products and heat treatment and storage conditions of canned products. So it could be stated that other ingredients of canned beef goulash and canned cured beef are responsible for the higher corrosion rate. For canned cured beef such ingredients are nitrites and for canned beef goulash it is, first of all, tomato concentrate. Surely, one of decisive factors in the more intensive corrosion processes in the canned beef goulash was also the higher fluidity of can content being in the contact with aluminium. The finding of significant differences in aluminium quantities in samples of the same series of canned beef products, especially in the case of canned beef goulash, could be explained by uneven distribution of corrosive ingredients in cans.

The aluminium corrosion in canned beef did not produce off - organoleptic properties of those products. It is interesting to mention that the can content surfaces with concentrated corrosion products of aluminium not even were discoloured but their appearance was more attractive than it was in the central part of can contents.

pH of canned beef goulash showed a small rise in the storage period while pH of two other products had no significant changes up to the termination of experiments (Table 1).

All tested canned beef products of A, B and C series showed satisfactory results in respect of can tightness.

CONCLUSION

Based on the experimental results it can be concluded that the only effect of internal corrosion of canned beef products was the increase of aluminium quantities in can contents without the deterioration of the product quality. As aluminium has not been in the group of toxic metals i.e., its quantities in foods have not been limited, it may be stated that the tested products are safe, of acceptable quality and satisfactory shelf-life in the course of 6 month storage at room temperature.

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