SUMMARY

PhD thesis title: *"RESEARCH ON ACRYLAMIDE CONTENT IN BAKERY PRODUCTS"*

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In our country, the bakery industry holds a leading position, given that bread and similar varieties are bought on a daily basis. But the way bread is prepared and consumed can make a huge difference when it comes to acrylamide (a recently studied contaminant that derives from the product during the technological process). Exposure can not be avoided and a huge range of factors can influence the amount of food in the diet.

Genetic factors (species, variety, genes involved in asparagine amino acid biosynthesis and carbohydrate biosynthesis, etc.) and agronomic factors (soil fertilization with sulfur, crop area, harvest year, environmental conditions - precipitation, drought etc.) affects the amount and concentration of asparagine and reducing sugars in cereals - precursors of acrylamide formation. Instead, food habits, raw material quality and processing conditions (production recipe, fermentation time, baking time and temperature, water activity and type of food matrix) influence both the formation and the possibility of acrylamide reduction.

Until now, various analytical methods have been developed to quantify acrylamide in food, and the researchers' effort is to find new optimal solutions for extraction procedures, sample purification, quantification of acrylamide in food, obtaining detection limits and quantification, small enough to evaluate as accurately as possible the concentration of this process contaminant. And in our country exists since 2015, a method for determining acrylamide in food, a standardized method at European level.

As far as the reference level for acrylamide is concerned, it decreased in 2017 compared to the recommendations made in 2013 when there were only indicative values for this. This reduction is observed in the following matrices: potatoes (from 1000 to 750 μg/kg), white bread (80 to 50 μg/kg), biscuits and wafers (from 500 to 350 μg/kg) and ginger bread (from 1000 to 800 μg/kg).

The condition for Romanian food to enter the European Union market and other markets is that they are of good quality and do not pose food safety problems.

Based on these aspects, this paper addresses current food safety issues and chemical process contaminants, addressing raw material, manufacturing recipe and processing parameters as a first step in lowering the acrylamide level and implicitly in obtaining a sensory qualitative product.

The thesis **"Research on acrylamide content in bakery products"** has as main objectives:

- ✓ Carry out a documentary study on the general aspects of acrylamide, the level of this contaminant in the food normally consumed, and ways to reduce it at industrial and pilot levels.
- ✓ Experiments that aims the influence of the four extraction degree used on the acrylamide level of bread, the production recipe, the baking time and the way the dough is prepared, as well as the relationship of these factors and the color parameters with the level of acrylamide formed.
- ✓ Analysis of bread types on the Romanian market in terms of content in acrylamide (bread assortments obtained from different suppliers or from the same supplier - but different batches) as well as the correlation of the color parameters with the determined acrylamide level.
- ✓ Formulating general and specific conclusions and recommendations regarding the research topic.

The written thesis contains a number of 163 pages, including 40 tables, 62 figures and 157 bibliographic references. The doctoral thesis is structured in two parts, the documentary study and own researches, ending with the general conclusions, the bibliography and the annexes of the studies.

Part I of the thesis, **Chapter I - Study concerning the international and national situation of acrylamide level in food**, presents general data related to acrylamide, the training mechanisms, its level in food, the existing legislation, the analytical methods of determination, and studies on the influence of some factors on the level of acrylamide in food, but also on how to reduce the level in the product.

Part II, regarding own experiments includes the following chapters:

Chapter II - Purpose of research and working method

This chapter investigates the importance of technological factors and their correlation with the acrylamide content in bread and other similar assortments.

The working material is represented by 26 samples of bread with flour type 480, 550, 1000, 1250 and were made at pilot level in the Cereal and Flour Processing Pilot Experimental Station at

INCDBA - IBA Bucharest, with equipment specific to bakery production technology, and another 14 assortments of bread available on the Romanian market and ranked first in terms of buyer options. The assortments were also chosen according to the degree of extraction of the flour used, the batch, the supplier and the manufacturing process.

The working methods used are specific to physico-chemical and chromatographic determinations.

Chapter III - Results and discussions concerning acrylamide content in bread products

The chapter is divided into six subchapters, as follows:

Subchapter 3.1, Research regarding the influence of flour extraction degree on acrylamide level in bread comprises the results of experiments on three types of flour with different extraction degrees and the way the acrylamide level affects the assortments of bread obtained at pilot level.

From chromatic parameters point of view, the sample with the low ash content of the flour has been highlighted and has a higher luminance value (color closer to white). The same use of low-ash flours also determines an increase in the acrylamide content of bread compared to the use of higher flours.

Subchapter 3.2, Research regarding the recipe influence on the bread acrylamide level studied the interaction of a number of four manufacturing recipes (for the assortments: "Simple bread bar", "Olive bread bar", "Walnut bread bar", "Onion bread stick ") with the formation of the acrylamide level.

When comparing the color parameters (using black wheat flour), it can be seen that they vary in almost the same way as for the white flour assortments. However, the luminance values are lower than those obtained with white wheat flour assortments. The lower values are recorded for breads obtained from flour type 1250, and the upper ones in the assortments bread made from flour type 480.

The highest concentrations in acrylamide were obtained from products made from white flour type 480 and the smallest were obtained in assortments made from black flour type 1000.

Regarding the manufacturing recipe, for assortment "Simple bread bar", the lowest value of acrylamide concentration was obtained.

The increase in the acrylamide level for "Onion bread bar" assortment (regardless of the type of flour used) is explained by the fact that the dehydrated onion added adds carbohydrate content of the finished product compared to the other ingredients used.

Taking into account the level of acrylamide formed in the assortments of bread obtained with different manufacturing recipes and color parameters, we can say that there is no correlation between the level of acrylamide formed and their color.

Subchapter 3.3, Research on the influence of time baking on the level of acrylamide bread investigated how baking time affects the amount of acrylamide accumulated in "Bread on tray" assortment.

The results showed that this product, by constantly maintaining the temperature and varying only the cooking time (from 40 minutes to 60 minutes), the acrylamide level in bread increased by almost 30%.

Correlation of the acrylamide level with luminance formed in all three experimental variants demonstrates that a lower concentration level in acrylamide (baking time of 40 minutes) results in a higher brightness value.

Subchapter 3.4, Research on the influence of the dough preparation process on acrylamide level in bread has investigated the assortments obtained by direct and indirect process. For each of these, four types of bread were made: "Bread on tray", "Simple bread bar", "Olive bread bar" and "Onion bread bar".

Regardless the process used in the production, the assortments presented the same variations of the chromatic parameters.

Bread assortments prepared by the indirect process had the lower acrylamide level compared to those obtained by the direct process. The highest acrylamide level was obtained in the added ingredient assortments (whatever the production process).

For "Simple bread bar" and "Bread on tray" assortment, the highest brightness values and lowest acrylamide levels were determined.

By correlating the added ingredient (onion/olives) with the brightness paramethers and acrylamide level, lower brightness values and high levels of acrylamide were obtained. These parameters being explained by the ingredients added.

Subchapter 3.5, Research regarding bread assortments analysis, with different extraction degrees of flour, on the Romanian market in terms of acrylamide content investigates the level of acrylamide in eight most bought bread types by the consumer.

Concentrations in acrylamide above the limit (over 50 μg/kg according to Regulation 2158/2017) were found in four of bread assortments purchased from the market that used whole grain wheat flour as raw material, with the highest content in the range of bread with the highest ash

quantity (sample using whole wheat flour, fermented wheat flour and soybean meal). The correlation of bread crumb color with the acrylamide level reveals that for some assortments the acrylamide level is lower as the bread has a higher luminosity. Thus, a lighter color of the bread determines a lower acrylamide level.

Toast type bread was compared, resulting that using a whole wheat flour (60%), brings on one hand a nutritional intake in the finished product, but on the other hand it determines higher acrylamide levels than the assortment compared to, and a darker color of the bread determines a higher acrylamide level.

Investigating bread varieties from the same supplier (with predominantly white wheat flour) shows that the antioxidant (sage) added determines a lower content of acrylamide compared to the second product and similar to the above tests, and a darker color of the bread determines a higher acrylamide level.

Analyzing bread varieties with different supplier and having predominantly white wheat flour, it appears that for both, the acrylamide level was almost identical, causing a low level regardless the processing conditions. The same results were obtained by comparing the assortments that were predominantly made with black flour.

For the predominantly black wheat flour (different suppliers), the results of the determinations offers a lower acrylamide level (for 100% use of black wheat flour) compared to other products (with different types of flour used). A darker color of bread does not mean the highest level of acrylamide.

Subchapter 3.6, Research regarding the analysis of the same bread assortment on the Romanian market in terms of acrylamide content compares bread products with predominantly whole flour, that have supplier and three different manufacturing batches for each product.

Supplier A's product has significant differences between batches and higher acrylamide levels compared to B supplier. This type of data can also be a guide for consumers in choosing brands with lower acrylamide levels. Consequently, this may give industry an incentive to lower acrylamide levels in their products.

Correlating the acrylamide concentration with chromatic parameters for supplier A assortment, the darker color of the bread determines a higher acrylamide concentration level and a lighter color determines a lower acrylamide concentration level.

The paper ends with general conclusions summarizing the results of the researches undertaken, as well as recommendations on the consumption of food (bread) with as little acrylamide as possible. Completes with the bibliographic list and the annexes on the chromatographic curves specific to the analyzed samples.