Chemistry and Industry for Teachers in European Schools

THE CHEMISTRY OF CANNED RAVIOLI

Hans Joachim Bader

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THE CHEMISTRY OF CANNED RAVIOLI

Contributors to the project "Chemistry of canned Ravioli":

Ute Albrecht, Melanie Escher, Susanne Hartnagel, Alexandra Heinz, Jürgen Knapp, Anita Kohlenberger, Matthias Leibold, Barbara Lesniak, Jörg Ludwig, Nicole Rust, Clemens Schwanzer, Oliver Solleder, Timo Vogt, Kirsten Fischer, Silke Heuser, Dr. Stefan Horn, Dorothea Klüsche-Hudson, Dr. Barbara Patzke, Dr. Jürgen Richter, Dr. Christiane Schüler

SUBJECT SPECIFIC DIDACTIC CLASSIFICATION

A project-oriented teaching approach is the basis for this presentation. Firstly, a seemingly mundane object is investigated and looked at from many different aspects, from a chemical point of view. It was not the intention to collect a selection of new and elaborate experiments for chemistry classes. Instead, it was to be shown with an everyday product, in this case canned ravioli, what insights can be gained with simple well-known chemical tests for detection.

Since the activity of the students themselves was to come to the fore in the planned project, the emphasis was put on student experiments. The order of the experiments was to follow to the usual method of research, which requires the student to approach the object of the research and to gradually gain more insight into it. The first thing that one observes on a can of ravioli in the supermarket is its colourful packaging, the printed paper label. When this is removed the metal can is revealed underneath, whose composition may be determined. The question arises why such an elaborate and costly packaging is needed. The answer is given when one considers the different ways of preserving food. When the can is finally opened, the noodles are revealed, which in themselves are the “packaging” for the meat. (Ravioli filled with vegetables will not be considered here.) Finally thickening agents and pigments can be detected in the sauce. All in all, the following areas of investigation arise:

Packaging:	paper label can and preservation
Contents of the can:	pasta part of the ravioli meat filling sauce and its components

Thus many different areas are addressed, all of which, as is well known, cannot be considered at the same time in regular chemistry class. If one does not want to limit oneself to a merely phenomenological level, the chemical basics of the topics metals, electrolysis, types of chemical bonds in organic molecules (single and double bond), carbohydrates, proteins and fats should be known. The “ravioli in a can” project is especially suited to an “end of course” exercise at the end of secondary school or at the end of eleventh grade in high-school or grammar school, when topics, which are already known, are to be considered in a more in-depth manner with the help of a practical example.

The topic offers a number of interdisciplinary points of contact for expansion. They span from the discussion on profitability of recycling of tinplate cans to modern dietary patterns and to the question whether food additives are to be considered questionable to health. In any case it gives an opportunity to see beyond the end of one’s own nose.

The individual subject matters of the "Ravioli in a Can" – project

The paper label

The paper label on cans has the purpose of providing information on the content. Secondly the design follows certain sales psychological objectives. Experiments on the analysis of the printing inks used would go beyond the scope of this project. But experiments on the investigation of the paper used are carried out easily, for instance the detection of starch – a usual additive to fill papers or the hydrolysis of cellulose and the detection of reducing sugars in the hydrolysate (the product of hydrolysis.)

Further extension experiments beyond the scope of this project could be the production of paper from fresh cellulose as well as from used paper [1,2]. Bleaching of cellulose is also possible with simple student experiments [3].

The can

To prevent cans from rusting they are made from tinplate, i.e. from an iron plate with a thin layer of tin. Today tinplating is done by electrolysis, while in the past the iron plates were immersed in molten tin. Using this method, one did not obtain tinplate with a uniform thickness and the consumption of this comparatively rare (and expensive) metal was higher.

To avoid possible changes to the taste of the contents, the tinplate cans are coated with lacquer on the inside. In canned ravioli the white protective layer is easily visible. An experimental approach to this topic can be found with the detection of tin and iron as components of the tinplate. Furthermore, the corrosion-preventive effect of tin-layering can be shown in an impressive experiment. Experiments on galvanising are numerous in experimental literature (e.g. [4]) and can round off the topic.

The design of the can itself provokes an interesting mathematical question: What size do the height and the diameter of the can need to be to minimise the expense of material used? How might we cut down on the amount of material used to make the can? The can must be able to hold 880 ml of contents.

The most economical shape is a cylinder. Application of simple mathematical formulae allows us to calculate the height of the can and its diameter. To make things more practical the bottom of the can is manufactured with a slightly larger diameter than that of the lid. By making this modification, we can stack the cans more easily.

Overall this example can show students how much know-how is at the heart of such a trivial everyday life product.

The preservation

Only physical methods are used for the production of cans to reach a satisfactory durability. Through sterilisation, i.e. through heating to more than 100 °C in autoclaves, the bacteria and germs are eliminated in the food which is to be canned. After they are canned the can is hermetically sealed, which prevents micro-organisms from entering and thereby the contents from spoiling. This process makes a decade-long storage life possible. Since there is a loss in taste after a while, however, a much shorter storage life is printed on the can.

Consequently, the chemical preservation does not play a part in the "ravioli in a can" project. Yet, it is very interesting to point out to the students a historical incident that preserves were not always as acceptable as they are today. As a basis one can use the book "Buried in Ice" by Beattie and Geiger [5]. In it the story of the expedition of John Franklin is told, who attempted to explore the Northwest Passage with three ships in 1845. The venture was extremely well-equipped, with among other things, a large amount of canned food. The expedition failed with no survivors. Investigations were without success for years. Later finds only offered more riddles. For instance a lifeboat was found, which part of the crew pulled across the ice to reach the mainland, and in it completely unnecessary items such as sterling cutlery and silk handkerchiefs were found. Finally the exhumation of bodies, which were completely preserved in the permafrost, revealed the truth in the eighties: Many of the seamen appeared to have died from lead poisoning. The cans back then were soldered with lead, which means that the crew constantly consumed lead with their food, which led to the typical symptoms like mental and physical weakness.

To expand the topic one can deal with more methods of food preservation. A collection of suggestions can be found in [6].

The noodles

In Europe noodles are mainly made from wheat flour or white grits. The first step is to knead the flour or the grits with water and, where applicable, egg or egg powder to form a dough. Here, the water is bound by the starch as well as by the adhesive proteins in the wheat flour body. The dough is moulded and dried.
Starch is the main component in noodles. (The protein content in wheat flour varies between 10 – 15 % depending on the brand.)

When the noodles are isolated from the ravioli dish, it is easy to detect starch. For this a sample of the noodles are heated with water in a test-tube for a short time and iodine/potassium iodide solution is added. Admittedly, the test is also positive with the sauce, since some of the starch dissolves into the sauce during preparation and starch is also used as a thickening agent in the sauce.

In a second experiment it can be shown that reducing sugars are not present in noodles (whether raw or cooked) or the ravioli filling. Only after splitting the starch with acid can reducing sugars be detected, using Fehling's solution. More experiments on wheat and its components – on the protein content as well - can be found in the literature stated below [7].

The meat

It is a well-known fact that ravioli usually contains a meat filling. For the students it is important to realise that meat is one of the important sources of protein in our food, but in addition, depending on its source, it contains fat to a greater or lesser extent.

The meat in the ravioli can be easily isolated by removing it from the ravioli and the protein can be detected by using the xanthoprotein reaction. The familiar biuret reaction can also be carried out and is positive, as is expected.

The consumer would of course like to know, how much fat is contained in the meat filling. For this purpose the filling from a number of different types of ravioli is dried in a desiccator over phosphorus pentoxide or another drying agent, for at least 24 hours. (The meat should not be dried in a drying cupboard as it develops an unpleasant smell.) After the extraction of the meat with petroleum ether and the evaporation of the solvent in a beaker (which as previously weighed) the fat content can easily be determined. (For the product that we tested the content was about 25 % of the dry matter.) The fat stain test indicates that the petroleum ether extract contains mostly fat. The detection of unsaturated fats with bromine solution was positive as well.

The sauce

Ravioli gets its typical taste by the addition of the red sauce. It is made with tomatoes and spices. However, to round off the taste sugar, salt and – so the sauce does not have the consistency of soup – thickening agents such as starch, are usually added as well.

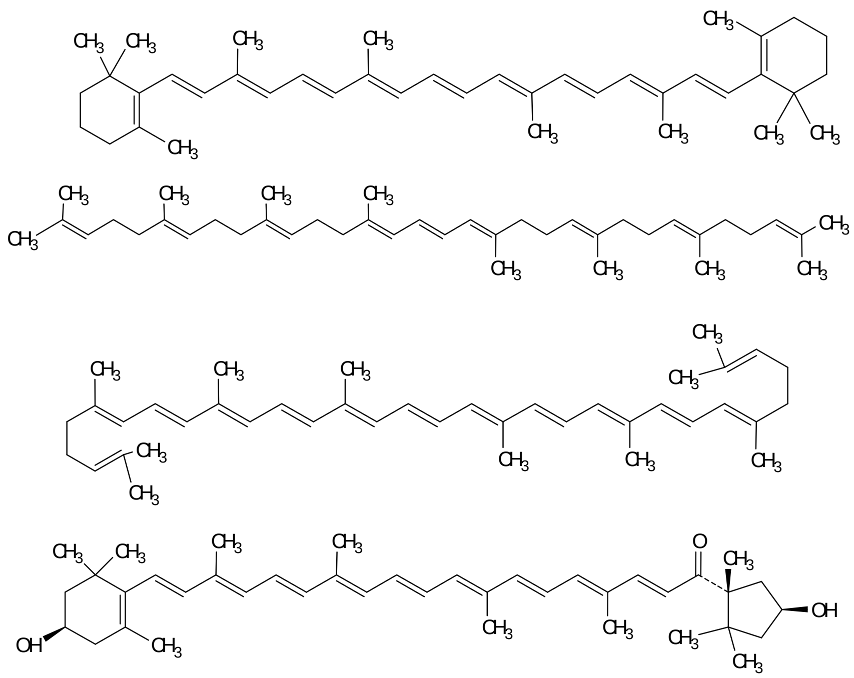
All three ingredients can easily be detected. For this a small amount of sauce is filtered through cotton wool and to the resulting solution Fehling's solution is added. Another part of the filtrate is used for the detection of chloride. Starch is detected directly in the sauce with iodine/potassium iodide solution.

Tomatoes contain different carotenes as pigments; their contents vary in each species [8]. One of these for example can be, beside others, β-carotene, which is also contained in carrots. In the species "High Beta" 36 ppm of β-carotene can be found. In other species the main components are phytoene and lycopene, which differ only slightly chemically from β-carotene, Table 1.

	β-carotene	**phytoene**	**lycopene**
Campbell	1,4	24,4	43,8
High Beta	35,6	32,5	0
Jubilee	0	68,6	5,1

Tab. 1: Carotenes (selection) of three species of tomato, given in ppm, [8]

The great chemical similarity can be seen in their chemical structures. In this context it is interesting to compare them to the pigments in red pepper powder. The main carotene here is capsanthin, which is notably more polar due to its two hydroxyl groups.



ß -carotene

phytoene

lycopene

capsanthin

Fig. 1: Structural formula of ß-carotene, phytoene, lycopene and capsanthin

Separation, using TLC and identification of the individual carotenes in the tomato sauce cannot be conducted in school with the normal simple equipment. A summary classification, however, is possible: comparable chromatograms from petroleum ether extracts of the sauce and of carrots show orange-red substance stains with almost identical R_f values. A distinct difference is seen when compared to a red pepper powder extract, whose chromatogram shows a deep red stain (probably capsanthin) at a notably lower R_f value.
Flavour enhancers are often added to sauces. Some canned ravioli also contains monosodium glutamate (E651), which enhances the taste of salty food without showing a taste of its own [9].

To expand the topic of spices, a number of experiments can be used such as the isolation of pepper flavour and caraway oil. [10]

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