

Information

Studies of the Formation of 3-MCPD Esters in Vegetable Oils

Development of Strategies for their Minimization

In December 2007 the CVUA (Chemisches und Veterinär-Untersuchungsamt) Stuttgart reported for the first time on the discovery of fatty acid esters of 3-monochloropropane-1,2-diol (3-MCPD esters) especially in refined oils and fats as well as in fat-containing food. The levels were between 0.1 ppm and 4 ppm. These new findings are of particular importance with regard to infant food as for its production refined fats are partly necessary. The pathways of decomposition of 3-MCPD esters are not yet exactly known. As a precaution, the German Federal Institute for Risk Assessment (BfR) has assumed that 3-MCPD esters are hydrolysed by 100 % during human digestion. The Joint FAO/WHO Committee on Food Additives (JECFA) has recommended a tolerable daily intake (TDI) of 2 µg/kg bw /d because of a carcinogen effect proven by animal experiment. This value can be exceeded according to a caution assessment of BfR.

Need for Action

There is a strong necessity for the reduction of 3-MCPD esters in refined fats and oils as well as in products containing them. Especially oil mills are working on the problem in order to change their refining process in a way which avoids or at least reduces the formation of 3-MCPD esters. As products from oil mills are used in various foodstuffs, downstream branches of the food industry are concerned likewise.

Current Research Status

Results from other projects show that especially the refining process of fats and oils and here above all the deodorization has to be considered as critical with regard to the formation of 3-MCPD esters. But so far it is unknown to what degree the other steps of the refining process influence the formation, even if during these steps a formation of 3-MCPD esters cannot be noticed.

New Research Project

The German food industry campaigns a sustained minimization of the undesirable compound. It has initiated a research project which was started in April 2009. The projects' first aim is to clarify the connections between the formation of 3-MCPD esters, the process conditions and the involved components and to deduce strategies for the minimization of 3-MCPD esters from these results while keeping up high product quality.

Aspects to be analysed within the project are:

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- the oil composition (e.g. proportions of mono- and diacylglycerides as well as free fatty acids and the chloride content)
- the process conditions during refining (e.g. temperature, type and composition of used bleaching earth, composition of added chemicals, amongst others water, acids, lye and other processing aids)
- conditions during fat hardening or transesterification

Already existing methods for the quantification of 3-MCPD esters are to be optimised and, additionally, new methods are to be developed. Formation mechanisms of 3-MCPD esters are to be clarified on the basis of model studies. Another object of research is to examine to what degree contents of 3-MCPD esters in refined oils can be reduced by treatment with suitable adsorbents.

From Model Scale to Industrial Process

The influence of different production parameters is analysed first in model scale using about 100 g oil. Subsequently, the results will be verified first by using a semi-industrial unit with a working capacity of 50 kg per day and finally in an industrial unit with up to 1000 t working capacity per day. In fat extraction and processing a multitude of technical facilities and possibilities for the treatment of various kinds of oil may occur. The systematic analysis of processing steps is necessary to offer suitable solutions not only for individual oil mills but also for a wide range of different process conducts. By way of using this step-by-step method it becomes possible to flexibly and efficiently adjust to results. However, due to the complexity of the problem short-term results cannot be expected.

Project Grant

The project is funded by way of the industrial community research: by the German Federal Ministry of Economy and Technology (BMWi) through the FEI (Research Association of the German Food Industry) (AiF Projekt 16004 BG). On the part of industry the project is supported by the German Federation of Food Law and Food Science (BLL) and its affiliated industrial associations. A project steering committee chaired by the BLL assures a regular exchange of knowledge between research centres and food industry.

Participating Research Centres

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The MRI is a research centre of the German Federal Ministry for Food, Agriculture and Consumer Protection.

Task in the Course of the Project

MRI is responsible for the project coordination as well as for the comprehensive evaluation of used raw materials and obtained products concerning different chemical, physical and sensory parameters. MRI has a wide experience in this area. The characterization of raw materials requires the analysis of chlorine compounds and chloride ions, halogenated hydrocarbons (only for olive oil), glycerol, free fatty acids, mono- and diacylglycerides, phospholipids and the composition of fatty acids.

Besides that, an evaluation of the products won during separate steps of the refining process is necessary, as the reduction of the contents of 3-MCPD esters must not lead to a deterioration of the product quality. Apart from the concentration of 3-MCPD esters and their sensory evaluation, those parameters are used which in industry normally serve for product specification; for example colour index, peroxide value, rancidity or Iodine value (in the process of fat hardening).

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PPM (Pflanzenöltechnologie Magdeburg e.V.) is an extra-faculty non-profit private research centre specialized in experimental research projects for the development of new methods of production, processing und application of vegetable oils and fats. For this purpose PPM runs a pilot scale processing plant in Magdeburg.

Task in the Course of the Project

PPM analyses the influence of technological parameters of the refining process, of hydrogenation and of transesterification on the formation of 3-MCPD esters in different types of oil. The tests are carried out in laboratory scale and semi-industrial scale and include as many industrial process variants as possible. The technological parameters to be analysed are the temperature within the different stages, the quality of the used processing aids like water, acids, lye and adsorbents as well as the particular process procedures.

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Task in the Course of the Project

The DFA investigates the development of new improved methods for the analysis of 3-MCPD esters and tries to clarify formation pathways of these toxicologically critical compounds. In doing so, DFA's extensive knowledge of handling stable isotopically labelled compounds, which are used as precursor (for traceability of the formation pathway) or internal standard (for quantitative analysis) is a major benefit.

Deficiencies of existing methods for analysis of 3-MCPD esters ought to be eliminated by: optimization of the sample processing in combination with the use of stable isotopically labelled leading substances and alternative separation techniques (HPLC-MS). 3-MCDP esters are optically active agents. Thus there is the possibility of human lipase cleaving only one enantiomer enzymatically. This would mean an automatic reduction of a free 3-MCPD contamination by 50 %. The development of an enantioselective method would therefore be of special importance.

Another main focus is the clarification of formation pathways of 3-MCPD esters. Model studies to this end, in which precursors (for example different derivatives of glycerol like emulgators or glycidyl fatty acid esters) are analysed for their potential of forming 3-MCPD esters, are planned.

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The DIL is an independent, extra-faculty research centre, which is engaged in procedurally orientated research and development within the whole area of food processing.

Task in the Course of the Project

The institute works on possibilities of subsequent reduction of the contents of 3-MCPD esters in already refined oils through a treatment with suitable adsorbents. This approach is based on the removal of polar fractions from frying fats for extending their lifetime in the deep fat fryer. In doing so, differences between the polarity of 3-MCPD esters and triacylglycerides as the main fat compounds are made use of. This way a reduction of the 3-MCPD ester concentrations can possibly be reached, which could without much delay be put into practice with special oils, for example those used in infant food.

To reach this goal a screening is intended according to the reduction effect for 3-MCPD esters with different inorganic adsorbents. The oil will be mixed with the adsorbent for a defined period and filtered off again. The oils treated this way will be analysed regarding their concentration of 3-MCPD esters (before and after the treatment) as well as regarding possible effects on the quality. A second step will be the optimization of treatment conditions, e.g. temperature for the best suitable adsorbents (regarding a reduction of 3-MCPD esters and keeping-up the quality of the oil).

Management of the Project Advisory Board**German Federation of Food Law and Food Science (BLL)**

The German Federation of Food Law and Food Science (BLL) is the leading association of the German food sector. Its membership includes some 500 associations and companies representing the entire food chain – from industry, trade, craft and agriculture to adjoining sectors.

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