REDUCTION OF MUTAGENIC/CARCINOGENIC HETEROCYCLIC AMINE REPRESENTATIVE MEIQX BY THE USE OF CYSTEINE/RIBOSE DURING MAKING OF HAMBURGER MEAT PATTIES

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Keywords heterocyclic amines, cysteine, ribose, MeIQx, Hamburger

Background

Heterocyclic amines (HA) could be formed during normal household cooking methods between the muscle-meat specific compound creatin/in and products of the Maillard reaction. A typical, widely spread representative of this class is 2-amino-3,8-dimethylimidazo[4,5-*f*]quinoxaline (MeIQx), which belongs to the most potent mutagens in AMES testings and shows carcinogenicity in animal testing. Therefore different approaches have been used to lower the content of these hazardous substances by the use of antioxidant food additives [1] or Maillard reaction inhibiting organosulphur compounds [2, 3] in model systems.

Objective

The aim of this study was to reduce the formation of MeIQx in household prepared hamburger products using different types of cysteine/-hydrochloride applications. Meat-like aromas can be formed when Maillard reactions between cysteine and ribose take place. We expect therefore, that the additional use of ribose should lead to an improvement of the sensory properties of the product.

Methods

Beef was purchased from a local wholesaler, cut into 2x2 cm pieces and minced through a 9 and 3 mm grinding plate. Meat was stored until use at -20°C. The chemical analysis data were: moisture 69.0%; fat 10.3%; protein 20.3% (connective tissue: 3.2%) and ash 1.00%. All chemicals were purchased from Merck, Darmstadt, Germany in p.a. quality.

Preparation of Hamburger

Batches of 1 kg minced meat and 13 g NaCl were mixed for 3 minutes with a Kitchen Aid, (Hobart, Troy, USA). Portions of 80 ± 0.5 g meat were formed with a hamburger former into patties of 10 cm diameter and 16 mm thickness. Patties were heated with a double-sided contact plate heating device (Nevada, Neumärker, Germany) for 5 minutes at a heating plate surface temperature of 230°C. These heating conditions have been shown in pre-tests to produce the most appetising burgers for the sensory panel. 4 hamburgers were heated in parallel on tin aluminium foil (with little oil) to avoid contaminating the following batches. The burgers were then stored at -20°C until sensory evaluation and analytical HA determination.

- For the experiments with the cysteine/ribose **coated** hamburgers, the patties were dipped into a viscose 0.5% solution of commercial grade carrageenan (S.B.I., Paris, France) which, after letting excess solution drip off, left 4.2±0.4 g coating on the beef patty. This solution contained 0%, 0.5% and 1% cysteine-hydrochoride-monohydrate and in some experiments ribose was added in the ratio of 1:1, 2:1 and 3:1 to the content of cysteine-hydrochoride-monohydrate.
- For the experiments with the cysteine/ribose **containing** hamburgers, 0 g; and 1.0 g of cysteine or cysteine-hydrochoride-monohydrate were mixed with the 13 g NaCl. Furthermore, ribose was added in the ratio of 1:1, 2:1 and 3:1 to the content of the cysteine compound.

Sensory evaluation

Our sensory test panel of 30 persons were recruited from students and scientists of our institute. Each person got a plate with coded numbers of 4 pieces of burgers and a form to write down the results. For each sample the sensory panel made a comment on colour, smell (data not shown) and taste, by putting a mark on a 10 cm bar from dislike (at 0 cm) to like (at 10 cm). For evaluation, the place of the mark on the bar was measured with a ruler up to one decimal place. This value was used for statistical analysis performed by SAS software.

Sample clean up and HPLC analysis

Sample cleanup procedure and analytical HPLC determination was performed according to the method of Gross and Grüter [4] with some modifications.

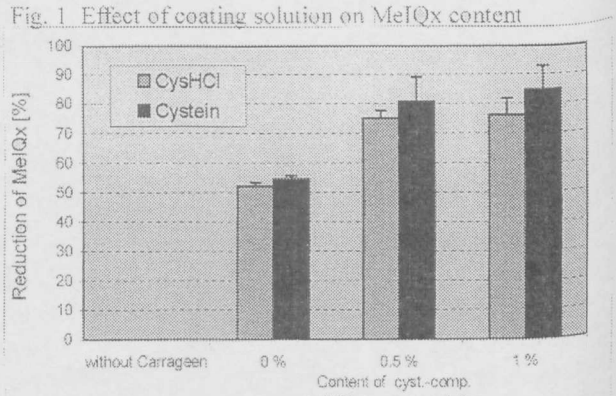
Results and discussion

Experiments with cysteine/ribose coated hamburgers

Figure 1 shows in an impressive way that by simply coating the meat patties with 0.5% carrageenan solution results in a 50% reduction of MeIQx formation. This could be explained by the physical effect of a less efficient heat transfer and a chemical effect of the carbohydrate carrageenan which could influence the Maillard reaction, a major route in MeIQx formation. The addition of 0.5% or 1% cysteine or cysteine-hydrochloride-monohydrate to the carrageenan-coating liquid extended the MeIQx reduction up to 85%.

The results of the sensory evaluation of taste of these products are presented in Figure 2. As it can be seen, they were clearly worse when compared with the burgers heated without cysteine-hydrochloride. To improve this deficiency we used 1.5% ribose (ratio of 3:1) in

Fig. 1 Effect of coating solution on MeIQx content



addition to 0.5% cysteine-hydrochloride in the coating liquid. Figure 3 shows that this treatment results in a higher MeIQx-content in this batch than in the samples which were only treated with carrageenan/-cysteine-hydrochloride coating solution. Nevertheless the MeIQx reduction of these samples is approximately 50%, compared to the uncoated products. Furthermore, we observed a pronounced positive ranking of this sample in taste, as it is demonstrated in Figure 2.

Fig. 2 Sensory evaluation of taste (coated hamburger)

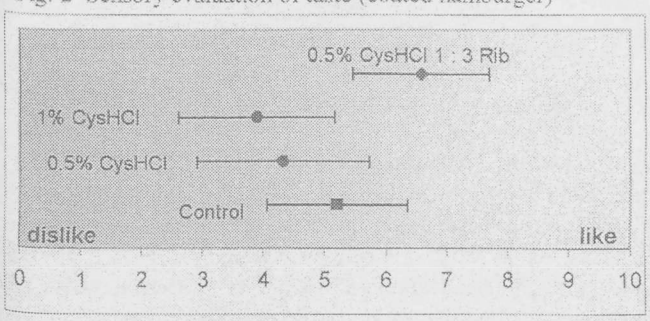
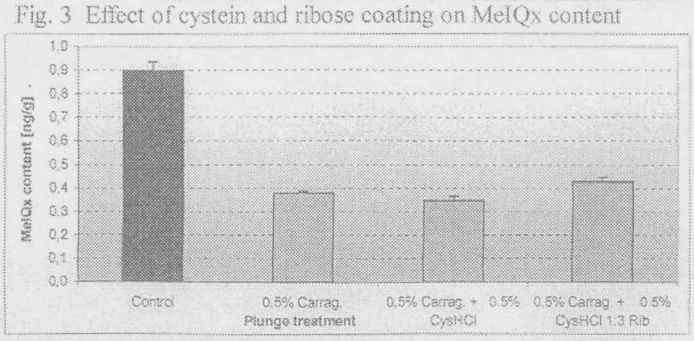


Fig. 3 Effect of cystein and ribose coating on MeIQx content



Experiments with cysteine/ribose added hamburgers

Figure 4 shows that the addition of 1000 ppm cysteine or cysteine-hydrochloride causes a significant, approximately 50% decrease in MeIQx formation. These finding is in correspondence with our previous studies which show a dose depend decrease in MeIQx content after cysteine/-hydrochloride addition [5].

The content of MeIQx rise if ribose is added in a equal or doubled proportion to the cysteine content. However, with the highest content of 3 parts ribose to 1 part cysteine, the MeIQx concentration decreased to a lower level than the control batch. These findings are in agreement with results from aqueous creatinine/glycine model systems when sugars are added in higher amounts [6].

Model systems show that characteristic aromas of cooked meat can be formed when Maillard reactions between cysteine and ribose take place [7]. We expect therefore, that the addition of ribose and cysteine-hydrochloride might have a beneficial effect on flavour development in hamburger products.

Figure 5 presents the sensory assessment of taste for burgers supplemented with L-cysteine-hydrochloride-monohydrate and ribose. As we expected, the taste of the ribose/cysteine-hydrochloride-monohydrate (ratio 3:1) supplemented burgers ranked markably better than the taste of burgers from other trials. This could be explained by the flavour-generating reaction between ribose and the cysteine compound during the thermal processing of the hamburger.

Fig. 4 Effect of cysteine and ribose addition on MeIQx

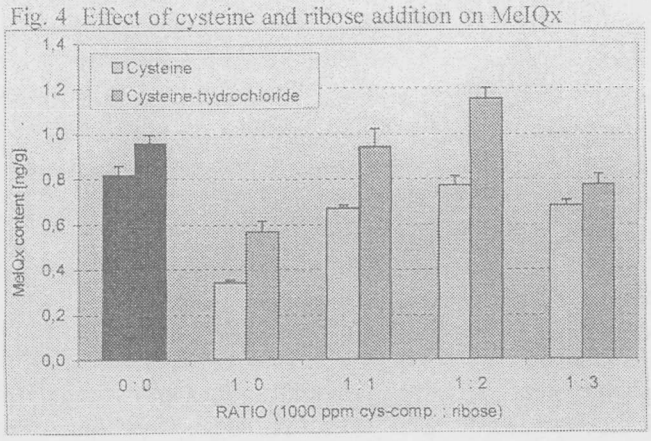
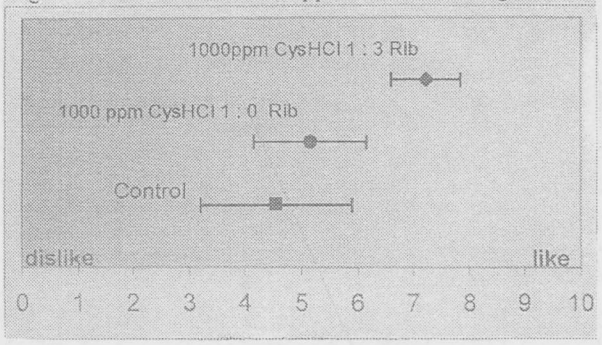


Fig. 5 Evaluation of taste (supplemented hamburger)



Conclusions

Cysteine and cysteine-hydrochloride-monohydrate provide as a additive, as well as in a coating liquid, different opportunities to significantly reduce formation of mutagenic/carcinogenic MeIQx. Furthermore, they offer in combination with ribose a beneficial effect on the taste of hamburger products.

References

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