

# Morphine in Poppy seed food: Influence of food processing and guidelines for reduction

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## Introduction:

The morphine content of poppy seed, which is widely used in dishes and pastries in central Europe, has recently raised major concerns. Cases of intoxication after consumption of strongly contaminated poppy seed even led to a discussion about maximum limits. The Federal Institute for Risk Assessment (BfR) derived a provisional guidance value of 4 mg morphine/kg poppy seed based on a maximum daily intake of 0,38mg Morphin/person. The maximum-value of 4 mg morphine/kg poppy seed might have led to a nearly complete market shake-out because a great deal of all products had concentrations above this limit. However, the influences of seed preparation or food processing is disregarded in the establishment of this provisional guidance value, although such influences were previously reported. Our working group systematically researched the influences of food processing and found a significant reduction of morphine during steps like grinding and baking. Poppy seed for decorative purposes (e.g. as topping on buns) could contain up to 100 mg/kg of morphine without even nearing the tolerable daily intake. A guidance value of 20 mg/kg was proposed for poppy seed intended for baking. Maximum limits have therefore, to be established under consideration of the intended purpose and Manufacturer of pastries containing poppy seed have to ensure with their HACCP conception that there is no exceeding of a maximum daily intake of 0,38mg Morphin/person.

## Materials and Methods:

The optimized and validated method after Sproll et al. [1] was used without modification. In short, a portion of 10 g poppy seed was placed into a 100 ml glass flask with screw cap, mixed with 30 ml of extraction solvent (methanol with 0.1% acetic acid), and the flask was immediately sealed. The flask was agitated for 60 min in an automatic shaker at 250 rpm. After that, the supernatant liquid was filtered through disposable syringe filters. 200 µl of the extract were diluted with 700 µl of methanol and 100 µl of morphine-d<sub>3</sub> solution as an internal standard (10 mg/l). In case of very high morphine contents, the extracts were diluted with extraction solvent before adding the internal standard. One µl of the extract with added morphin-d<sub>3</sub> solution was injected into the LC/MS/MS system.

LC/MS/MS system: Agilent (Waldbronn, Germany) 1100 HPLC system coupled with a Thermo Finnigan (Dreieich, Germany) TSQ 7000 mass spectrometer.

LC separation: Gemini column 150x2mm, 3µ (Phenomenex Aschaffenburg, Germany) at 40 °C, 20 mM ammonium hydrogen carbonate // water/methanol 5:95 (v/v), 20 mM ammonium hydrogen carbonate, both adjusted with ammonia to pH 9 in a gradient program with a flow of 0.2 ml/min. Electrospray ionization (ESI): positive ion mode, capillary temperature 280 °C, spray voltage 2.8 kV, sheath gas nitrogen/70 psi, collision gas Argon, offset voltage of collision cell 45 eV for all transitions. For quantitative analysis the following fragmentations with the highest intensity were monitored in the selected reaction monitoring (SRM) mode: m/z 286→153 and m/z 286→165 for morphine, m/z 289→165 for morphine-d<sub>3</sub> as the internal standard, and m/z 300→165 for codeine. Furthermore the method is qualified for Detection of Thebain, Noscapin and Papaverin.

## Results and Discussion:

### Influence of grinding

Large influence has the grinding of seeds. Using a laboratory mill, the ground samples had significantly lower morphine contents than the untreated ones. This effect was confirmed by analysis of 37 samples. The morphine loss due to grinding was 34 ± 5% (p<0.001).

Additionally, the grinding using a specialized poppy mill was studied. Such mills are widely used in households and bakeries because poppy cake recipes demand grinding with such mills to improve the aroma of the product.

Grinding using the poppy mill significantly (p<0.0001) reduced the morphine content of our poppy seed sample from 219 ± 14 mg/kg to 166 ± 6 mg/kg (Fig. 1). The codeine content was also significantly reduced from 42 ± 5 mg/kg to 34 ± 4 mg/kg (P=0.0049).

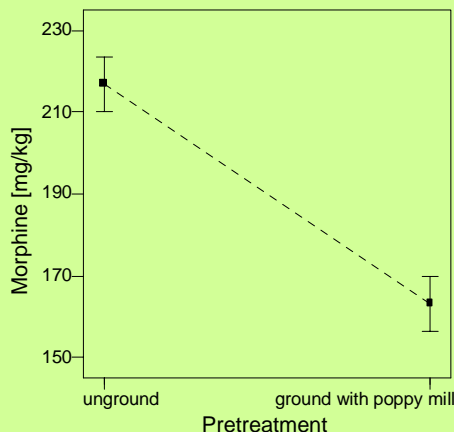


Figure 2: Influence of grinding with a poppy mill on the morphine content of poppy seed

### Influence of baking

The results of the food processing experiments were calculated as percentages of the original morphine content before food processing. All experiments lead to a significant reduction of morphine and codeine. For poppy cake, only 16-50% of morphine and 10-50% of codeine were recovered, in the poppy bun experiment at the highest temperature only 3% of morphine and 7% of codeine were found. Pretreatment had a significant influence in all cases: ground poppy seed showed lower content than untreated seed. The poppy bun experiment proved significant quadratic influence of baking temperature, which means that at first the reduction is relatively low up to 135 °C (around 30%), but at 220 °C a reduction of 80-90% was determined.

The influence of the baking process was verified by preparing a cake that was spiked with morphine. The spiked cake was analyzed before and after baking for 20 min at 180°C. Furthermore, the cake was prepared with untreated and grinded seeds. Again, the Analysis of Variance showed a highly significant influence of baking and grinding (p<0.0001). The results are shown in Fig. 2. This experiment with spiked morphine verifies the influence of baking found previously and excluded artifactual influences.

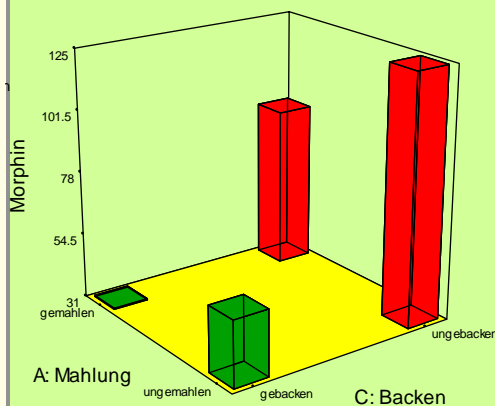


Figure 2: Influence of grinding and baking on the morphine content of poppy seed cake

## Guidelines for consumers and bakeries to reduce the morphine content in poppy seed food

The most feasible conditions to reduce the morphine content were found to be the washing of poppy seed using hot water from the centralized hot water installation (around 60°C) for some minutes. Using this method, samples were washed and analyzed. In all cases, the reduction was significant (p=0.0070). The morphine content was reduced by a mean of 73 ± 13%.

Our experiments allow to derive the guidelines for consumers and bakeries given in Table 1 about a correct treatment of poppy seed. The poppy seed should be washed with water as described above, afterwards the seed must be dried to prevent microbiological contamination, germination and rancidity. The seed should then be grinded using poppy mills. If the poppy is used for baking purposes or for decoration of bakery products, the baking should be done at the highest possible temperatures.

Using the proposed treatment consisting of washing, drying and grinding, not only the morphine content is significantly reduced but also the organoleptical quality of the poppy seed is notably enhanced as we detected during sensory tests of all samples used in this study.

Table 1 Guidelines for reduction of morphine in poppy seed intended for food purposes

Technological step	Description	Effect
Washing	Rinsing with water above 60°C for at least 2 min	Morphine reduction
Drying	Removal of water residues (e.g. 50°C for 2 hours)	Prevention of microbiological contamination, germination and rancidity
Grinding	The washed seeds must be grinded using poppy mills	Further morphine reduction, improvement of the aroma
Baking	Heating at high temperatures above 135°C	Further thermal morphine degradation

## Conclusion:

Our statistically designed experiments confirmed the significant reduction of morphine during food processing. Mechanical pretreatments such as grinding, as well as heat treatment, were found to have the greatest influence on morphine reduction. These results may explain the fact that no intoxications were reported from the consumption of cake or buns with poppy seed. The cake recipes bakeries use demand grinding to improve the aroma of the product. Cakes and buns are then baked at high temperatures around 200°C. These processes make a decrease of the morphine content by at least 80% possible. Our results were recently confirmed by investigations of the food industry. Kniel reported results of analyses made on different stages during the manufacture of baking mixes. A median of 6.8 mg/kg was determined in the original poppy seeds. A significant reduction was found in the convenience baking mixes that are manufactured including grinding and heating steps (median 3.9 mg/kg). In the finished products found in bakeries and supermarkets, morphine could not be detected anymore (< 1 mg/kg). The fear stated in the tabloid press that all foods containing poppy seed are "toxic" and have to be banned from the market could not be maintained. By the use of seed with low morphine content from controlled producers and the possibilities to reduce the morphine level furthermore during food processing, the proposed limits can easily be kept. Hopefully, the traditional variety and craftsmanship of high-quality poppy seed bakery products on the European market will not suffer from risk assessments and exaggerated fear of the public.

## Reference:

Sproll C, Perz RC, Lachenmeier DW (2006) J Agric Food Chem 54:5292-5298  
Kniel B (2006) bmi aktuell 1/2006:2-4

