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# THE FORMATION OF CARCINOGENIC COMPOUNDS IN SOLUBLE POWDER OF JERUSALEM ARTICHOKE

**Abstracts**

The extraordinary problem of production of quality foodstuffs is that they have various harmful substances, heavy metals and radionuclides. The most dangerous things for human health are cancerogenic substances which contained in negligible concentrations in foodstuffs and cause malignant formations in organism. One of the most dangerous carcinogen is N – nitrozodymetylamin wich is formed during formation amine groups under the influence of temperature. This paper presents the results of researches to determine the formation of N – nitrozodymetylamin during receiving powdered extract of Jerusalem artichoke.

## Introduction

The problem of food-stuff contamination with substances causing cancer is highly topical now in connection with establishing of great quantity of small and middle enterprises engaged in production of food-stuff and processing of farming raw-materials [2]. These enterprises are in rush to get profit as soon as possible and not always strict to proper technologies, and technological equipment that not always fit for realisation of concrete production tasks. To add, the flow of production of low quality made abroad is of great concern [6].

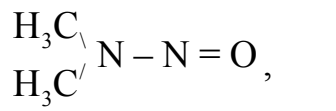
Due to introduction of obligatory certification of all goods there is a possibility to make analysis revealing content of various hazardous substances, heavy metals and radionuclides in food-stuff, but still some harmful admixtures containing in products are of no attention. The most dangerous substances for a man are those causing cancer. Their contemptible quantity in food-stuff can lead to malignant tumours in organism [1].

Research of NA in food-stuff has been treated in Ukraine since 1969. During investigation of cancerous substances content in malt and beer conducted by collaborators of National University of Food Technologies, Institute of Food Industry at Academy of Medical Science in Russia and scientific-industrial unions of beer and alcohol-free manufacturing there was revealed N-nitrosodimethylamine mainly (NDMA).

## Problem research

NDMA is very affective cancerous substance numbered to other nitrosocombinations by International Agency on Cancer Investigation (IACI) as a combination cancerous properties of which are of no doubt. Attack of this cancerous substance is fully described in literature [4, 5].

The structural formula of NDMA is as follows:

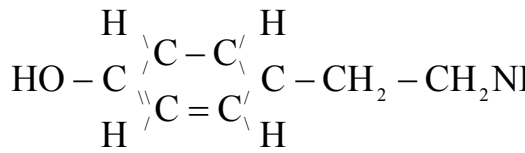


(1)

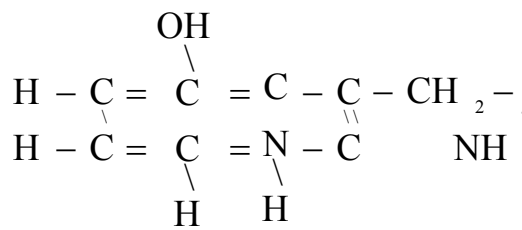
molecular weight is 74,0; density is 1001,8 kg/m$^3$, boiling temperature is +153 °C. The substance is easy dissolved in water, thermoresistant in the temperature range of technological process of Jerusalem artichoke extraction, and due to all these properties can be easily transferred into a ready product.

NA appears as a result of nitrosation of amines and aminocombinations. Nitrosation is realised by nitrogen acid and its derivatives. Therewith, secondary amines form stable NA. Nitrogen oxides, nitrates and products of their transformation should be numbered to the NA predecessors.

Accumulation of amines in Jerusalem artichoke extract is initiated during the process of extraction. Investigation of chemical content of Jerusalem artichoke showed that its roots contain 0,4 % of amino acid at 21,5 % of dry substance in the total mass of the plant. At the extractivity of Jerusalem artichoke approximately 10 % extract contains 17 μ/kg of amino acid. In the process of extraction they form amines such as tiramine and triptamine:

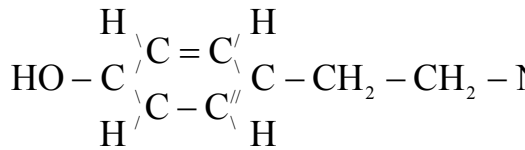


- tiramine; (2)



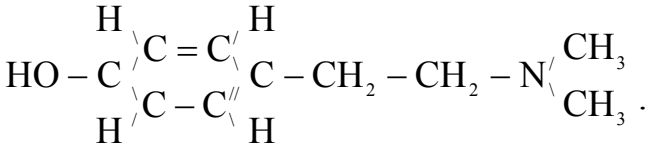
- triptamine. (3)

By the action of ferments the process of metalisation of tiramine accompanaying with N-methyltiramine formation, takes place:



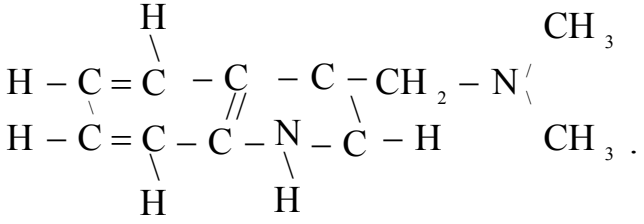
(4)

At the time of administration of another combination, gordenine, agromatic combination, is derived which is to be considerd as NDMA prdecessor:



(5)

Metalization of triptamine is realised analogically to formation of gramine:



(6)

Nitrosation of amines is affected by means of nitric acid and products of its decomposition. Nitrates can be found mainly in soil and plants. One can consider remains of nitric fertiliser in fields as the source of accumulation in soil. Ammonia that can be derived as a result of albumen decomposition, is oxidised under the effect of micro-organisms according to the following scheme:

$$2NO_3 - O_2 \rightarrow HNO_2 + 2H_2O\ ; \tag{7}$$

$$2HNO_2 + O_2 \leftrightarrow 2HNO_3\ . \tag{8}$$

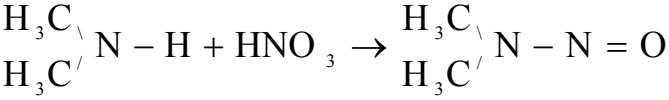
A little quantity of nitrates and nitrites in atmospheric air caused by intensive development of industry and transport can be marked.

The way of penetration of nitrites and nitrates is technical water. The most reactively capable among them is nitrogen dioxide ($NO_2$). The reaction of nitrogenous and nitrogen oxides takes place in the extract.

$$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2\ . \tag{9}$$

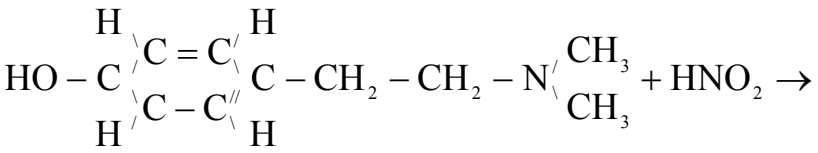
Content of main quantity of NDMA in the extract from Jerusalem artichoke testifies the fact that nitrosation of amines is realised both by the products of decomposition and nitrogen oxide proper. It can be explained by linking of nitrates and nitrites with other matters before amines accumulated which are predecessors of

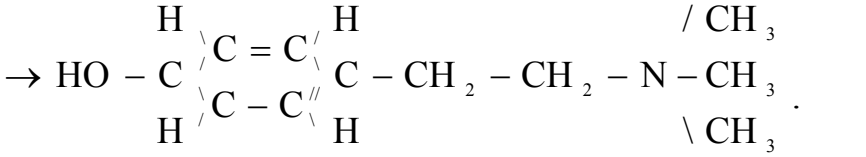
Dimethylamine is formed in the process of extraction of dry substance by extragent (water) from the cells of Jerusalem artichoke chips according to the following scheme:



(10)

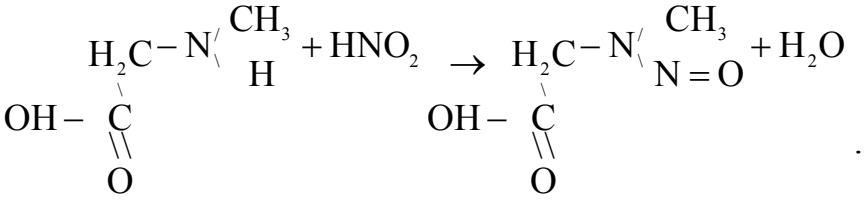
Under the same conditions the reactions of gordenine and gramine nitrosation are possible. For example, gordenine is nitrosided as follows:





(11)

At the temperature of drying above 60°C some amino acids such as sarcosine can be subjected to nitrosation:



(12)

sarcosine nitrosarcosine

And as a result of dicarbonsination of nitrosarcosine NDMA can be formed.

Works reviewed made it possible to determine the average daily usage of NA by a man in different regions of the world. In Federal Republic of Germany for example every inhabitant consumers 7,0-1,0 μ/kg of NA per week.

## Results and discussion

Results of the experiments conducted on Jerusalem artichoke, sort «Interes» of spring harvesting in 2013 using laboratory equipment showed that the recreated processes of extraction and evaporation are typical for real conditions. Extract and its concentrate from Jerusalem artichoke were of high quality.

It was established that the vigour of accumulation of NDMA during the extraction from Jerusalem artichoke increases as the concentration of dry substance in extragent is risen that testifies nitrosation of amines and aminogroups during transition from the cells of Jerusalem artichoke chips into the solution by nitrogen acid and by products of its decomposition. Nitric acids, nitrates and products of its transformation are also subjected to nitrosation. Increasing of NDMA formation activity in the middle of the extraction process can be explained by the fact that only secondary amines are stable.

Rising of process time also influences negatively on the quality of extract, therefore to intensify extraction. the process took place during boiling [3].

The second main factor that influences the process of NDMA formation in the process of extraction is acidity of environment. Extreme of intensity of NA formation is observed at pH≈3. The process reduces as pH increases and with reducing towards alkali environment (fig. 1.).

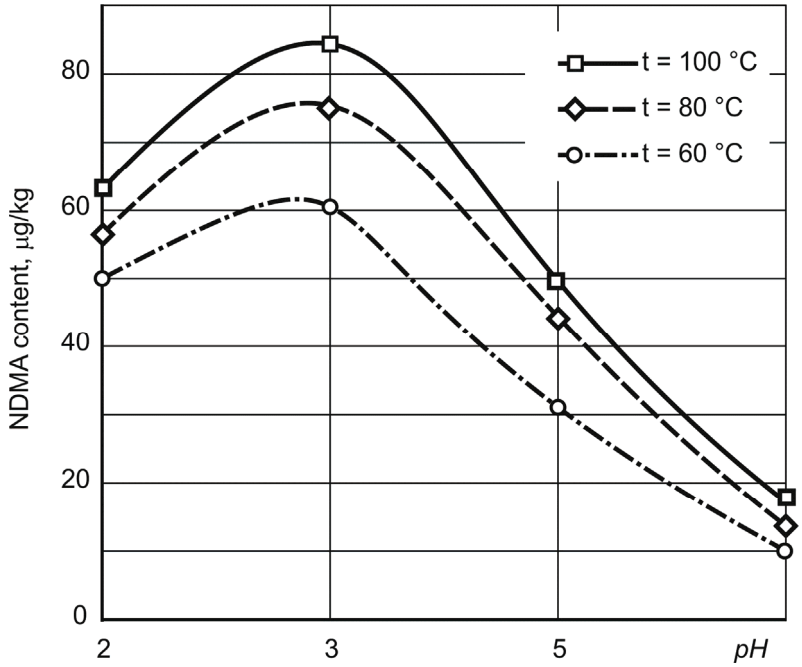



***Fig. 1.*** **The plot influence of temperature and acidity of environment on NDMA content in the extract of Jerusalem artichoke**

For experiments aimed to evaporation of extragent the installation was used remarked by the fact that condensate from condenser was removed and did not returned into the device again. The results of the experiments shows that there is a running of processes of NDMA formation typical for process of extraction (fic. 2). But alongside with further nitrosation of amines, nitrates and products of its transformation under the influence of temperature, rising of temperature is also causes reducing of NA concentration in concentrate of extract from Jerusalem artichoke (fic. 3). The given process is explained by volatilisation of nitrosamines towards carrier, i.e. water steam.

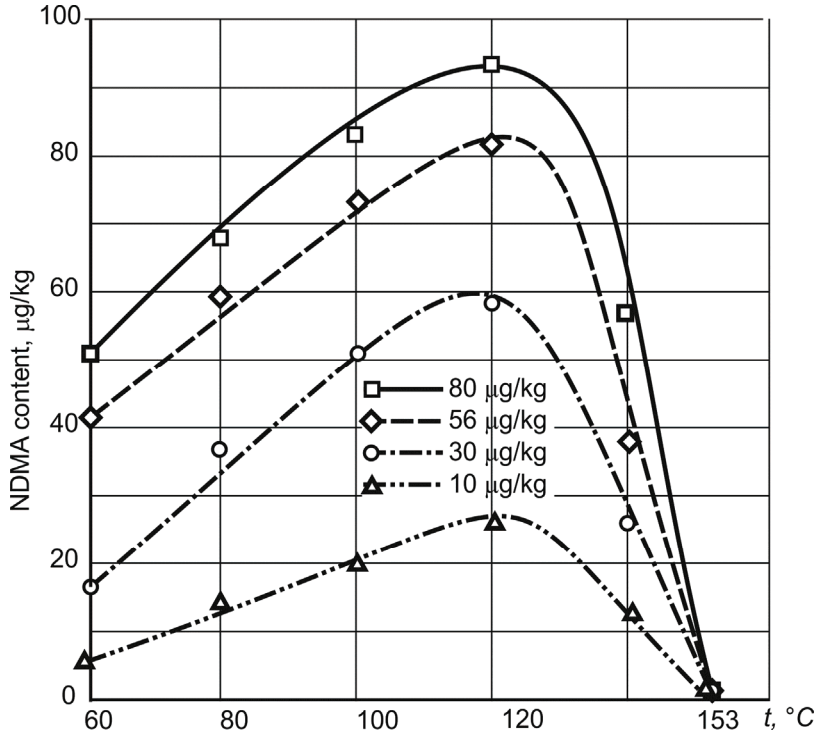



***Fig. 2.*** **Graphs of the effect of temperature on evaporation NDMA content in the concentrate extract of Jerusalem artichoke**

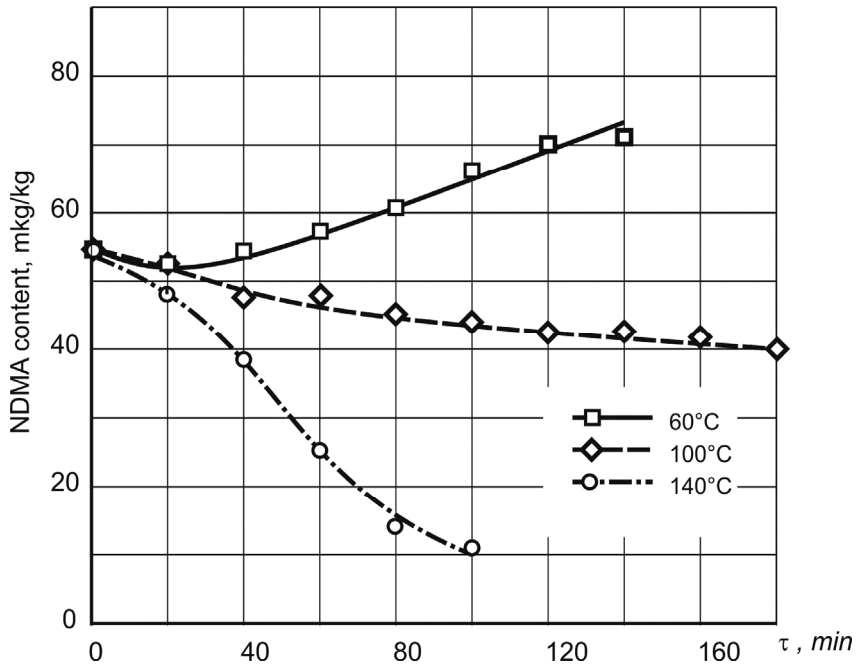



***Fig. 3.*** **Accumulation of NDMA during evaporation**

In the process of drying using experimental installation it was established that concentration of nitrogen dioxide during its running through drying camera is dropping that proves absorption of nitrogen dioxide by extract from Jerusalem artichoke. More intensive absorption of $NO_2$ is observed on the first stage of drying and is ex-

plained by existence in the extract of great amount of free moisture, an excellent absorber of nitrogen dioxide.

On the second stage of drying when moisture of extract is lower the zone of moisture evaporation is replacing towards the middle of the drop and intensity of nitrogen dioxide absorption is reduced.

On the first stage of drying up to 80 % of nitrogen dioxide absorbed and sorbet by the extract over the whole period of drying at the time of drying of 60 s is the first 40 s.

The quantity of absorbed nitrogen dioxide makes up to 35-50 % of the total quantity, the introduced quantity into the drying camera over the whole period of drying. Moisture realizes absorption producing nitrogen acid $HNO_2$ and products of its decomposition. This fact can be proved by increase of nitrates and nitrites concentration in the extract during the drying (fig. 4).

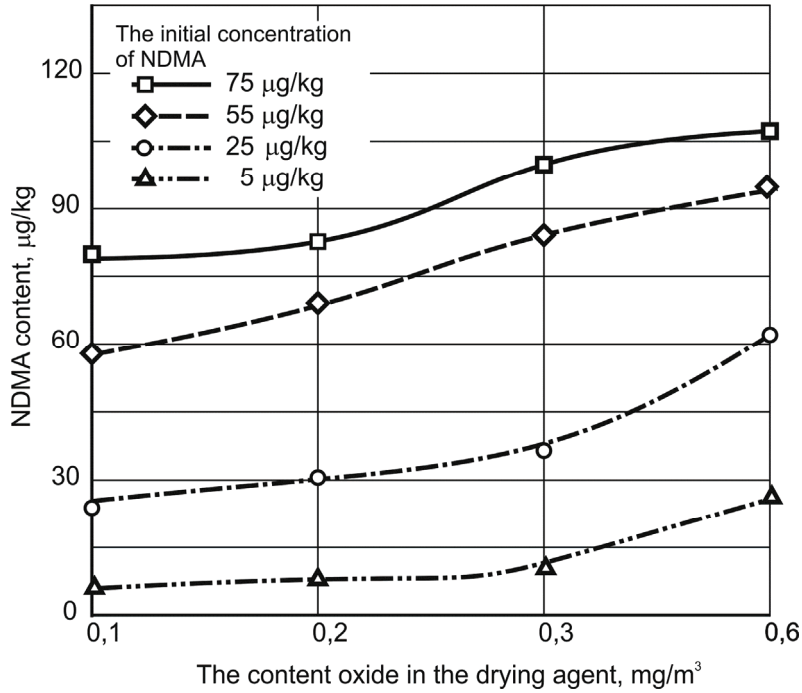



***Fig. 4.*** **Schedule effects of nitrogen dioxide content of the drying agent on the content of NDMA in a dry Jerusalem artichoke extract**

Following dynamic of change in the quantity of nitrates and nitrites it should be stressed the fact of increase of nitrates and nitrites concentration during which intensity increases as concentration of nitrogen dioxide in drying agent at the entrance of the drying camera is also increased. Nitrates and nitrites concentration in the dried extract of Jerusalem artichoke is 7-80 μg/kg, content of nitrates in 4-5 times lesser than nitrates that can be explained by instability of the latter. Nitrates and nitrites concentration in some orders higher in their values needed for NDMA formation in admissibly high concentration which are nominated in μg/kg. During increasing of nitrates and nitrites concentration in the extract, increasing of NDMA content in it was marked.

The concentration of nitrogen dioxide in the drying agent exerts the most effect on intensification of NDMA formation process in the extract from Jerusalem artichoke as it is shown on the plot. Increasing of concentration of nitrogen dioxide in drying agent from 0,1 to 0,6 mg/kg tends to increase NDMA concentration in dry extract from Jerusalem artichoke in 1,2-3 times. NDMA content in dry extract reaches 80 μg/kg.

The results of the experiments on drying by atmospheric air with no dosing of nitrogen oxides shows that formation of nitrates, nitrites and NDMA in the extract from Jerusalem artichoke is still observed. That proves the fact of absorption of atmospheric nitrogen dioxide by the extract.

## Conclusions

Evaluating all facts totality that have effect on the content of NDMA in dry extract from Jerusalem artichoke it should be stressed that the determining factors are: temperature and environmental acidity at the stage of extraction, temperature of evaporation during the extract concentration and in the process of drying the concentration of nitrogen dioxide in the drying agent.

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