# ANTIOXIDANT TREATMENT OF APPLES AT THE DRYING PROCESS

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**Abstract:** The paper presents the results of researches on the use of antioxidants - ascorbic acid, citric acid and sulfur dioxide for the treatment of unpeeled apples, without seeds, cut plates at different thicknesses, different concentrations of solutions and treatment duration. It has been established that the most optimal concentration of SO2 solution is 0.075% at which the technological process can be organized and accumulates a minimum amount of SO2 in the dry product. The optimal parameters for SO2 solution treatment are: apple thickness - 6 mm; time of treatment - 8 min; concentration of the solution 0.075%; temperature of solution 23 ± 2 ° C.

**Key words:** Unpeeled apples, drying process, antioxidants, solutions, immersion.

## Introduction

The food industry of the Republic of Moldova has a significant potential for the processing of the vegetable raw materials. One of the methods of processing that provides a stable preservation is the drying process, which can be carried out by various drying methods. The main problem in drying process, of cut, peeled apples and without seed box is the process of browning at the contact with oxygen with the surface of the cut apple.

Currently, branch companies use different antioxidants to prevent the process of oxidation-reduction (browning) of cut and dried apples. Residual concentrations of SO2 are used from 200 to 1000 mg / kg of dry product. The standards for dried apples used in the Republic of Moldova allow the SO2 concentration in the finished product - dehydrated with brown stains, insect attack, small dehydrated apple pieces, excessive residual of sulfur dioxide as a result of color preservation treatments, mineral impurities etc.

In this context, it is welcomed to solve the problem of processing of peeled apples without seeds, with the elaboration of the technological parameters of manufacturing, at each technological operation, the elaboration of preventive treatment regimes, the selection of the advanced machinery for drying, and elaboration of the technology and techniques for industrial processing of dried apples, and for obtains a quality products with certain properties according to the requirements of the consumer.

The aim of the research is to establish the optimal technological parameters of treatment at each technological process, by antioxidant treatment of cut and unpeeled apples, the analysis of the chemical and physico-chemical for quality indices, the organoleptic and rehydration properties of dried apples.

## Materials and methods

For research, as raw material was used fresh apples - Iadared from the northern part of the Republic of Moldova in the baking and consumption era. During the research process the apples were stored in the refrigerator at a temperature of 0…1,5 °C and humidity 90 ± 2,0%. The apples were subjected to the washing process, water leakage, process of peeling and seeds removal, plate cutting, treatment with antioxidant solutions to stop the browning process and convective drying at 80 ± 2 ° C. As solutions of antioxidants was used ascorbic acid, citric acid and sulfur dioxide - SO2. The quality of

fresh apples - raw material, the quality of dried apples was determined by standard methods - the mass of dry substances, the total acidity and pH, the content of carbohydrates, color and amount of polyphenols - by the spectrophotometric method.

**Results and discussions**

For study the antioxidant treatment process, were selected 3 substances with antioxidant properties: ascorbic acid, citric acid, SO2. From these substances were prepared the solutions with concentrations specified in the table below.

***Table 1.*** Preparation of acid solutions

| Acid name | Concentration, % | Amount per 1 liter of solution | | |
|---|---|---|---|---|
| | | Acid, g | Sodium chloride, g | Water, g |
| **Citric** | 2 | 20 | 1,5 | 978,5 |
| **ascorbic** | 2 | 20 | 1,5 | 978,5 |
| | 6 | 60 | 1,5 | 938,5 |

Treatment with 2% citric acid and 2% and 6% ascorbic acid at various time, from 4 to 20 minutes by immersion and drying of these apple samples, didn't show the expected effects, but the acidity of the dry product, preventively treated with 6.0% ascorbic acid solution is very high and causes sensation of discomfort in organoleptic tasting. Apples treated with solutions of 2.0% citric and ascorbic acids are white-brown and don't meet the requirements of quality for dried apples. These acids have been excluded from experimental research.

At present, in the processing industry, sulfur is used to obtain dried apples with a pleasant appearance, natural color and long-term storage. It can be used both in gaseous form and as solutions. Researching the bibliographic sources, it has been noticed that requirements for SO2 content in dried apples differ across countries. In Republic of Moldova, SO2 content of dehydrated apples must not exceed 0,1% (1000 mg / kg), in Romania - 0.02% (200 mg / kg). Since SO2 is a toxic substance that can have serious consequences for human health, it has been decided to carry out research into the reduction of residual SO2 content in the product - dried apples. In order to study the process of SO2 treatment of apple and cut apples, solutions of the concentrations specified in Table 2 were prepared with the addition of sodium chloride at the concentration of 2%.

***Table 2.*** Preparation of SO2 solutions

| Required concentration, % | Amount per 1 liter of solution | | |
|---|---|---|---|
| | Sodium bisulfite, g | Sodium chloride, g | Water, g |
| **0,050** | 2,085 | 2 | 995,92 |
| **0,075** | 3,127 | 2 | 994,87 |
| **0,100** | 4,170 | 2 | 993,83 |
| **0,150** | 6,255 | 2 | 991,75 |
| **0,200** | 8,340 | 2 | 989,66 |
| **0,250** | 10,425 | 2 | 987,58 |
| **0,300** | 12,510 | 2 | 985,49 |

Preparation of the solutions is done as follows: in the 1000 $cm^3$ flask is added the sodium bisulfite mass, containing 24% SO2. Is added distilled water at 20 - 25 °C to 3/4 of the volume of the flask. The compounds are mixed vigorously, then 2 g of NaCl is added to obtained solution and again vigorously mixed. After that is added the solution to distilled water and shake to completely dissolve the components.

In order to study the optimization of the sulphurization process of cut and peeled apples, first was studied the possibility of using SO2 solutions of different concentrations. Fruits cut to 6 mm thick plates were subjected to SO2 treatment solutions by immersion in the solution with hold time 8 min, then subjected to drying at a temperature of 80 °C heat. The positive effects of the solutions for all the studied samples were observed. A finely finished product with a pleasant appearance and an apple variety characteristic is obtained. No essential color changes occurred during drying and storage for 12 months. Treated apples at different concentrations (Table 2) of SO2 at one and the same time provide the various concentrations showed / SO2 content in the dried product. The results obtained are shown in Figure 1. An excess concentration of SO2 in the dry product can be noted for treatment in solutions with a concentration greater than 0.15%. By analyzing the residual SO2 content in the dried product (Figure 1) it can be noted that the concentration of the solution in the range of 0.05 ... 0.15% sulfur dioxide accumulation in the dried product is virtually proportional to the concentration of the treatment solution. At a concentration greater than 0.16% in the solution, the SO2 content in the final product is suddenly increased to a concentration of 0.2%, after which the accumulation of SO2 is slow within the range of 0.2 ... 0.3%.

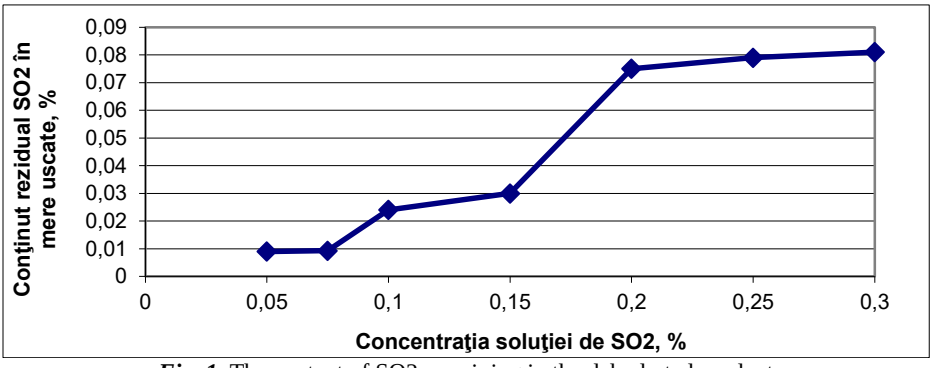


***Fig. 1***. The content of SO2 remaining in the dehydrated product

Also, the graph shows that only in the case of apples treated with solutions of 0.05 ... 0.15% concentrations of residual sulfur content meets the requirements of the regulation "Sanitary rules and regulations concerning food additives" of 0.06% and only dried apples treated in solutions with concentrations of 0.05 and 0.075% to 0.02% corresponds to the value set in the "norms on the nature, content, production, quality, packaging, labeling, storing and transport of dehydrated apples" of Romania. The retained content of SO2 in 0.05 and 0.075% solutions differs insignificantly.

Pre-treated dry apple samples at various concentrations of SO2 solutions have accumulated different amounts of sulfur dioxide. The product was stored in the desiccator for 1.5 months, after which the color was visually determined. An insignificant color in

dry apple at the concentration of 0.075% was found. Starting with the concentration of 0.075% and up to 0.3%, the apple color was identical and uniform throughout its surface and volume. For these reasons, the minimum optimal concentration required to treat 0.075% apples at the treatment time of 8 minutes was selected. In order to determine the optimal parameters in terms of thickness of the layer, were carried out researches on the drying apple plates of 4, 6, 8, 10, 12 mm, which were preventively treated with solution at the concentration of 0.075%. The dried apple plates were characterized by one and the same color - light cream, maintaining their natural appearance. In dry apples the residual SO2 content was determined, which is different depending on their thickness. The results obtained are shown in Figure 2. Analyzing the curve of the concentration of SO2 concentration in the dry product (Figure 2) it can be mentioned that the maximum residual sulfur dioxide content in the product is maintained in the plates with a layer thickness of 8 mm. The concentration distribution curve of SO2 is characterized by a maximum of 8 mm layer thickness.

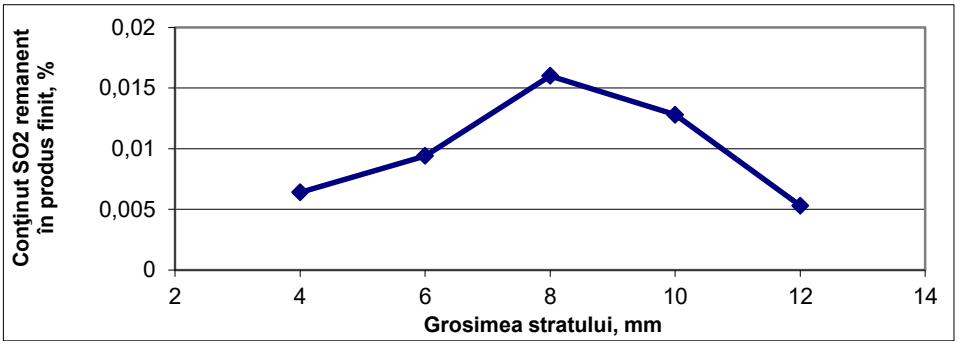


***Fig. 2.*** Residual SO2 content in dehydrated apples treated with SO2 solution at the concentration of 0.075% and duration 8 min.

This process can be explained by the diffusion of the sulfur dioxide solution, which reaches the center of the slices to 8 mm in thickness for 8 minutes. For thicknesses greater than 8 (up to 12 mm) the diffusion does not reach the center of the product. The higher thickness of the layer, the greater amount of pulp of the plates is not treated with SO2. That is why in the finished product the amount of sulfur accumulated in a layer of 4 mm on one side and the other refers to the whole volume, which leads to the reduction of the SO2 quantity. In the thicknesses of 4, 6 and 8 mm, the SO2 diffusion occurs up to the center of the product, inactivation of the enzymes takes place under the action of SO2. In the case of 4 and 6 mm thick layers, most of the sulfur is removed during drying and storage, whereas in the 8 mm thick plates the sulfur is removed from the superficial layers but is maintained in larger amounts in the center of the product. In apple boards with a layer thickness of 10 and 12 mm, diffusion occurs only in the superficial layers. In their center, enzyme inactivation takes place only under the action of the drying agent temperature. Due to the large thickness of the layer, the sulfur can't penetrate to the center and is eliminated in large proportions during drying and storage. In order to study the optimization of the apple sulphiding process at various time exhibitions, researches were carried out with solutions of concentration of 0.075% and thickness of 6 mm layer. The cut apples were treated with SO2 in antioxidant solution for 2 ... 12 min. with the 2 minute

interval. The results obtained are shown in Figure 3. A linear increase of the SO2 content in the finished product is observed with the increase of the treatment time in the solution up to 8 minutes. In the samples exposed to antioxidant treatment for 8, 10 and 12 minutes, the SO2 content remains approximately constant.

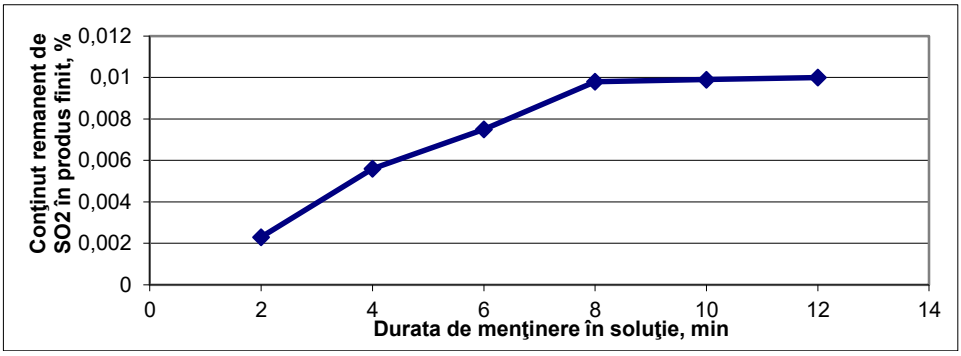


***Fig. 3***. Residual SO2 content in apple slices of 6 mm thickness depending on the duration of exposure in solution of 0.075%

The treatment of cut apples over 8 to 12 minutes practically doesn't influence the increase of SO2 concentration in the finished product. This situation can be explained by the small difference in the concentration of the solution and the sulphated product, which virtually stops the further accumulation of sulfur in the treated apples. This phenomenon has an advantage in the process of sulphation and drying because, in case of degradation of the treatment period, the SO2 accumulated by the apple doesn't adversely affect the quality of the dry product, which ensures a minimum SO2 concentration according to the sanitary norms and norms of food additives" in Moldova.

## Conclusions

1. The research has demonstrated the efficacy of sulfur dioxide in the antioxidant treatment of plate, cut apples to ascorbic acid and citric acid.

2. In the antioxidant treatment of apples with SO2 solutions, the most optimal concentration is 0.075%, at which the technological treatment process can be organized, which leads to the accumulation of the minimum quantity of SO2 in the dry product.

3. The optimal parameters for SO2 solution treatment are: cut apples thickness - 6 mm; treatment time - 8 min; concentration of solution 0.075%; solution temperature 23 ± 2 °C.

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