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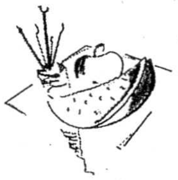

PROCESS OPTIMIZATION AND MINIMAL PROCESSING OF FOODS

Contract CIPA - CT94 - 0195
COPERNICUS PROGRAMME

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Minimal & Combined Processes

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P3.2/P - Combined Treatments using Bacteriocins for Inhibition of Growth of *Listeria monocytogenes* - J. FARKAS, University of Horticulture and Food Industry, Budapest, Hungary

P6/SC - High Oxygen-Modified Atmosphere Packaging, a Novel Approach with Minimally Processed Vegetables - L.G.M. Gorris and A. AMANATIDOU, Institut voor Agrotechnologish Onderzoek, Wageningen, The Netherlands

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P12.2/P - Optimisation of Pre-Cooking and Extension of Shelf-Life for Sous Vide Cooked Meat - M. Voldrich and T. MARTENS, Alma University Restaurants VWZ, Leuven, Belgium

P12.3/P - The use of Lactic Acid and Lactates in the Mechanically Deboned Poultry - P. Pipek, J. BRYCHTA and J. Jelenikova[1]

P12.4/P - Active Packing - Immobilisation of Preservatives on/in PPacking Materials - J. Dobias, M. VOLDRICH, M. Marek and M. Cerovsky, Institute of Chemical Technology, Praha, Czech Republic

PROCESS OPTIMIZATION AND MINIMAL
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Application of Hydrodynamic Cavitation for Purification of Water-Alcohol Solutions

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The main objective of this paper is to show how some injurious phenomenon, known in fluid dynamics as hydrodinamic cavitation, can be successfully used for purification of water-alcoho solutions. The water-alcohol solution mixed with active carbon flows through a zone of strong hydrodynamic cavitation. The active carbon is previously ground and activated. The active carbon and the air that is in its micropores serve as nucleous for cavitation cavern centres. Th cavitation effect ensures additional penetration of the water-alcohol mixture into the whole volume of adsorbent and contributes to the improvement of the oxidation and adsorption properties of the active carbon. In this method, cavitation blows are concentrated on th surface of adsorbent grains and, after their disintegration, new adsorption and cavitatio centres are continuously generated. In the zone of developed cavitation silver ions are released, which additionally accelerate the oxidation processes on active carbon. The metho of cavitation treatment possesses high productivity and does not require much energy. The spectral characteristics in UV field of water-alcohol solutions were used to assess the extent of their clarification. On the base of experimental investigations, a mathematical model was obtained. The experiments were carried out under various conditions with different cavitation numbers. It was found that the cavitation treatment leads to quantitative changes in the mixture. The quantity of higher alcohols, esters, aldehydes and volatile acids was lower in the samples treated by cavitation than in the control ones.

P11.5/P
Minimal & Combined Processes

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APPLICATION OF HYDRODYNAMIC CAVITATION FOR PURIFICATION OF WATER-ALCOHOL SOLUTIONS

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ABSTRACT

The main aim of this article is to show how some injurious phenomena, known in fluid dynamics, can be successfully used for purification of water-alcohol solutions. Such phenomenon is the hydrodynamic cavitation. The water-alcohol solution mixed with active carbon passes through the zone of a strong hydrodynamic cavitation. The active carbon is previously ground and activated. The active carbon and the air that is in its micropores serve as formators of cavitation cavern centres. The cavitation effect ensures additional penetration of the water-alcohol mixture into the entire volume of the adsorbent and contributes to the improvement of the oxidative and adsorptive properties of the active carbon. In this method, cavitation blows are concentrated on the surface of adsorbent grains and continuously, after their disintegration, a new adsorption and cavitation centres are generated. In the zone of developed cavitation silver ions are released, which additionally accelerate oxidation processes on active carbon. The method of cavitation treatment possesses high productivity and does not require much energy. The spectral characteristics in UV field of water-alcohol solutions were used to assess the extent of their clarification. On the base of experimental investigations a mathematical model was obtained. The experiments were carried out under various conditions. It was found that the cavitation treatment lead to quantitative changes in the admixture. The quantity of higher alcohols, esters, aldehydes and volatile acids was lower in the samples treated by cavitation than in the control ones. The cavitation treatment can be used in different fields of food technology for purification of liquid foods.

1. INTRODUCTION

One of the main problems in the development of new food technologies is how to increase the shelf-life of food products. Another problematic aspect is how to purify the food products from undesirable impurities as well as to obtain homogenous mixtures with the aim of their incorporation as additional components in bulk masses. Numerous methods for solving these problems are known. The physical methods have been widely applied in the recent years.

The aim of this work is to demonstrate how some harmful phenomena known in fluid dynamics can be utilized for solving the discussed matters. Such phenomenon is the hydrodynamic cavitation (White, 1994). The cavitation influence on the surfaces, surrounding the site of its generation is known. Destruction of the surfaces as a result of cavitation caverns impact is observed. This fact created the idea to utilize the opportunity for hydrodynamic treatment of liquid foods mainly by cavitation impact.

2. MATERIALS AND METHODS

The first tests were carried out with the aim of qualitative estimation of cavitation impact on the shelf-life of drinks "Schweppes". The experiments were carried out on the experimental device, described in details in (Angelov *et al,* 1983). The results showed that the shelf-life of the drinks "Schweppes" increased approximately twice.

The other type of experiments was carried out with the aim of improving the composition of Soya milk in regard of its homogeneity. It was found that the disperse structure of Soya milk was significantly improved. Fine grinding of the solid components under the cavitation field influence was observed that allowed a better perception of Soya as food additive.

The main course of experiments was carried out with the aim of investigating the effect of physical and physique-chemical impact of the cavitation field on the processes taking place on the phase surface solid-liquid. It turns out that the changes in the pressures and local superheating, together with the surface microwaves, provoked by the ultrasound can be successfully used to increase the adsorbtivity of the natural adsorbents. The adsorption goes on under radically different conditions. The conditions for adsorption in adsorption columns are well known and described (Taran, 1983). The liquid velocity near the adsorbent is very low, the liquid is practically static and the adsorption goes slowly mainly due to slow diffusion process. It is proven that the active surface in this case is within 5-10% (Taran, 1983). The difference of the conditions is due to fact that the adsorbent is mixed with the liquid and they moves together at a velocity that allows cavitation in a particular zone to be formed. The cavitation impact, mainly expressed by cavitation percussion, is concentrated on the surface of the adsorbent granules while new adsorption centres are continuously being formed.

At the same time the adsorption strains and the air in their micropores play the role of cavitation centres. As a result, the cavitation formation takes place much earlier. Silver ions are being released in the cavitation field zone. They catalyse the oxidative processes by intensifying the decomposition and the binding of badly smelling impurities. The cavitation capillary effect contributes to a better penetration of the liquid into the entire volume of the adsorbent that favours multiple increase in oxidative and adsorptive properties of the adsorbent. The intensively developed cavitation erosion has also a positive effect. The preliminary studies showed that the comparatively best quantitative and qualitative estimation can be done when water-alcohol solutions were processed. The most correct analytical data about the purification level of these solutions can be obtained spectrophotometrically when active carbon is used as an adsorbent (Podlubya, 1984). In addition the number of testers is the highest in this field of sensory evaluation of purification of water-alcohol solutions.

The optical density **D** of the processed alcohol in the UV region is the parameter under control. When the absorption spectra of the alcohol impurities as well as of the fractions from alcohol rectification were studied it was established that the diluted ethanol has an absorption maximum at the λ=260 nm. That is the reason **D** to be recovered at this wave length. The spectrophotometrical method is based on the property of the various product impurities to absorb UV light. Pure ethanol and distilled water do not absorb UV light from the range of 200-350 nm. The value of contamination with organic impurities is characterised by the parameter optical density **D** in UV region. As the optical density decreases, the amount of badly smelling and harmful substances decreases as well. The difference between **D** of the product before and after treatment with active carbon characterises its adsorption activities and the effect of purification respectively.

The following parameters influencing the final product quality can be chosen with the aim of experimental design:

- - percentage of alcohol in water-alcohol solution - %,
- - adsorbent quantity per product unit - g/dm,
- - quantity of hydrogen peroxide necessary for the intensification of oxidation, dm^3/dm^3,
- - catalyst- $AgNO_3$, (silver nitrate) - mg/dm^3,
- - time for treatment - min,
- - cavitation number

When these parameters are chosen, the conditions for their independence and compatibility are taken into consideration i.e. they have to be measured and controlled in the course of the whole experiment.

3. RESULTS AND DISCUSIONS

To carry out experiments with the aim of utilisation of water-alcohol mixtures for perfumery industry, the following parameters were chosen:

- X_1 - water-alcohol solution
- X_2 - adsorbent quantity (in this case active carbon was used)
- X_3- quantity of hydrogen
- X_4- time for treatment.

The experiments were carried without catalyst and at constant cavitation number. The natural values of the factors are shown in table 1. The experimental design from the type 2^4=16 was used. The experiments were taken using a experimental device shown in fig.1. The water-alcohol solution mixed with active carbon passes through the zone of a strong hydrodynamic cavitation. The active carbon is previously ground and activated. The active carbon and the air that is in its micropores serve as formators of cavitation cavern centres.

Fig.2 shows the variation in spectral density when the chosen parameters were combined : X_1 at the upper level, the rest - at the lower level and different time of cavitation impact. The effect of purification in comparison to the control sample grows with the increase of the time for cavitation treatment. The same result is also observed in other combination of the parameters - fig.3. Statistically significant differences between treated and non-treated samples are established by tasting that expresses the improved product quality. It was found that the cavitation treatment leads to quantitative changes in the admixture. The quantity of higher alcohols, esters, aldehydes and volatile acids was lower in the samples treated by cavitation than in the control ones.

With the help of the matrix for experiment design, shown in table 2, with a PC and level of confidence 95%, we have received adequate regression equation that describes the relations between the parameters of optimisation and the independent variables which natural value and coded values are shown in tables 1 and 2 respectively (Cornel, 1981).

$$D = 0.035 - 0.024X_1 - 0.0005X_2 - 0.001X_1X_2 - 0.0057X_1X_3 + 0.0016X_1X_4 + 0.004X_2X_4$$

This equation describes the significance of every variable and the average results of three parallel experiments are shown in table 2.

Table 1
Intervals of variation of the process variables

Independent variables (Input factors)	Basic level	Interval of variation	Upper level	Lower level
X_1, water-alcohol solution - %	83	13	96	70
X_2, active carbon - g	40	20	60	20
X_3, quantity of hydrogen - ml	10	5	15	5
X_4, time for cavitation treatment - min	7	4	11	3

Table 2.
Matrix for experiment design

Number of experiment	X_0	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3
1	+	-	-	-	-	0.058	0.059	0.056
2	+	-	+	-	-	0.055	0.056	0.052
3	+	+	+	-	-	0.030	0.031	0.029
4	+	+	+	-	-	0.003	0.003	0.003
5	+	-	-	-	+	0.052	0.051	0.050
6	+	-	+	-	+	0.051	0.050	0.051
7	+		-	-	+	0.002	0.002	0.002
8	+	+	+	-	+	0.034	0.035	0.036
9	+	-	-	+	-	0.066	0.064	0.068
10	+	-	+	+	-	0.078	0.077	0.076
11	+	+	-	+	-	0.017	0.019	0.018
12	+	+	+	+	-	0.001	0.001	0.002
13	+	-	-	+	+	0.060	0.058	0.059
14	+	-	+	+	+	0.058	0.056	0.055
15	+	+	-	+	+	0.003	0.004	0.002
16	+	+	+	+	+	0.001	0.001	0.001

We can make the following conclusion from the experimental investigation and from analysis of the regression equation:

1. The cavitation treatment contributes to the increase of the quality of the liquid food products.
2. Decreasing of the spectral density is the proof of the purification.

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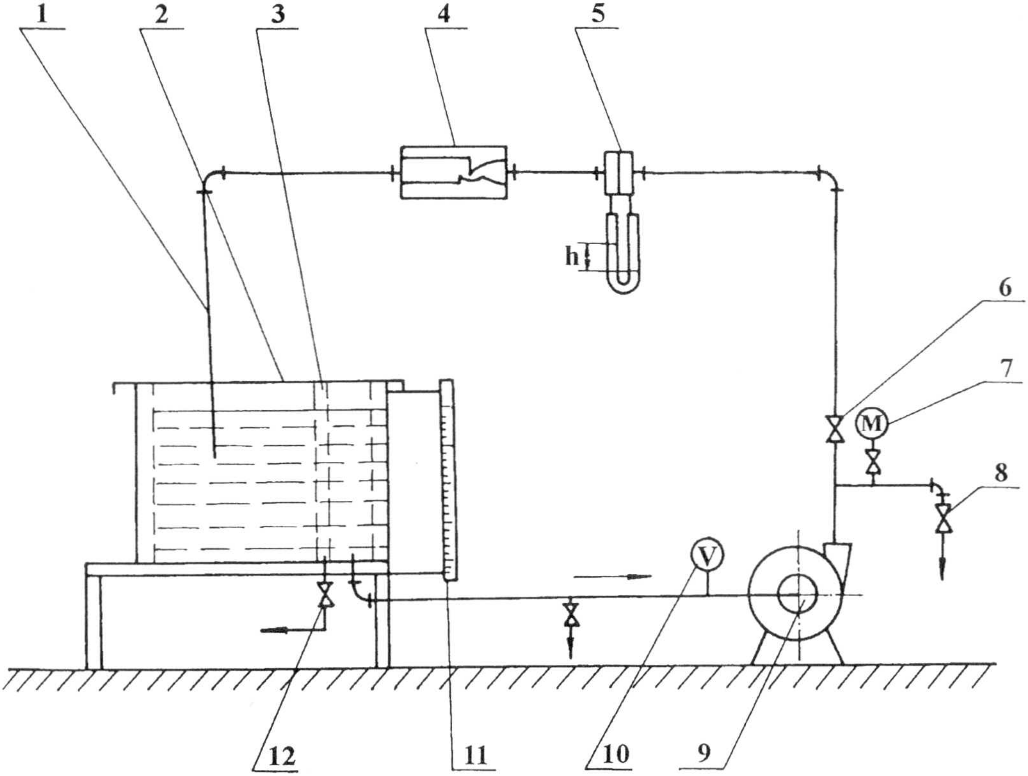

FIGURE 1.1- pipe system, 2 - feed-tank, 3 - grid, 4 - cavitator, 5 - flowmeter, 6 - turn-cock, 7 -pressure gauge, 8 - turn-cock, 9 - rotary pump, 10 -vacuum gauge, 11 - level gauge , 12 - turn-cock

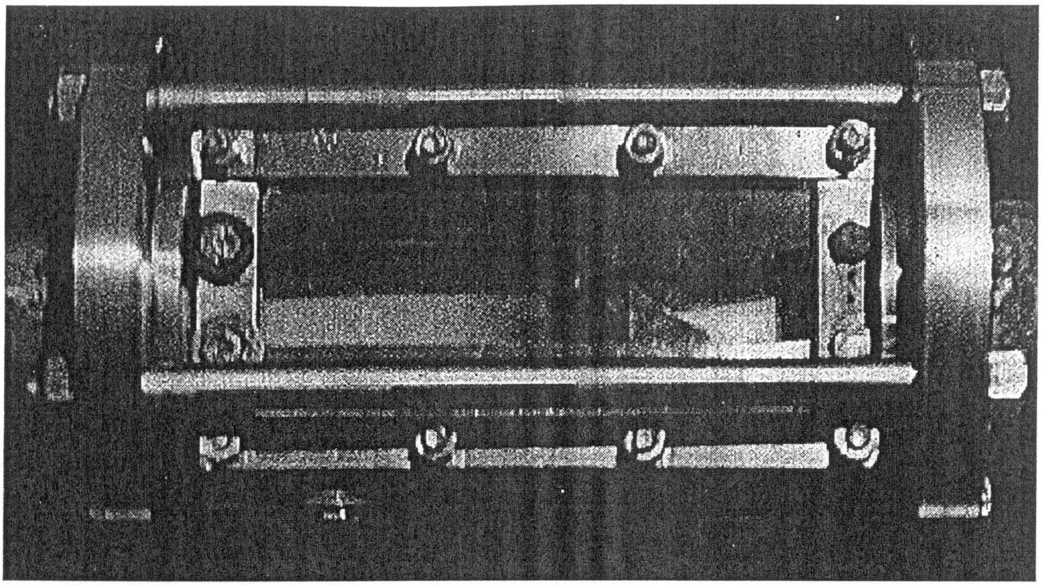

FIGURE 2. A photo of the cavitator

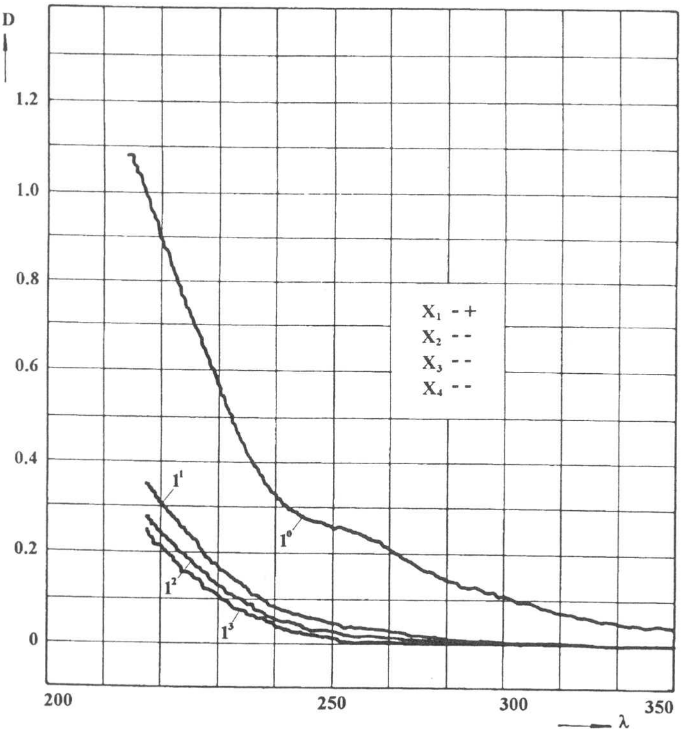

FIGURE 3. Changing of the spectral density on different time of cavitation treatment, when X_1 is in upper level and X_2, X_3, X_4 - in lower level; 1^o - control sample ,1^1 -3 min,1^2 - 7 min,1^3 -11 min;

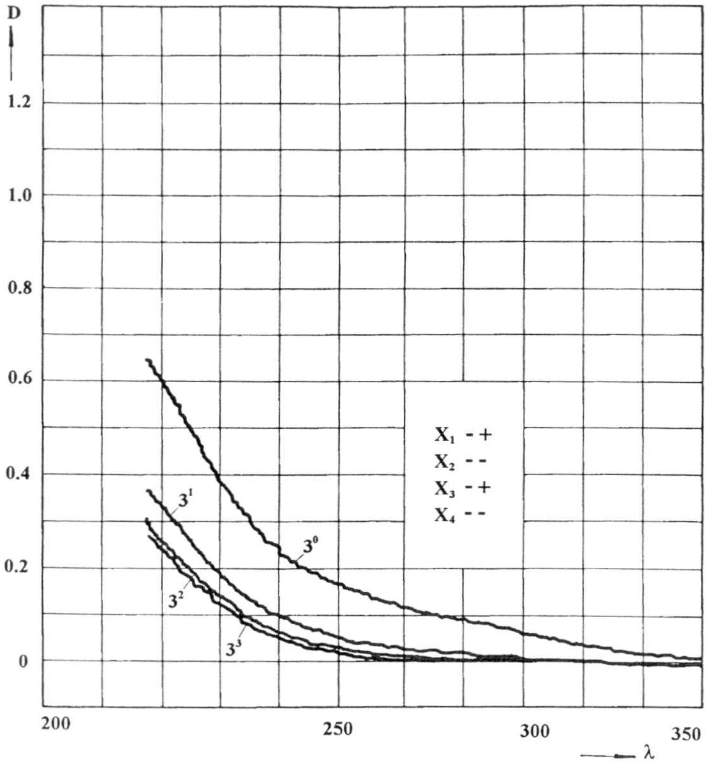

FIGURE 4. Changing of the spectral density on different time of cavitation treatment, when X_1 and X_3 is in upper level and X_2, X_4 - in lower level; 1° - control sample ,1^1 -3 min,1^2 - 7 min,1^3 -11 min;