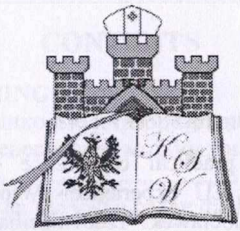
Kujawska Szkoła Wyższa we Włocławku
(Cuiavian University in Wloclawek)

TECHNICAL SCIENCES: HISTORY, THE PRESENT TIME, THE FUTURE, EU EXPERIENCE

INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE

Wloclawek, Republic of Poland
September 27–28, 2019



Cuiavian University in Wloclawek

International scientific and practical conference

TECHNICAL SCIENCES: HISTORY, THE PRESENT TIME, THE FUTURE, EU EXPERIENCE

September 27–28

ELECTRICAL ENGINEERING
POWER ENGINEERING
CONSTRUCTION
ARCHITECTURE
FOOD INDUSTRY
CHEMICAL TECHNOLOGY AND INDUSTRY
GENERAL ISSUES OF THE TECHNICAL SCIENCES

Wloclawek,
Republic of Poland
2019

International scientific and practical conference «Technical sciences: history, the present time, the future, EU experience» Wloclawek, Republic of Poland, September 27–28, 2019. Wloclawek: Izdevnieciba «Baltija Publishing», 2019. 188 pages.

ORGANISING COMMITTEE
dr inż. **Michał Sójka,** Dean of the Faculty of Mechanical Engineering of Cuiavian University in Wloclawek;
dr inż. **Mirosław Radwański,** Faculty of Mechanical Engineering of Cuiavian University in Wloclawek.

Each author is responsible for content and formation of his/her materials. The reference is mandatory in case of republishing or citation.

ISBN 978-9934-588-08-2

© Cuiavian University in Wloclawek, 2019

CHEMICAL TECHNOLOGY AND INDUSTRY

CAVITATION LIQUID EXTRACTION OF ORGANIC SUBSTANCES

Litvinenko A. A.
Doctor of Technical Sciences, Professor
The National University of Food Technologies

Kadomskyi S. V.
Candidate of Technical Sciences, Associate Professor
The National University of Food Technologies

Boyko Yu. I.
Candidate of Technical Sciences, Associate Professor;
The National University of Food Technologies

Pashchenko B. S.
assistant
The National University of Food Technologies

Shtefan E. V.
Doctor of Technical Sciences, Full Professor
Igor Sikorsky Kyiv Polytechnic Institute
Kyiv, Ukraine

The principal and most lengthy process in existing production technologies for biologically active substances-based preparations is a liquid extraction, effected at a mechanical stirring of a preliminary ground raw material in an extragent. The traditional technology, however, fails to provide a complete enough extraction of components being extracted, and therefore improving the process of liquid extraction of organic substances is aimed at increasing the degree of extraction of the components from the raw material being processed and shortening the process time [1].

One of the most promising ways for solving these problems is to utilize the erosional effect of the hydrodynamic cavitation. It's dispersing effect results from action of numerous force impacts of collapsing cavitation bubbles on the medium being processed and associated physico-mechanical effects which instantaneously break down the cellular structure of the raw material [2].

This process has been effectively implemented in production equipment of a new type: Hydrodynamic Cavitation Apparatus (HCA), where the medium under processing is intermittently or continuously acted upon by hydrodynamic cavitation, purposefully generated in the production flow. The medium is fed by a pump to the HCA, where it passes through a zone of cavitation excited be a cavitator. The governing effect on the efficiency of extraction is exerted by design features of the HCA, parameters of the process, and physico-chemical properties of the raw material.

Processes in the HCA are based on using hydrodynamic cavitation and connected with physical and mechanical effects (shock waves, cumulation, self-excited oscillation, vibroturbolization, straightened diffusion) arising at a collapse of cavitation bubbles. The volume concentration of the cavitation bubbles in devices reaches the value of the order of 1…1010 $1/m^3$. At the collapse of each small bubble pressure pulses reaching 103 MPa are initiated. Such high shock wave pulses with the volume of concentration of bubbles in the operating HCA zone being high make the specific power fed to the unit of volume equal to $10^4…10^5$ kw/m^3. It is several orders higher than the specific power released during the processing of the technological media in ultrasound devices, disintegrators, vortex layer devices. Such an influence results in formation of conditions for occurrence of hydromechanical, physical and chemical processes which are hampered or impossible under ordinary conditions. In addition, a vacuum space with a pressure ranging from 4 to 10 kPa is created in the HCA various liquid and gaseous components immediately to the device.

The HCA advantages are as follows. Increased output: a high carrying capacity helps to reduce mixing process 3…10 fold. Low power rate: at the expense of the local power concentration in the flow. Reaction course acceleration: at the expense of an increase of interphase surfaces the course of the mass transfer processes and chemical reactions is accelerated 2…10 fold. Production quality improvement: essential saving of reagents, emulsifiers, stabilizers and other admixtures. Long service life: at the expense of a simple construction and absence of mowing parts. Minimum of working areas: at the expense of installation immediately on technological pipe lines. All-purpose character of employment: at the expense of a constructive version facilitating its maintenance. The processing may be exercised both periodically and continuously.

The HCA are handy combined with majority of standard equipment but in comparison with it, HCA has considerable advantages. An option of a construction of the HCA and a place of its sating in a scheme is determined by concrete conditions and characteristics of the process.

To study the influence of hydrodynamic cavitation on the process of liquid extraction of organic compounds, the authors conducted laboratory experiments on extraction of adenosine triphosphoric acid (ATP) by water. The raw material was extracted ground meat, processed by the traditional technology, where the practical ATP yield amounts to 1.4-1.6 g per 1 kg of ground meat, depending on its quality. Extracting a greater amount of ATP in the existing processing cycle is impossible. The raw material was processed in the experimental plant as follows. The ground meat, mixed with distilled water in a ratio of 1:20, was drawn from a service tank by a centrifugal pump and fed by it into the HCA, where it was subjected to the action of cavitation. Then the stock being processed was returned to the service tank, and the processing was repeated cyclically. The processing time was of 3-60 s depending on the number of passes through the HCA. Test samples were taken at definite time intervals and the mass content of additionally extracted ATP in them was-determined spectrophotometrically. A number of specific processing conditions were also taken into account in the study. The action on the stock being processed was not too «hard» and long enough; temperature conditions were maintained within 4-5°C.

The results are presented in the table below. Their analysis indicates, that the action bf hydrodynamic cavitation on the process of ATP extraction by water makes it possible to extract additionally 0.34 g of ATP per 1 kg of a ground meat having been, processed by the traditional method and thereby to increase the practical yield of the product by 22% on the average. A prerequisite for this process is that the passage of the stock being processed through the HCA is repeated many times; the greatest effect was observed at 20 processing's. A further processing results in irreversible destructive changes of the product because of a higher force action on the stock and process temperature rise. The provision of required temperature conditions and improvement of hydrodynamic conditions of the cavitation processing, however, can increase the practical ATP yield.

Thus, the use of hydrodynamic cavitation processing in the course of liquid extraction of ATP provides a more complete extraction of the desired component as compared with the technology used at present. Replacement of traditional extractors with HCA in the ATP extraction production line will greatly increase the yield of the finished product, shorten 2.5-3 times the process time, and cut down the specific power consumption.

Results of laboratory studies of ATP extraction from extracted ground meat

Number of passes through HCA	1	3	6	10	20
ATP extraction, g/kg	0.02	0.09	0.11	0.17	0.34

The HCA allows an effective cavitational processing of various production media. For example, a substantial effect was found in extraction of protein from de-

greased ground bones. The process of extraction by a similar scheme at 18-20°C yielded additionally 4-6% of protein with respect to the mass of bones.

Similar results have been obtained in extraction of biologically active substances from a vegetable stock.

References:

1. Молчанов Г.И. Ультразвук в фармации : монографія. Москва : Медицина, 1980. 175 с.

2. Кавітація в харчових і переробних виробництвах : монографія / Сухенко Ю.Г., Литвиненко О.А., Муштрук М.М., Слободянюк Н.М. Київ : ІНКОС, 2018. 369 с.

International scientific and practical conference «Technical sciences: history, the present time, the future, EU experience» Wloclawek, Republic of Poland.

September 27–28, 2019

Izdevnieciba «Baltija Publishing»
Lacplesa iela 41A, Riga, LV-1011

Iespiests SIA «Izdevnieciba «Baltija Publishing»
Parakstīts iespiešanai: 2019. gada 18. oktobris
Tirāža 100 eks.