The text is a scientific article discussing the perspectives of using ultrasonic cavitation in water treatment technology for the food industry. The article highlights the importance of water quality in food production and the challenges faced by manufacturers in ensuring adequate water treatment. It introduces ultrasonic cavitation as a new approach to improving water properties and composition in the food industry. The article also presents an introduction to the topic, discussing the regulation of water quality standards in Russia and other countries, and the need for new methods to meet these standards.
Table 1. Requirements for the quality of drinking water (optional).

| Options                  | Water Quality Standards of public health regulations 2.1.4.1074-01 | European Union Council Directive 98/83 / EC | World Health Organization, Geneva |
|--------------------------|---------------------------------------------------------------|------------------------------------------|----------------------------------|
| Odor, points             | 2                                                             | 2/3                                      | absent                           |
| Chromaticity, degrees    | 20                                                            | 20                                       | 15                               |
| Turbidity, mg / dm³ / unit EYF | 1.5 / 2.6                                                   | 1.0                                      | 2.0                              |
| Sediment                 | –                                                             | –                                        | –                                |
| pH                       | 6.0 – 9.0                                                     | 6.2 – 8.5                                | 6.5 – 8.5                        |
| Permanganate oxidation, mgO₂ / dm³ | 5.0                                                        | 5.0                                      | –                                |
| Ammonia Nitrogen, mg / l | 2.0                                                           | 0.5                                      | 1.5                              |
| Nitrite Nitrogen, mg / l | 3.0                                                           | 0.5                                      | 3.0                              |
| Nitrate Nitrogen, mg / l | 45.0                                                          | 50.0                                     | 50.0                             |
| Sulfates mg / l          | 500                                                           | 250                                      | 250                              |
| Fluoride mg / dm³        | 1.5                                                           | 0.7 – 1.5                                | 1.5                              |
| Alkalinity, mEq / L      | 0.5–6.5 2                                                     | 30                                       | –                                |
| General hardness, mEq / l| 7.0                                                           | 2.9                                      | 2.5                              |
| Total iron / dissolved., Mg / l | 0.3                                                          | 0.2                                      | 0.3                              |
| Manganese, mg / dm³      | 0.1                                                           | 0.1                                      | 0.05                             |
| Hydrogen sulfide, mg / dm³ | 0.03                                                        | –                                       | 0.05                             |
| Sulfides, mg / dm³       | absent                                                        | absent                                   | absent                           |
| The total bacterial count, cells / ml | ≤50 at 22 ° C                                              | 100 at 37 ° C                          | –                                |
| Total coliform bacterium cells / 100 ml | absent                                        | absent                                   | absent                           |

The tightening requirements for water quality for producers inevitably associated with the search for new opportunities and affordable mechanisms to intensify and improve the efficiency of manufacturing processes, the special importance at this stage of the process becomes a cycle as the water treatment.

For the organization of an effective water treatment businesses need to keep track of the main critical water quality parameters used by them for production.

At the food production, water is used as a system of potable water supply, and is extracted from underground water sources.

To determine indicators measuring system discrepancy to its purpose and its lack efficacy, we analyzed the water quality within the framework of one of the leading enterprises in the food industry of the Ural region ("Vitex" company). The studies were conducted on the season during 2010–2017. (Table. 2)

Was found that the test water samples two indicators: total hardness and iron content, are symptoms, it is a systematic deviation from the norm was observed for them.

The data indicate that acute facing the enterprises of food industry task efficient cleaning, disinfection, correction of organoleptic characteristics and conditioning mineral composition of the water used for food production.

The selection and combination of the method of water treatment is defined as the appearance and the type of food production, as well as the properties and the quality of the incoming water. The analysis proposed in the literature of water treatment methods allowed them to systematize the subject carried out the purposes (Fig. 1).
- water clarification;
- water desalination;
- water disinfection;
- water softening

To solve these problems, using physical, physico-chemical and chemical processing methods. In practice, there is often the combination of physical factors of influence that accelerates water purification processes. In particular, the application of an electric field accelerates the processes of flocculation and sedimentation of coagulated slurry increases the degree of purification of water from organic and inorganic impurities filtration; improved separation of algae.

Table 2. Results of the study of water quality (tap water).

| Level of quality                  | Winter      | Spring     | Summer     | Fall        |
|----------------------------------|-------------|------------|------------|-------------|
| chromaticity                     | 5.0±0.6     | 4.6±0.6    | 5.6±0.6    | 6.4±0.6     |
| Turbidity (as kaolin)            | 1.2         | 1.0        | 0.8        | 1.4         |
| pH                               | 7.6±0.14    | 7.8±0.16   | 7.2±0.18   | 7.0±0.1     |
| Total hardness, mEq / dm³         | 8.2±0.3     | 11.6±0.4   | 10.6±0.6   | 10.4±0.4    |
| Oxidation permanganate, mgO₂ / dm³| 4.7±0.2     | 4.3±0.2    | 4.8±0.2    | 4.6±0.3     |
| Sulfates, mg / dm³               | 236±2.6     | 248±2.6    | 296±2.3    | 312±2.8     |
| Chloride, mg / dm³               | 245±2.6     | 324±2.4    | 318±2.8    | 296±2.2     |
| Iron, mg / dm³                   | 0.6±0.06    | 0.4±0.04   | 0.5±0.05   | 0.6±0.05    |
| Magnesium, mg / dm³              | 38.6±2.0    | 42.1±2.1   | 38.1±2.1   | 40.1±2.2    |
| Silica, mg / dm³                 | 2.3±0.4     | 0.6±0.2    | 1.6±0.4    | 1.3±0.2     |
| Lead, mg / dm³                   | 0.005±0.0005| 0.007±0.0005| 0.007±0.0005| 0.006±0.0005|
| Copper, mg / dm³                 | 0.8±0.005   | 0.6±0.005  | 0.68±0.005 | 0.71±0.005  |
| Cadmium mg / dm³                 | 0.0008±0.0000 | 0.0006±0.0000 | 0.0008±0.0000 | 0.0004±0.0000 |
| Mercury mg / dm³                 | less 0.0005 | less 0.0005| less 0.0005 | 0.0001±0.0000 |
| The total bacterial count, CFU / ml| 8           | 18         | 10         | 10          |
| General coliforms bacteria in 100 ml| absent      | absent     | absent     | absent      |
| Thermotolerant coliform bacteria, bacteria in 100 ml| absent | absent | absent | absent |

* The table shows the average data for the period 03.10 – 12.17 Year

The required safety criteria are more correspond to physical (reagentless) water treatment methods. In accordance with modern requirements for food production and the development of science as a water treatment consists in cleaning contaminants from a variety of factors, and to improve the properties of drinking water quality without altering their composition.

To solve the problem of water quality parameters in order to adjust the total content of iron and stiffness, contact exposure was chosen to water ultrasonic cavitation.

Regarding the effect of ultrasonic treatment on the structure and properties of the water there is many conflicting data, explains the different theories. However, it is undeniable that the ultrasonic exposure to water causes changes in its structure, which in turn is reflected in varying degrees the properties and performance of water quality.
Changes in the structure and properties of water are determined by a number of effects caused by sonication. According to the data (4), one of the most powerful effects is the cavitation disintegration, causing the dissociation of water molecules and destruction of the substances present therein. Ultrasonic vibrations (frequency above 20 kHz) lead to the formation of zones in an aqueous medium of high and low pressure, wherein the distance between adjacent areas of compression (or stretching) is wavelength. This snapshot is moved to the medium speed of sound (1 – 3, 9 – 12), which can not but affect the component composition and structure of water. Deep study of ultrasound given in the works of IE Elpinera, L. Bergman, I. Peirsol, R. Knapp, LD Rosenberg and many others, indicate its ability to concentrate the sound energy, causing a number of specific effects (4, 16 – 20).

For applied research Ultrasound technology "wave" model UZTA-0.4 / 22-OM (operating principle is based on the properties of high intensity ultrasound in liquid environments).

Ultrasonic cavitation treatment mode: 2 kW at a frequency of 22 kHz ± 1.65. Tap water in a volume of 250 ml sonicated device power 30%, 45% and 60% (120 W, 180 W, 240 W), the exposure time of 1, 3 and 5 minutes. Monitoring was carried out according to the nomenclature of the critical targets set in the previous stage of the research.

As a result, the most effective set of ultrasonic treatment regimes for adjusting water quality (reduced index relative to the initial value):

| General hardness | Iron content |
|------------------|--------------|
| 180 W, 5 min     | 180 W, 3 min |
| 180 W, 5 min     | 180 W, 3 min |
| 240 W, 3 min     | 180 W, 5 min |
| ultrasound + filtration |

It has been found that the use of sonication to reduce the water hardness. When processing power of 180 W and 240 W for 3 minutes, – an average of 20 – 24%, ultrasound exposure for 5 minutes under these facilities to reduce the stiffness value still only 5% -7. The resulting effect is based on the destruction of propagating pressure pulses in the water of hydration shells by cavitation and the dissolved ions existing in the form of calcium and magnesium bicarbonates and thereby stimulate the transition of the hardness salts in amorphous colloidal form carbonates, which can exist in water without crystallizing. Interactions of calcium and magnesium salts, ultrasonic treatment promotes the precipitation of sediment in them, thereby softening the water. Evaluation results of water hardness in function of time and power affecting factors are plotted (Figure 1).

**Figure 1.** Dependence of water hardness on the power and duration of sonication.
These figures make it possible to note the positive trend of the impact of ultrasonic vibrations to reduce water hardness. When mechanical effects the destruction of hardness, reduced concentration, which has a positive effect on food production technologies.

The trend is that different power ultrasound destroys various salt water, less power ultrasound destroys calcium salts, with the allocation of the water of calcium ions, which increases its share in the overall reduction of water hardness. Sonication power greater effect on increasing the magnesium salts with magnesium ions also shares at lower total water hardness.

To ensure effective water purification from iron was necessary to set the initial state of the element in the test water samples and the effect of ultrasonic treatment on him. Monitoring was performed using Purbe diagram. It was found that ultrasonic treatment accelerates the oxidation of Fe\(^{2+}\) to Fe\(^{3+}\) with subsequent formation of Fe(OH)\(_3\).

Because of the insolubility of Fe(OH)\(_3\) for water purification from iron it was nice on the need to further filter the water samples studied.

As a result, it was found that ultrasonic treatment followed by filtration reduced the iron content in water (with respect to the filtered water) in the processing mode power 180 W, exposure time 5 minutes and 3 – 15 and 23%, respectively.

Ultrasoundization 180 watts for 3 min, allowed to reduce the total count value, but this mode can not be acknowledged effective. The increase in power as sonication exposure possible to achieve the best results, the effect of ultrasonic impact of 180 W, 5 minutes, and 240 watts, 3 minutes and 5 differed slightly. Using the mode sonication power of 180 W for 5 minutes and 240 watts power for 3 and 5 minutes, allowed to reduce the value of 6 TMC of water – 7 times.

Comprehensive analysis of the results allowed us to determine the most effective regimen of ultrasonic influence - 180 W, the exposure time of 5 minutes.

To determine the degree of effectiveness of the modified water treatment technology comparative analysis of water quality was performed, produced using traditional and updated technology.

The results of these studies have shown that using a modified technology using sonication allows to adjust the values of indicators beyond the standard values, and ensure that the water quality standard.

The results of the indicator of total hardness of the test water samples are provided in Figure 2.

**Figure 2.** The dependence of the total hardness of the water from the power and duration of exposure to ultrasound.

As seen from the data presented below, the ultrasonic treatment of the water reduces the overall stiffness index values. The nature of the dependency of the total hardness of the power of ultrasonic influence is somewhat different. Similar curves were obtained by ultrasonic treatment 180 and 240 watts of power. Reducing the overall rigidity is most active in the processing 1 and 3 minutes – an
average of 20%, the effect of ultrasound for 5 minutes under these facilities to reduce the value of this indicator is still only 5 – 7%.

Considering the effect of ultrasonic treatment of water in the values of total hardness, depending on the power of the ultrasound, we can say that similar values reduce the effects of this indicator observed for 1 minute treatment. The intensity of total hardness reduction in the processing capacity of 30% for 3 and 5 minutes, significantly inferior to the results of the water treatment capacity of ultrasound 180 and 240 watts.

Studies have shown that the ultrasonic water treatment is also possible to reduce the total content of iron in it, the most pronounced reduction effect was noted when processing in the power mode – 180 W, 3 min exposure. Obviously ultrasonic impact accelerates the oxidation of Fe2+ to Fe3+ with subsequent formation of Fe(OH)3.

Thus, in our view, the use of ultrasonic cavitation in water treatment technology in the production of food is justified to solve unconditioned quality of tap water used manufacturing enterprises.

The most effective mode of combination of power and 180 watts accepted exposure time 3 min.

In the literature, there is quite a lot of evidence on the effect of ultrasound disinfecting fluids, including water.

According to data (13), the death of microorganisms in a liquid medium under the influence of ultrasound, occurs mainly due to the destruction of cell membranes secondary sound. The destruction occurs instantly or almost instantly – over several periods or periods of tens of forcing oscillator.

Lethal threshold sound field characteristics different for different microorganisms and depends on the shape of the shell and its mechanical strength. We know that Rod and flagellated bacteria are killed in the acoustic field likely than coccoid. It is also associated with a difference limit mechanical stresses arising in the envelopes under the influence of deformation, which arises with deformation of the medium through which the pressure disturbance spreads. It was established that the lethal effect of decreases in inverse proportion to the square of the distance of the biological object to the point of collapse of cavitation bubble (8).

Does not exclude other mechanisms ultrasonic disintegration. So, the hypothesis is known about the possibility of the destruction of material wedging pressure fluid forced into micro-relief of the interface in high-pressure phase after the transition to a low-pressure phase (Paulter effect).

Known hypothesis about the participation in the destruction of highly monovalent and divalent hydroxyl materials (Taylor effect) resulting from cavitolisation water. There mechanisms to achieve the result may be merely chemical character. In the process of sterilization it can be disinfectant action of hydroxyl ions and hydrogen peroxide (5).

But, one way or another, an exceptional role in the occurrence and effect of all these effects is the presence of mechanical forces associated with the emergence of shock waves resulting from collapse of the cavitation bubbles, that is, the acoustic cavitation fields or secondary audio.

As the most effective modes of disinfection in the literature indicated: frequency above 20 kHz power greater than 150 W, and the duration of exposure of 3 minutes or longer.

In this connection, we carried out a series of experiments on the effect of ultrasonic treatment on the value of the index total bacterial count of water. Samples were sonicated in water mode: frequency 22 kHz, power 180 W and 240, the duration of exposure to 3 and 5 min.

The results of these studies have shown that 180 watt sonication for 3 minutes, allowed a few to reduce the value of the total count, but this cannot be considered an effective treatment.

The increase in power as sonication exposure significantly reduced the TMC, and the effect ultrasound exposure of 180 W for 5 minutes and 240 W 3 and 5 min differed slightly.

In general, the ultrasonic treatment modes Power 180 W effects and 5 minutes and 240 watts of power 3 and 5 minutes, allowed to reduce the value of TMC of water in 6 – 7 times.

The findings suggest the possibility and high efficiency of the use of ultrasonic processing, water disinfection within the food production.
2. Conclusion

Thus, in our view, the use of ultrasonic cavitation in water treatment technology in the production of food is justified as long as the water works to ensure an unconditioned quality of tap water used by food industry.

As the most effective water disinfection regime was installed sonication frequency of 22 kHz to 180 watts exposure time of 5 minutes and 240 watts for 3 minutes exposure time; for reducing the iron content and the water hardness – a combination of 180 watts of power and exposure time 3 min.

3. References

[1] Amarowicz R, Troszyńska A, Pegg R B 2008 Antioxidative and radical scavenging effects of phenolics from Vicia sativum I Fitoterapia V 79 pp 121–122

[2] Andriy G 2013 Development and validation of a RP-HPLC method for the simultaneous estimation of luteolin and apigenin in herb of Achillea millefolium P Ilano Innovation no 2 pp 7–14

[3] Ashokkumar M Rink R Shestakov S 2011 Hydrodynamic Cavitation – an Alternative to Ultrasonic Food Processing Electronic Journal Technical Acoustics 9 Available at http://www.ejta.org

[4] Ashokkumar M Sunartio D Kentish S Mawson R Simons L Vilku K Versteeg C (K) 2008 Modification of food ingredients by ultrasound to improve functionality: A preliminary study on a model system Innovative Food Science and Emerging Technologies 9 (2) pp 155–160

[5] Fatkullin R Popova N Kalinina I Botvinnikova V 2017 Application of ultrasonic waves for the improvement of particle dispersion in drinks Agronomy Research no 15 pp 1295–1303

[6] Jolhe P D Bhanvase B A Patil V S Sonawane S H Potoroko I 2017 Ultrasound assisted synthesis of performic acid in a continuous flow microstructured reactor Ultrasonics Sonochemistry V 39 1 pp 153–159

[7] Khmelyov V N Tchyanok S N Barsukov R V Lebedev A N 2005 Designing and efficiency analysis of half-wave piezoelectric ultrasonic oscillatory systems. 6th Annual International Siberian Workshop and Tutorials on Electron Devices and Materials, EDM no 1523197 pp 82–85

[8] Knorr D Zenker M Heinz V Lee D U 2004 Applications and potential of ultrasonics in food processing Trends in Food Science and Technology 15 (5) pp 261–266

[9] Krasulya O Bogush V Trishina V Potoroko I Khmelev S Sivashanmugam P Anandan S 2016 Impact of acoustic cavitation on food emulsions Ultrasonics Sonochemistry Volume 98–102

[10] Krasulya O Shestakov S Bogush V Potoroko I Cherepanov P Krasulya B 2014 Applications of sonochemistry in Russian food processing industry Ultrasonics Sonochemistry V 21 6 pp 2112–2116

[11] Naumenko N V Kalinina I V 2016 Sonochemistry effects influence on the adjustments of raw materials and finished goods properties in food production International Conference on Industrial Engineering 19 May 2016 through 20 May 2016 Chelyabinsk Russian Federation 870 pp 691–696

[12] Naumenko N Paymulina A Ruskina A Khudyakov V 2017 Effects of various raw ingredients on bread quality Agronomy Research V 15 Issue Special 2 pp 1375–1385

[13] Nilova L Naumenko N Kalinina I 2017 A study of the forms of bound water in bread and bakery products using differential thermal analysis Agronomy Research 15 Issue Special Issue 2 pp 1386–1398

[14] Porova N Botvinnikova V Krasulya O Cherepanov P Potoroko I 2014 Effect of ultrasonic treatment on heavy metal decontamination in milk Ultrasonics Sonochemistry 21(6) pp 2107–2111

[15] Qiang H Lin L Xiong F 2007 Ultrasound effects on the structure and chemical reactivity of cornstarch granules Starch/Staerke 59(8) pp 371–378

[16] Shanmuga Sundaram Rajagopal Babitha K Vazhayil Liz Varghese Mahadevan Nandajian Development 2017 Validation of RP-HPLC Method for Simultaneous Determination of
Apigenin and Luteolin in Ethanol Extract of Clerodendrum serratum (Linn.) Leaves Asian Journal of Applied Sciences no 05(01) pp 52–60

[17] Valentina A Samylina A Kiritchkova I 1993 The genus Czekanowskia Heer: principles of systematics, range in space and time Review of Palaeobotany and Palynology 79 pp 271–284

[18] Vostalova J Glandakova A Palikova I Ulrichova J Dolezal D Lichnovska R Vrbkova J Rajnochova A S 2013 Kompliment caerulea frukty snizhaut UF-inducirovannogo povrezhdeniya v bezvelosy myshe Review of Palaeobotany and Palynology 79 pp 271–284

[19] Xiao Q C Jian B X 2009 RP-HPLC-DAD determination of flavonoids: separation of quercetin, apigenin and luteolin in Marchantia convolute Iranian Journal of Pharmaceutical Research 54 pp 175–181

[20] Zuo Y Y J Hébraud P Hemar Y Ashokkumar M 2012 Quantification of high-power ultrasound induced damage on potato starch granules using light microscopy Ultrasonics Sonochemistry 19(3) pp 421–426

Acknowledgments
This article was written with support from the Government of the RF (Resolution №211 of 16.03.2013), Agreement № 02.A03.21.0011 and subsidies for the fulfillment of a fundamental part of a state order, project №40.8095.2017/BCh and project №.№19.8259.2017/BCh The work was supported by Act 211 Government of the Russian Federation, contract № 02.A03.21.0011.