BOHR International Journal of Engineering
2023, Vol. 2, No. 1, pp. 38–42
DOI: 10.54646/bije.2023.16
www.bohrpub.com

RESEARCH

Juice concentration using juice electrolysis generated by solar cells of solar panel

Michael Shoikhedbrod*

Electromagnetic Impulse Inc., North York, ON, Canada

***Correspondence:**
Michael Shoikhedbrod,
michaelshoikhedbrod@bell.net

Received: 05 October 2023; **Accepted:** 17 October 2023; **Published:** 11 December 2023

Juice concentrates are made by extracting water from freshly squeezed juice. Extracting water from fresh juice today is done by evaporation, freezing of the water, or using diaphragms. During evaporating, freshly squeezed juice is heated in a vacuum below the boiling point to preserve all its beneficial substances. When water freezes, it is removed by cold. When using diaphragms, freshly squeezed juice is passed through a membrane with tiny cells, as a result of which water penetrates through the membrane, and large molecules of freshly squeezed juice concentrate are deposited on the membrane. All these methods of concentrating freshly squeezed juice require large economic costs. The article presents the concentration of fresh juice, using electrolysis of the aqueous component of fresh juice, generated by direct electric current from a solar cell of a solar panel, leading to the formation of negatively charged microdispersed electrolytic hydrogen bubbles and the production of high-quality fresh juice concentrate by flotation of microsolid components of fresh juice with these bubbles. In the process of freshly squeezed juice concentration, water is not removed from the juice, but itself ensures that a high-quality foamy juice concentrate is obtained in an electroflotator-concentrator simply, quickly, and economically (without the cost of electricity).

Keywords: concentrates of juice, solar cells of a solar panel, electroflotator, hydrogen electrolytic gas bubbles, silicon semiconductor, solar energy

Introduction

Freshly squeezed juice with all the important components inside is water that combines valuable microscopic particles of sucrose, sugar, and acid.

Extracting water from fresh juice today is done by evaporation, freezing of the water, or using diaphragms.

During evaporating, freshly squeezed juice is heated in a vacuum below the boiling point to preserve all its beneficial substances (1–4).

When water freezes, it is removed by cold (5, 6).

When using diaphragms, freshly squeezed juice is passed through a membrane with tiny cells, as a result of which water penetrates through the membrane, and large molecules of freshly squeezed juice concentrate are deposited on the membrane (1–4).

All these methods require large economic costs.

The article presents the concentration of fresh juice, using electrolysis of the aqueous component of fresh juice, generated by direct electric current from a solar cell of a solar panel, leading to the formation of negatively charged microdispersed electrolytic hydrogen bubbles and the production of high-quality fresh juice concentrate by flotation of microsolid components of fresh juice with these bubbles.

In the process of freshly squeezed juice concentration, water is not removed from the juice, but itself ensures that a high-quality foamy juice concentrate is obtained in an electroflotator-concentrator simply, quickly, and economically (without the cost of electricity).

Materials for research

The developed concentration of freshly squeezed juice, using the electrolysis of freshly squeezed juice, generated by direct

electric current from the solar cells of a solar panel and a specially designed electroflotator-concentrator was tested at the ***Ganir*** plant (***Israel***).

The squeezed juices of different plants were used: orange, apple, and mango.

Research and results

Solar panels (7–9) operate on the basis of a special solar photomodule, which includes solar cells that capture solar energy and convert it into a DC electric current, using silicon semiconductors.

The solar cell in turn consists of two joint layers of silicon doped with phosphorus, which has four electrons in the outer orbit and, when combined with phosphorus, acquires five more electrons and, thus, nine electrons are formed in the common outer joint orbit of silicon. Therefore, one unpaired electron will be extra, easily separated from the doped silicon under external influences, an N-type (negative) silicon layer, since the total number of electrons in the common outer joint orbit of silicon and phosphorus should be eight and ligated with boron, which adds only three electrons to the four electrons in the outer orbit of silicon, and thus there will be seven electrons in the common outer orbit instead of eight and, therefore, one free space called a "hole" is freed up (P-type silicon layer (positive).

The generation of the electrolysis process of freshly squeezed juice, using solar cells of a solar panel powered by solar energy is carried out as follows.

When a solar cell of a solar panel is exposed by a solar ray, the "excess" electrons of the N-type silicon layer, due to their proximity to the "holes," begin to combine through the N-P junction with the "holes" of the P-type silicon layer.

As a result, the border region of the N-type layer, due to the fact that a small part of the electrons go into the region of the P-type layer, turns out to be partially positively charged, and most of the electrons "knocked out" by solar energy in the N-type layer move freely throughout the entire layer N-type.

The border region of the P-type layer turns out to be partially negatively charged, while the majority of unoccupied "holes" move freely in the general region of the P-type layer (**Figure 1**).

If electrodes (cathode and anode) are connected to the outer N-type layer and the following outer P-type layer, then two oppositely charged poles will appear on the electrodes: minus on the cathode, plus on the anode, which will lead to the creation of a potential difference. If the electrodes are connected to an electrical circuit, the load of which will be an electroflotator for concentrating freshly squeezed juice, then in the process of flowing direct electric current through the wastewater between the electrodes, the process of electrolysis of freshly squeezed juice in the electroflotator is generated (**Figure 2**).

In the developed method of concentrating freshly squeezed juice during the electrolysis of the aqueous component of freshly squeezed juice in an electroflotator-concentrator, microdispersed electrolytic hydrogen bubbles are formed that have a negative charge, are uniform in size, are slightly prone to sticking together after separation from the cathode, and maintain a constant diameter during the time they remain in the environment of freshly squeezed juice (10).

The formed negatively charged microdispersed electrolytic hydrogen bubbles, floating to the free surface of freshly squeezed juice, meet on the their way solid microparticles of sucrose, sugar, and acid, the size of which is much larger than the size of microdispersed hydrogen bubbles, induce a positive charge on the surface of the microparticles and, due to the resulting force of electrostatic attraction opposite charges and surface tension forces, acting in one direction, are fixed on the surface of solid microparticles, forming foam from hydrogen bubbles and solid microparticles of sucrose, sugar, and acid, the lifting volume of which increases sharply and, due to the increased force of Archimedes, the foam accelerates to the free surface of the freshly squeezed electroflotator juice.

Figure 3 schematically shows the design of the developed electroflotator-concentrator, powered by a solar cell of a solar panel, and the principle of its operation in the process of continuous concentrating freshly squeezed juice.

A structurally designed electroflotator-concentrator for continuous concentration of freshly squeezed juice, powered by direct electric current from the solar cell of the solar panel through electrodes -1 connecting the negative electrode of the N-type silicon semiconductor layer -2 with the cathode terminal of the electroflotator-concentrator, located on a special plug device, connecting external leads with the electrodes of the electroflotator-concentrator and the positive electrode of the P-type silicon semiconductor layer - 3, has a flotation chamber - 6, made in the form of a rectangular container, the corners of which are equipped with special inserts, as a result of which the inner part of the chamber takes the shape of a cylinder, and the rear upper part the wall is equipped with a reflector.

The main element of the developed electroflotator-concentrator is the electrolysis base-12, connected to the solar cell of the solar panel with a special plug device and containing a special mechanism, made from non-conducting material, installed on the cathode, which allows simply adjusting the size of the interelectrode gap.

During the concentration process, freshly squeezed juice enters the flotation chamber - 6 through a pipe with a valve 4, a pocket 5, and a slot 7.

When DC voltage is applied to the electrodes of the electrolysis base, the electrolysis of water component of freshly squeezed juice water occurs, intensively generating negatively charged microdispersed electrolytic hydrogen bubbles, which, floating to the free surface of the freshly

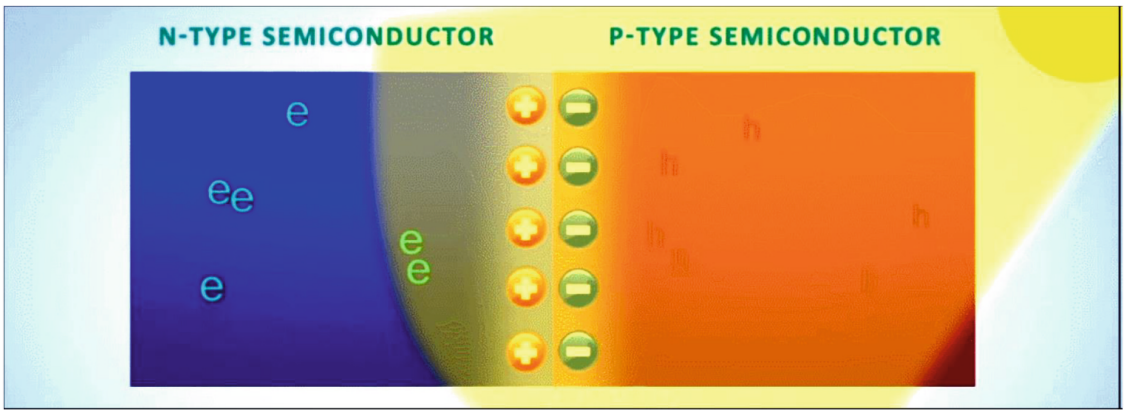

FIGURE 1 | The electron-hole P-N junction and electrons "knocked out" by solar energy move freely in the total N-type region, and unoccupied holes move freely in the total P-type region.

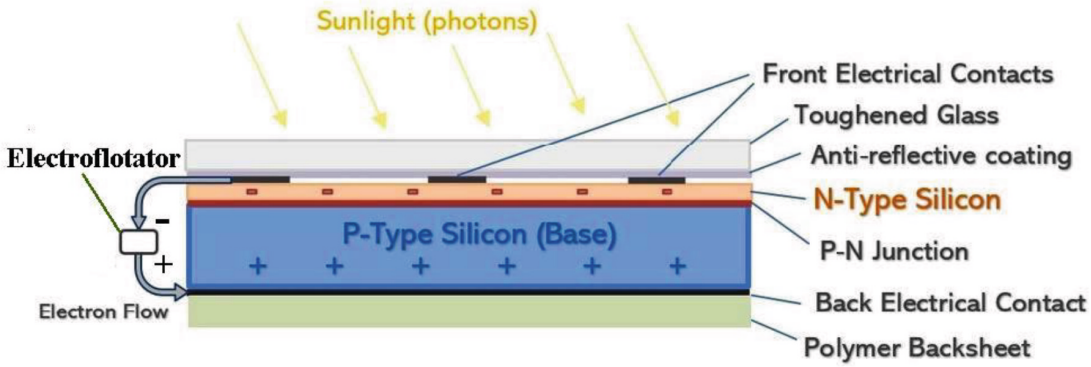

FIGURE 2 | Solar cell operation.

squeezed juicer, encounter in their path solid microparticles of sucrose, sugar, and acid, the size of which is much larger than the size of microdispersed hydrogen bubbles.

The negatively charged microdispersed electrolytic hydrogen bubbles induce a positive charge on the surface of the microparticles and, due to the resulting force of electrostatic attraction opposite charges and surface tension forces, acting in one direction, are fixed on the surface of solid microparticles, forming foam from hydrogen bubbles and solid microparticles of sucrose, sugar, and acid, the lifting volume of which increases sharply and, due to the increased force of Archimedes, the foam accelerates to the free surface of the freshly squeezed electroflotator juice.

Pop-up foam concentrate from hydrogen bubbles and solid microparticles of sucrose, sugar, and acid is collected in the upper part of the flotation chamber and removed by a paddle device - 9 into a special receiving capsule.

The clean water, having passed through the post-treatment chamber - 8, is drained from the electroflotator-concentrator through a pocket and a drain pipe with a tap - 10.

After completing the washing of the electroflotator-concentrator and removing all remaining water, a pipe with a tap is provided - 11.

Results

At the ***Ganir*** plant (***Israel***), a developed concentration of freshly squeezed juice, using electrolysis of freshly squeezed juice in a specially designed electroflotator-concentrator, generated by direct electric current from a solar cell of solar panel was tested.

The tests were carried out on a specially designed continuous-action electroflotator-concentrator (**Figure 3**), generating electrolysis of the aqueous component of freshly squeezed juice with a direct electric current, coming from the solar cell of the solar panel, causing intense formation of negatively charged microdispersed electrolytic hydrogen bubbles, flotation of solid microparticles of sucrose, sugar, and acid, which allows obtaining a high-quality juice concentrate, as well as purified pure water.

The foam concentrate from hydrogen bubbles and solid microparticles of sucrose, sugar, and acid is collected in the upper part of the flotation chamber of the electroflotator-concentrator and removed by a paddle device into a special capsule for receiving juice concentrate.

The concentration results are shown in **Table 1** (**I.R.D Laboratories**).

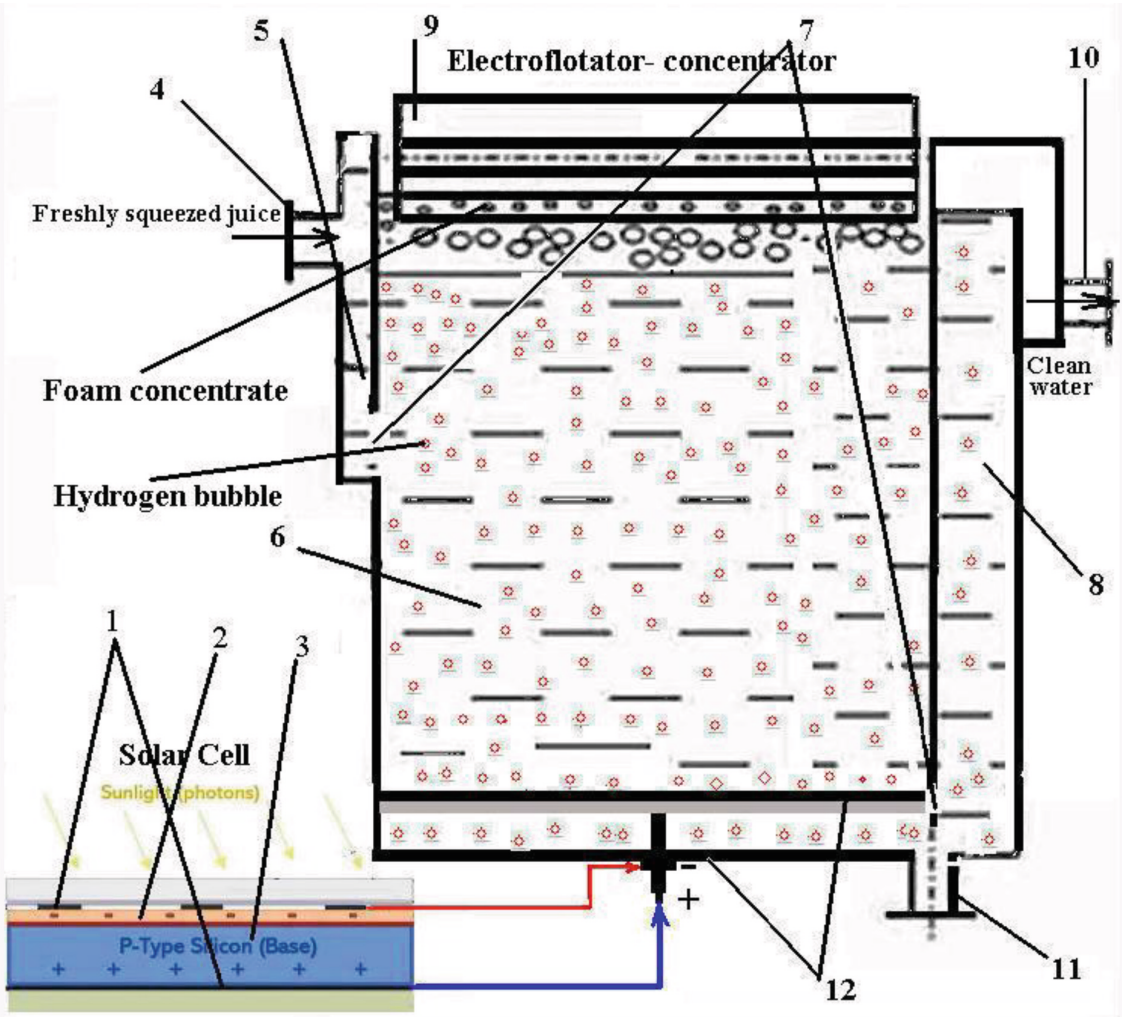

FIGURE 3 | Design of the developed electroflotator concentrator continuous type, powered by a solar cell solar panel.

The total time taken by the process of juice concentration was 18 s,

The ***Brix*** parameter in **Table 1** is a measure of the mass ratio of sucrose dissolved in water to liquid.

The ***Ratio*** parameter in **Table 1** is the ratio of sugar and acids in the obtained concentrate.

Table 1 shows the results of obtaining a high-quality juice concentrate.

The obtained concentrate is highly concentrated with solid microparticles of sucrose and sugar a foam juice, which can be used to prepare a hydrogen cocktail with various additives of fruit juice from different fruits.

TABLE 1 | Results of the tests of the juice concentration, using electrolysis of freshly squeezed juice in a specially designed electroflotator-concentrator, generated by direct electric current from a solar cell of solar panel.

Brix	Ratio	Ascorbic acid, Mg/L	Pulp,%
65.5	19.2	11.4	10

In order to determine changes in the parameters of the foamy juice concentrate, presented in **Table 1**, it was decided to determine the parameters of waste (purified) water, discharged from the flotation chamber of the electroflotator-concentrator after concentrating the juice, for the use of the developed electroflotator-concentrator in the process of treating wastewater, obtained after a general process at the plant.

Table 2 presents the results of wastewater treatment, obtained after the completion of the general technological process at the ***Ganir*** plant (***I.R.D. laboratories***).

The parameter ***COD*** (chemical oxygen demand) in **Table 2** determines the amount of organic pollutants of the water.

TABLE 2 | Results of the purification of waste water of the plant **Ganir.**

	Brix	Pulp,%	COD, мг/л
Before cleaning	0.4	2.5	7100
After cleaning	0.1	0	80

Table 2 shows that parameter ***Brix*** decreased from 0.4 to 0.1, and cellulose from 2.5% to 0.

The decrease in the values of these parameters is explained by the increase in their content in the juice concentrate after purification.

Attention should be paid to the ***COD*** parameter, which is the main indicator of water pollution by organic substances.

As follows from Table 2, after treatment, ***COD*** decreased from 7100 to 80 mg/l, which indicates the high efficiency of the developed method of juice concentration for wastewater treatment at this plant.

Conclusion

Developed concentration of fresh juice, using electrolysis of the aqueous component of fresh juice, generated by direct electric current from a solar cell of a solar panel, leading to the formation of negatively charged microdispersed electrolytic hydrogen bubbles and the production of high-quality fresh juice concentrate by flotation of microsolid components of fresh juice with these bubbles.

In the process of freshly squeezed juice concentration, water is not removed from the juice, but itself ensures that a high-quality foamy juice concentrate is obtained in an electroflotator-concentrator simply, quickly, and economically (without the cost of electricity).

The conducted tests confirmed the production of high-quality fresh juice concentrate by developed concentration in the special designed electroflotator-concentrator.

Tests have also shown that the developed fresh juice concentration and a specially designed electroflotator-concentrator can be effectively used for wastewater treatment at this plant.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

References

1. Alvesl VD, Coelhoso M. Orange juice concentration by osmotic evaporation and membrane distillation: a comparative study. *J Food Eng.* (2006) 74:125–33.
2. Belafi-Bako K, Nemestothy B. Comparative on concentration of juice from colorful wild berry fruits by membrane osmotic distillation. *Hung J Indust Chem Vesz.* (2012) 40:53–6.
3. Surin S, Thakeow P, Seesuriyachan P, Angeli S, Phimolsiripol Y. Effect of extraction and concentration processes on properties of long a syrup. *J Food Sci Technol.* (2014) 51:2062–9.
4. Elik A, Yanik D, Maskan M, Gogus F. Influence of three different concentration techniques on evaporation rate, color and phenolic content of blueberry juice. *J Food Sci Technol.* (2016) 53:2389–95.
5. Auleda JM, Raventos M. Estimation of the freezing point of concentrated fruit juices for application in freeze concentration. *J Food Eng.* (2011) 105:289–94.
6. Deshpande S, Cheryan M, Sathe S, Luh B. Freeze concentration of fruit juices. *C R C Crit Rev Food Sci Nutr.* (1984) 20:173–248.
7. Nelson J. *The Physics of Solar Cells*. World Scientific Publishing Company (2003). Available online at: https://books.google.ca/books?hl=ru&lr=&id=4Ok7DQAAQBAJ&oi=fnd&pg=PP7&dq=info:cwFo4nde9UgJ:scholar.google.com/&ots=j6kVRpT2HG&sig=H_ggAW85L4gxPJQmpncIbeXraE8&redir_esc=y#v=onepage&q&f=false
8. Bagher A, Vahid M, Mohsen M. Types of solar cells and application. *Am J Opt Photon.* (2015) 3:94–113.
9. Fraas L, Partain L. *Solar Cells and Their Applications*. John Wiley & Sons (2010). Available online at: https://books.google.ca/books?hl=ru&lr=&id=ds7vnCgmSnMC&oi=fnd&pg=PT2&dq=info:pyTVoSwt1AEJ:scholar.google.com/&ots=d_6y2FoA-c&sig=nr_Cixcw2IYh0OSlSURNa2n8-KA&redir_esc=y#v=onepage&q&f=false
10. Shoikhedbrod MP. Mechanism of formation of electrolysis bubbles in water and the use of their properties for the development of new technologies in microgravity. *J Fluid Mech Nutra Design.* (2021) 3.