Novel Designing of Reactors Can Help in Producing Natural Fruit Juice without any Preservatives

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"Eat Healthy Think Better"

The above tagline is not just a slogan of the major food corporation, but is really an adage. Healthy eating habits result in a rejuvenated body and mind that can be more productive and deliver better results for the society at large. However, our fast-paced lifestyle in present times often leaves us with no choice than to skip healthy food. Even worse, we forget to include fruits in our diet. It should not be forgotten that fruits are truly the gifts of nature and are rich sources of essential nutrients like proteins, vitamins, minerals, etc.

Of late, an alarming rise in lifestyle diseases has led toincreased health awareness. People have started to realise the benefits of consuming healthy food, including fruits on a regular basis. However, one cannot always carry a fresh fruit with him/her due to chances of degradation with time. Packaged fruit juices come to rescue in this regard, as they have a longer shelf life (time for which it remains fit for consumption) and thus, can be conveniently carried to places without any fear of degradation. But, these packaged juices have added preservatives, which are basically synthetic chemicals having severe and adverse health implications if consumed on a regular basis. Scientific studies have shown that regular consumption of synthetic food preservatives can lead to asthma, skin allergies, and even cancer. Thus, there is a dire need to perform research and develop some technology that will offer large scale production of natural fruit juices without the addition of harmful chemical preservatives.

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* Mr. Sourav Sengupta, Ph.D. Scholar from Indian Institute of Technology, Kharagpur, is pursuing his research on "Membrane Separation." His popular science story entitled "Novel Designing of Reactors can help in Producing Natural Fruit Juice without Any Preservatives" has been selected for AWSAR Award.

Research indicates that the main 'culprit' responsible for degradation of fruit is a polysaccharide called 'pectin'. Polysaccharides are essentially carbohydrates, consisting of a large number of sugar molecules bonded to each other. Thus, if pectin can be removed from the fruit juice by some process, then the fruit juice can be preserved for a longer period without adding any synthetic preservatives. In other words, de-pectinisation (i.e., removal of pectin) of fruit juice needs to be carried out, if we want a long shelf life of the preservative-free natural juice.

Recently, a team of researchers led by Prof. Sirshendu De of the Department of Chemical Engineering, IIT Kharagpur has successfully carried out de pectinisation of bael fruit (*aegle marmelos)* juice. Bael fruit is a rich source of vitamins such as A, B_1 and C. It is also rich in minerals like calcium, phosphorus, potassium, iron, etc. The researchers undertook enzymatic treatment (using pectinase enzyme) of the bael juice for the purpose of de-pectinisation. In other words, the bael juice was made free of pectins with the addition of an enzyme. They also successfully optimised the time and enzyme dosage of the process, which is very important in standardising the quality of the final packaged juice. The optimum time was found to be 60 minutes while the optimum enzyme concentration was obtained as 0.25 gram of enzyme per 100 gram of the bael juice.

For successful commercialisation of the fruit juice, large scale production is necessary. For that, the reactor where de-pectinisation is undertaken needs to be efficiently designed. In this context, the researchers have proposed a novel reactor designing scheme for de-pectinisation of bael juice in a continuous stirred tank reactor (CSTR) (a type of commercial reactor, used in industries). The scheme is generic in nature and thus can be suitably extended for processing of other fruit juices as well. This novel scheme ensures that the desirable product quality of the final processed juice is accurately maintained. The study combines both mathematical analysis and experimental validations to indicate that the residence time (time that the juice spends in the reactor) has to be greater than some threshold value, known as the 'critical residence time'. This will make sure that the final juice is prepared perfectly with regards to the nutritional value and other desirable parameters like pH, sugar, etc.

It was also elaborately shown in the study that if the threshold value is not maintained, the product quality will get affected. The critical residence time was found to decrease with enzyme concentration at lower values of enzyme concentration. However, at high enzyme concentration of 0.2 % weight of enzyme/weight of juice and above, the change in critical residence time was not significant. Thus, at the optimum enzyme concentration of 0.25%, there is no further variation in critical residence time. This is a very important observation, beneficial for actual processing of the bael juice.

Although a CSTR (which is an ideal reactor) was initially used in the analysis, in order to make the study more relevant to a broader audience, a non-ideal reactor was also considered in the latter part. This was done so as to include maximum possible configurations of the reactor in the analysis. It provided novel insights into the requirement of critical residence time for various possible reactor configurations. It was found that as the reactor became non-ideal, the critical residence time increased.

Interestingly, the study also suggested that the maximum conversion (percentage of juice converted into pectin-free juice) that is achievable in the reactor is also dictated by a mathematical principle called "contraction mapping". Any attempt to further increase the conversion will make the product quality unstable and unsteady. In other words, the product quality will no longer remain uniform. Maintaining the conversion within suggested limits will ensure smooth functioning of the large-scale process.

The treated juice was finally analysed, and found to be much less viscous than the original juice. This ensures that the end user buying the packaged juice has no difficulty in consuming it. Protein and polyphenol content of the treated juice was almost the same as that of the original juice, thus safeguarding the nutrient value of the juice.

The research team for the above study included Prof. Sirshendu De of the Chemical Engineering Department, along with research scholars Sourav Sengupta and Amit Jain. The results of their research have been published in the recent issue of the scientific journal *Reaction Chemistry & Engineering*.

Normally, we observe that scientists are often satisfied only in synthesising a product in the laboratory without thinking whether the product can be commercially made on a larger scale or not. But, that mentality is surely not sufficient in 21st century India. Taking the outcomes of scientific research from the laboratory to the outside society is definitely the need of the hour. It is our responsibility to serve the common citizens of this country who contribute for our expenditure in scientific research. The present study is definitely a positive attempt in that direction.