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Identification of Impurity level in Liquids Using Electronic Sensor Based System

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Abstract: Now a day, it is essential to detect impurity in liquids. The research project proposed is beneficial to the society by and large by giving the measure to reduce the adulteration practices in liquid. The concept of electronic tongues is more recent, and much less research has been undertaken on the development of liquid sensors and classification algorithms. By combining sensor systems e.g. Electronic noses and tongues together with a enhanced image processing techniques, the classification accuracy can be increased. In the proposed research work, an electronic system is developed so that it can be used for analyzing liquids like milk and water. The system hardware and software is designed and developed and efforts are taken to analyze a liquid. The research work involved is the use of image processing techniques, development of new algorithms, continuous monitoring of the liquids under test, and an evaluation of the quality of a liquid. This paper is based on new enhancement technique for infrared images which integrates the benefits of additive wavelet transformation and homomorphism image processing. In the final step these homomorphism enhanced sub bands are subjected to an inverse additive wavelet transform to get an infrared image with better visual details.

Keywords: Wavelet transform, Homomorphism processing, illumination component, reflectance component, sensor, sub band.

I. INTRODUCTION

Electronic Tongue and Electronic nose system provides more services in various fields such as environmental monitoring, food science, and point of care business. The concept of electronic tongues is more recent, and much less research has been undertaken on the development of liquid sensors and classification algorithms. A sample of water or milk has too high concentration of bacteria so to analyze bacterial growth is an important task since the bacteria can cause diseases and make the liquid unusable. Electronic tongue can be used to identify and recognize specific components in a solution. In this approach, experiments are conducted using an electronic tongue to virtually monitor the quality of liquid like drinking water, juice and oil.

For example, in [1] a four electrode conductivity probe is used and in [2] thick film based sensors are used for determining the quality of water .In [3] a lipid membranes designed sensor are used to detect pollutants in water and in [4] an optical fiber sensor system is used to detect particle concentrations in water. Multi sensor system is used as water quality instrument [5, 6] in few applications. Many available modeling approaches are able to simulate water quality using 3D mathematical model [7], artificial neural networks [8] and fuzzy probability [9]. The concept of electronic tongue [10,11] has been developed to attract the needs of on-line monitoring of aqueous samples. Principal Component Analysis(PCA) is a mathematical transform, which is used to explain variance in exponential samples. After collecting the samples the appropriate tests were conducted using the sensor system. After PCA analysis it is examined that there exists a clear distinction of the resulting cluster from the raw water and the purified water[12], such result would confirm the chemical change that occur in raw water.

The Paper is basically focus on impurity in water and Milk. Water is a natural resources abundantly available in nature. Water is a universal solvent which is never available in pure form. It doesn't matter how isolated it is with the sources of contamination, it will always have some or the other impurities dissolved in it. There are many causes of dissolved impurities in water which may either be natural or human. Natural causes are gases or minerals in the air, soil or rock dissolved by the water. Human causes are disposal of garbage or sewage or industrial chemicals in water causing water impurities.

These impurities are most of the times dangerous and undesirable. This impure water when consumed by human can result in serious health hazardous issues. Therefore it is very important to detect these impurities in water. It is not easy to detect impurities in water however there are several methods to do so, but all of them are less efficient in doing their job. There are several methods to detect impurities in water such as chemical treatment methods and many more. But these methods are proved to be less efficient because with these methods the water is tempered by mixing various chemicals in order to detect the impurities in water. Moreover, these chemical methods are unable to determine completely impurities in water. Hence it was realized that an method should be developed to determine impurities in water which is efficient enough and by which the water should not be tampered. Through

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the concept presented by this paper an efficient technique to determine impurities in liquids has been brought forward which is achieved by the use of electronic devices such as infrared sensor, receivers and camera's. The use of these electronic devices for determination of impurities in water is more efficient and the contents of liquids are also not tampered. In the proposed research work, it is planned to develop an electronic system that can be used for analyzing liquids like water. The system hardware and software will be designed and developed and efforts will be taken to analyze liquid. Research work involves use of Image processing techniques, developments of new algorithms, continuous monitoring of the liquids under test, and evaluation of properties of liquid and hence quality of liquid.

The following will be the steps under taken for the research work,

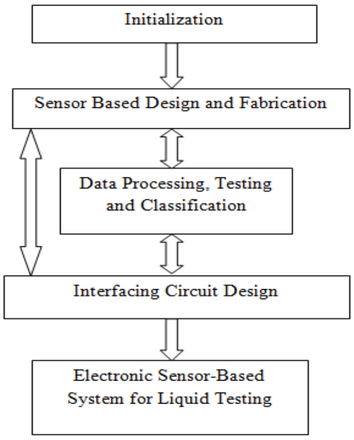

Figure 1: System representation.

- Detailed study of the concept, application and implementation of sensor networks.
- To design and develop an electronic sensor based system that can extract the information about the properties of the liquid.
- Identify and analyse the effect using sensor based system, due to the liquid or any other ingredients present in liquid.
- PC interface will be developed for online testing and monitoring.
- Evaluation results will be made available on display.

Image enhancement has became a very popular field in image processing . The main aim of Enhancement is to improve the visual quality of image and this is achieved by reinforcing edges and smoothing the flat areas. Several researches have adopted various techniques in past such as simple filtering , adaptive filtering, wavelet de-noising , homomorphic enhancement etc.,[24-29] and all these techniques concentrate on reinforcing the details of the images to be enhanced. Apart from all these techniques mentioned above , a new technique that is Infrared image processing has emerged for the evolution of night vision cameras. This technique has various advantages such as this technique has applications in thermal medical imaging[13-23]. With the evolution of night vision cameras , more researches are being performed in infrared image enhancement for information extraction from these images. Due to the absence of appropriate amount of light required for imaging , these images have a special nature of large black areas and small details . Hence , the main objective is to reinforce the details to get as much details as possible.

The enhancement of infrared images is slightly different from traditional image enhancement because this infrared image have large black areas and small details. So, our proposed methodology aims at separating the details in different subbands and processing each subband separately. It is found that additive wavelet transform is a very powerful tool in image decomposition and the details can be separated into the higher frequency subbands , if the images is decomposed using the additive wavelet transform.

In addition to all these we also use the homomorphic enhancement algorithm for transforming these details to illumination and reflectance components and then the reflectance components are amplified showing the details clearly. In the final step , to get an enhanced infrared image with much more detail , a wavelet reconstruction process is performed.

II. ADDITIVE WAVELET TRANSFORM

The main role of additive transform [16-19] is that it decomposes an image into the subbands using the “a’ trous” filtering approach in several consecutive stages. The low pass filter is used in this process and has the following mask for all stages:

$$H = 1/256 \begin{pmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{pmatrix} \quad ...... \quad (1)$$

Each difference between filter outputs of two consecutive stages is a subband of the original image. We can use these subbands for further processing using homomorphic enhancement.

III. HOMOMORPHIC IMAGE ENHANCEMENT

An Image can be represented by the following equation which is a product of a two component

$$f(n1, n2) = i(n1, n2)\, r(n1, n2) \ldots\ldots \quad (2)$$

where the obtained image pixel is given by f(n1, n2) and i(n1, n2) is the light illumination incident on the object to be imaged and r(n1, n2) is the reflectance of that object. It is known that light falling on all objects is approximately the same therefore due to this the illumination is approximately constant and the only change between the object images is in the reflectance component.

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The above mentioned equation 2 can be changed to addition process from multiplication process by applying logarithmic process to equation 2 and the new equation form by applying the same is as follows:

$$\log(f(n1, n2)) = \log(i((n1, n2)) + \log(r(n1, n2)) \ldots\ldots \quad (3)$$

As shown in the above equation the first term has smaller variations but the second term has large variations as it corresponds to the reflectivity of the object to be imaged. We can reinforce the image details by attenuating the first term and reinforcing the second term in equation (3).

IV. PROPOSED APPROACH

In the this method, infrared camera is used to detect impurities in liquid which is shown in Figure 2.

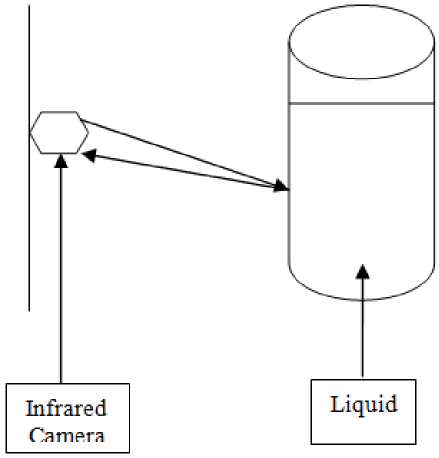

Figure 2 : Hardware representation

In this method we have used infrared camera to detect impurity in liquid. The image of the liquid is captured whose impurity is to be detected with the help of infrared camera. By using Matlab with Additive Wavelet transform the Peak Signal to Noise Ratio (PSNR) is calculated of the output image. For the pure water the value of PSNR is high and for impure water the value of PSNR is low.

In this approach , firstly the image is decomposed into subbands using the additive wavelet transform and then each subband is processed separately using the homomorphic approach to reinforce its details and by this way we merge the benefits of the above mentioned techniques. In the experimental setup we connect twenty infrared Light emitting diode (IR LED's) across camera and when this IR LED's is ON human eye cannot detect this but it can be easily captured by Camera.

The steps of the proposed approach can be summarized as follows:

1) In the first step Using additive wavelet transform and the low pass mask of equation (1) , the infrared image is decomposed into four subbands p3, w1, w2, w3.
2) In the second step, a logarithmic operation in each subband is applied to get the illumination and reflectance component of the subbands w1, w2 and w3 as they contain the details.
3) In the third step attenuation operation is performed on illumination component and reinforcement operation is performed on reflectance component in each subband.
4) Using addition and exponentiation processes each subband is reconstructed from its illumination and reflectance.
5) Perform an inverse additive wavelet
6) Transform on the obtained subbands by adding p3 w1, w2and w3 after the homomorphic processing to get the enhanced image.

V. EXPERIMENTAL RESULTS

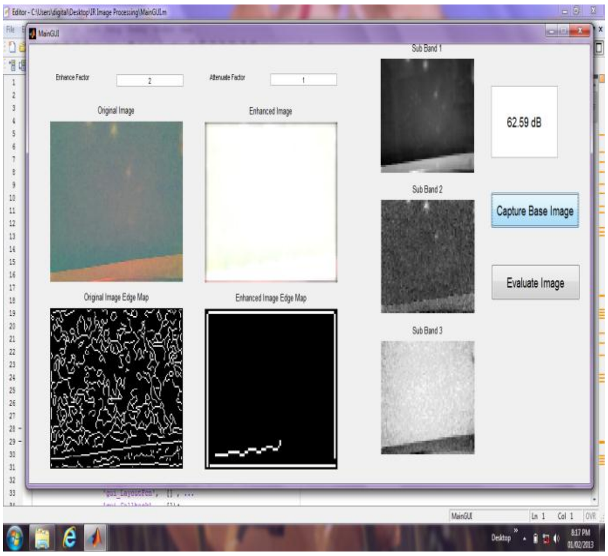

Figure 6 a) **:** Results (Liquid- Pure Water)

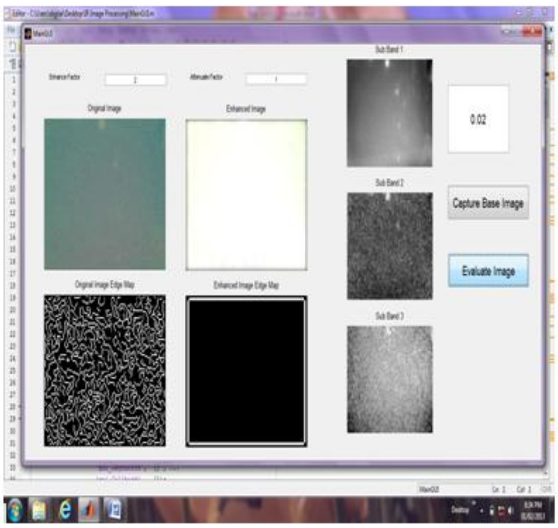

Figure 6 b) : Results (Liquid- pure Water)

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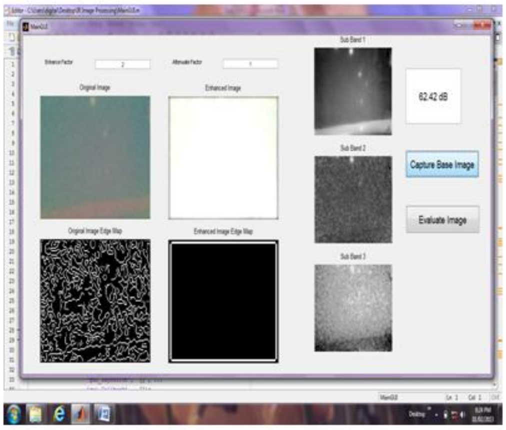

Figure 7 a) : Results (Liquid –Water with 2 % impurity)

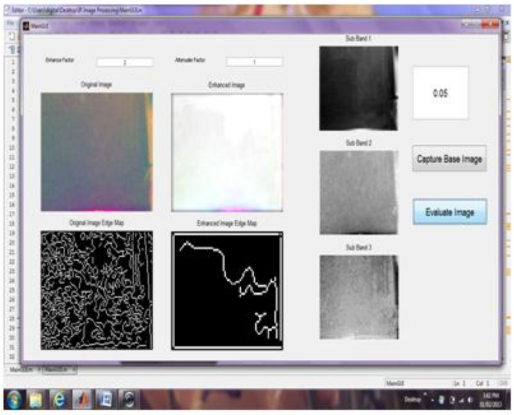

Figure 7 b) : Results (Liquid – Water with 2 % impurity)

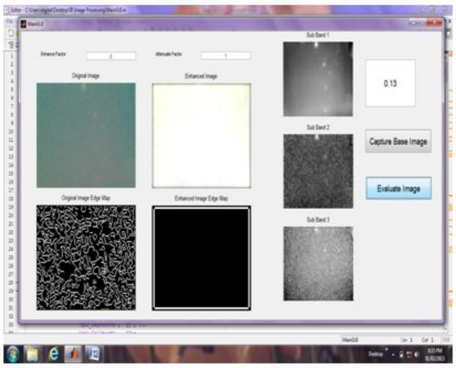

Figure 8 b) : Results (Liquid- Water with 5 % impurity)

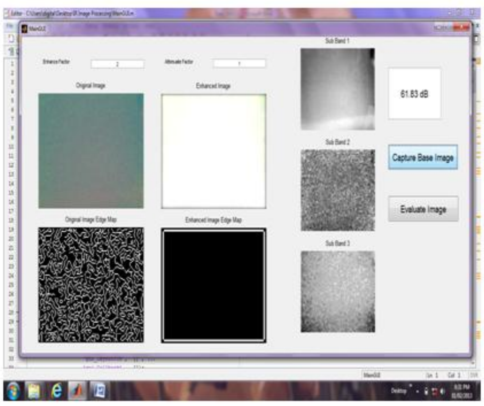

Figure 8 a) : Results (Liquid- Water with 5 % impurity)

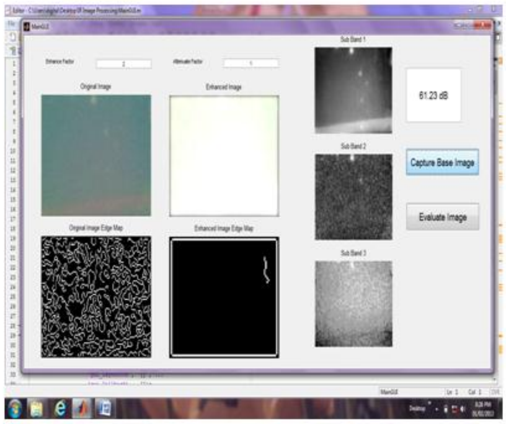

Figure 9 a) : Results (Liquid- Water with 10 % impurity)

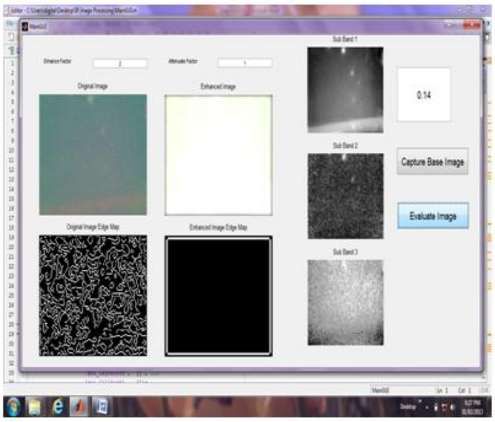

Figure 9 b): Results (Liquid- Water with 10 % impurity)

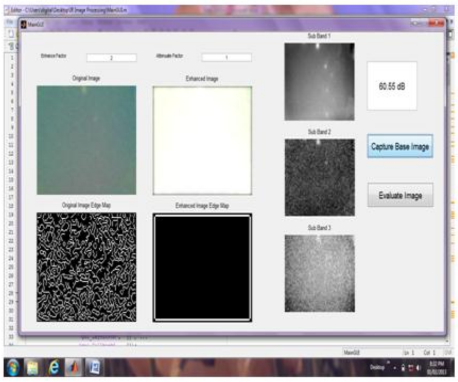

Figure 10 a) : Results (Liquid- Water with 15 % impurity)

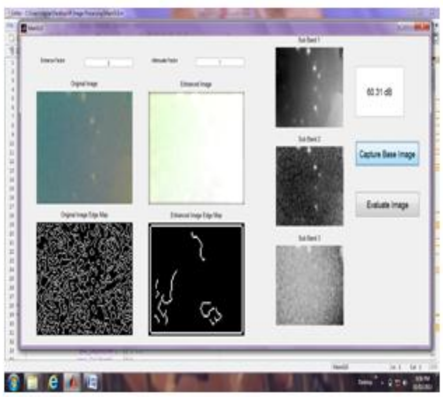

Figure 11 a): Results (Liquid- Water with 20 % impurity)

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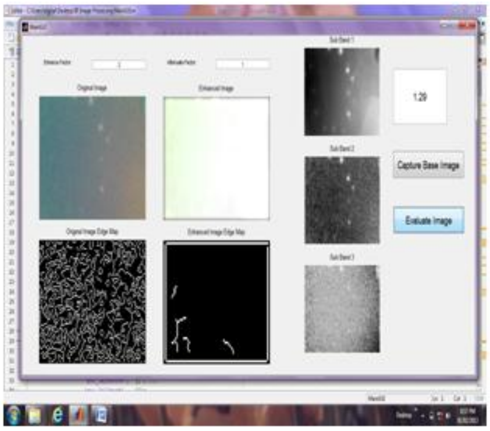


Figure 11 b) : Results (Liquid- Water with 20 % impurity)

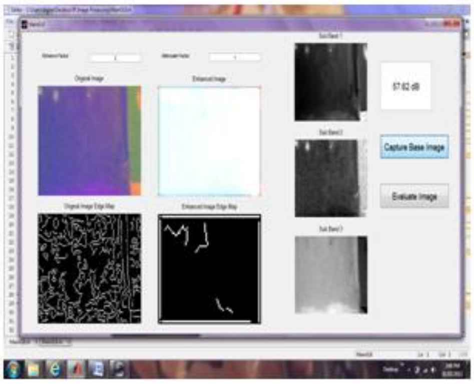


Figure 12 a) : Results (Liquid- Water with 50 % impurity)

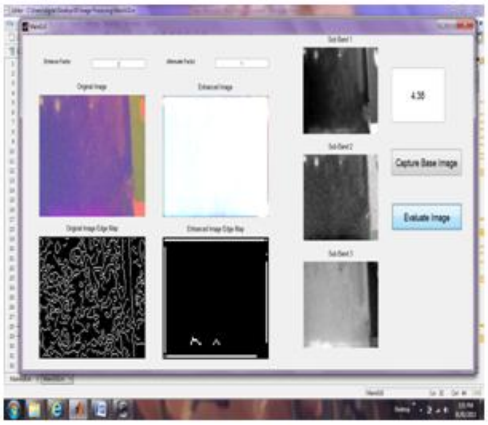
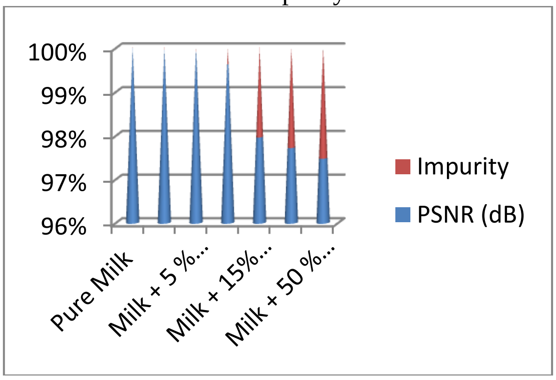


Figure 12 b) : Results (Liquid- Water with 50 % impurity)

TABLE I: DATA OBTAINED FROM FIGURES (LIQUID –WATER)

Liquid	PSNR (dB)	Impurity
Pure Water	62.59	0.02
Water + 2% Impurity	62.42	0.05
Water + 5 % Impurity	61.83	0.13
Water + 10 % Impurity	61.23	0.14
Water + 15% Impurity	60.55	0.24
Water + 20 % Impurity	60.31	1.29
Water + 50 % Impurity	57.62	4.38

PSNR Vs Impurity Level



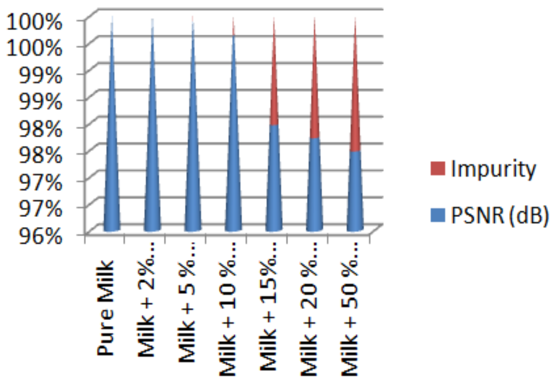
Pictorial representation obtained from TABLE I

Same type of process carried out for liquid Milk and Milk with some impurities.

TABLE II: DATA (LIQUID –MILK)

Liquid	PSNR (dB)	Impurity
Pure Milk	62.48	0.01
Milk + 2% Impurity	62.44	0.04
Milk + 5 % Impurity	62.39	0.07
Milk + 10 % Impurity	62.27	0.24
Milk + 15% Impurity	62.06	1.29
Milk + 20 % Impurity	61.36	1.43
Milk + 50 % Impurity	60.31	1.56

PSNR Vs Impurity Level



Pictorial representation obtained from TABLE II

The first three experiments (figure 6a to figure 12 b) are performed to test the performance of the proposed system. This experiment gives the original infrared image of liquid (Water) and the enhanced infrared image using the algorithm as well as its edge map. It is observed that the proposed sensor system with enhancement algorithm has enhanced the visual quality of liquid and its edge map. In these results first figure (a) shows the capture base image and second figure (b) shows the impurity level in the liquid.The second experiments are performed to test the performance of the proposed system shown in table 2 which again gives the PSNR values and Impurity for liquid as water and water with impurity.

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Similar experiments are carried out for another sample of liquid Water and Milk. It is clear that the peak signal to noise ratio (PSNR) of impure liquid is always less as compared to pure liquid, so it is similarly reflected in the result (Table I and Table II) that impurity level for pure liquid is less than the liquid with some amount of impurity. Pictorial representation is shown for all experimental results.

VI. CONCLUSION

This proposed system direct our attention to a new approach for infrared image enhancement. This approach clubs the additive wavelet transform and the homomorphic enhancement features. Each infrared image subbands are subjected to homomorphic processing separately. To reconstruct an enhanced image these subbands are merged again. The results obtained using this algorithm reveal its ability to enhance infrared images. Different experiments are carried out on liquid by using this proposed method & conclusion is the impurity level of pure liquid is less as compared to liquid with some impurity. In future we can implement this system for mass production in dairy and factory and will definitely reduce the adulteration practices in liquids .

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