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A STUDY ON REFRIGERATION AND FERMENTATION EFFECT OF COCONUT WATER USING THERMO OPTO –ACOUSTIC ANALYSIS

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Abstract
A systematic analysis has been done to study the effect of refrigeration and fermentation on the physical characteristics of coconut water. For this, fresh, refrigerated, air – fermented and yeast – fermented samples of coconut water were studied using thermo opto – acoustic analysis of derived parameter namely specific opto – acoustic velocity (η). It is found that the physical characteristics are unaltered in refrigerated samples whereas in fermented samples, the opto – acoustic parameter undergoes a relative shift, which is greater for yeast – fermented samples.

Key words: Coconut water, Thermo opto- acoustic analysis, Opto – acoustic velocity, Fermented samples

Introduction

The research group of our laboratory was engaged in a systematic study of liquids and liquid mixtures using optical, acoustic and opto – acoustic parameters. Coconut water (Cocos nucifera L.) is a sweet liquid with a pleasant flavor and taste. It is an ancient tropical beverage and its popularity in international market has gained much importance in recent years (Alexia Pradesh et.al., 2012). It has recently been caught on by athletes and health freaks in many developed countries. Media reports show that coconut water has become the fastest growing new beverage category in United States and is expected to be flourished in many other European countries. (Priya and Lalitha Ramaswamy., 2014). Since coconut is bulky, the storage of coconut water as such is difficult. Inorder to promote this cheaply and easily available hygienic drink as a substitute for commercial drinks, it has to be bottled and preserved. Preservation of tender coconut water is the biggest challenge because the processing methods may result in loss of nutritional effect of water (Mohan Naik et.al., 2020). Although many authors have cited the growth promoting activities and medicinal values of coconut water, (Zulaikhah, 2019) (Jean et.al., 2009), very few work has been published on preservation, refrigeration and fermentation of coconut water.(Chowdhury et.al., 2009) , (Alexia Prades et.al., 2012). Moreover, its effect on physical properties of coconut water has rarely been discussed. Hence a continuous analysis of fresh, refrigerated and fermented samples of coconut water for a period of five consecutive days were done to study its physical characteristics.

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Materials Methods

The sample taken is freshly obtained tender coconut water (TCW) from green coconut. A portion of it is refrigerated. Another portion is kept in a bottle covered with netted cloth for normal fermentation (air – fermented sample). 10 mg of yeast added to 100 ml of coconut water was considered as the yeast – fermented sample. All the above samples were analysed daily for five consecutive days. The sound velocity (U) and refractive index (n) of the samples were determined at six different temperatures from 298K to 323K at an interval of 5K. Ultrasonic velocities were measured using a single crystal interferometer (Mittal Enterprises – Model No: F 81) at a frequency of 2 MHz with an accuracy of 0.1m/s. Refractive index measurements were performed with the help of an Abbe's research refractometer having an accuracy of 0.01%. The temperatures of the samples were maintained steady by a thermostatically controlled water circulating arrangement within the error limit ±0.1K.

Theory

The deduction of specific opto – acoustic velocity and its dependence on molecular structure were studied and reported by Mohanan et.al (1997). A brief review is given below.

The decrease in refractive index per unit rise of temperature has an average value of 4.5 10^{-4}

$$\frac{1}{n}\frac{dn}{dt} \sim -4.5 \times 10^{-4} \qquad (1)$$

The average value of temperature coefficient of sound velocity according to Rao may be taken as

$$\frac{1}{U}\frac{dv}{dt} \sim -3 \times 10^{-3} \qquad (2)$$

Dividing equation (2) by equation (3), integrating and simplifying, we get

$$\frac{U^{0.15}}{n} = \eta \qquad (3)$$

where η is a constant known as specific opto – acoustic velocity.

Change in temperature is responsible for all thermal phenomena. Liquids on heating may go from one state to another resulting in rearrangements in molecular configuration which in turn causes changes in its physical properties. Since the thermal response of opto – acoustic parameter is not linear; every substance has its own characteristic response depending on its molecular structure, chemical environment and chemical composition. This is the basic principle of thermal opto – acoustic analysis.

Thermal variation of optical parameters enabled us to detect and estimate the major sugar content in coconut water (Bindu et al., 2001). The same technique using opto – acoustic parameter has been attempted in the present paper to study the refrigeration and fermentation effect of coconut water.

Results and Discussion

Ultrasonic velocity (U) and refractive index (n) of fresh, refrigerated, air – fermented and yeast – fermented samples of coconut water were -

determined thermally at six different temperatures viz, 298K, 303K, 308K, 313K, 318K and 323K.. Using these direct parameters, opto – acoustic derived parameter η has been evaluated using equation (3) and the values are tabulated in Table 1.The variation of η with temperature for different samples were plotted in figures 1(a), 1(b) and 1(c).

Figure 1 (a) shows the variation of specific opto – acoustic velocity as a function of temperature for fresh and refrigerated coconut water. Analysis of the figure shows that the graphs are crowded together and the nature of variation of all curves of refrigerated samples on consecutive 5 days is identical with that of the fresh sample. This shows that the physical characteristics of the samples do not undergo any change due to refrigeration. Also the η values of the samples do not vary appreciably from that of the fresh sample at all temperatures. All the curves retain almost the same shape as that of the fresh sample. Hence it is clear that the samples do not undergo any physical or chemical change on refrigeration

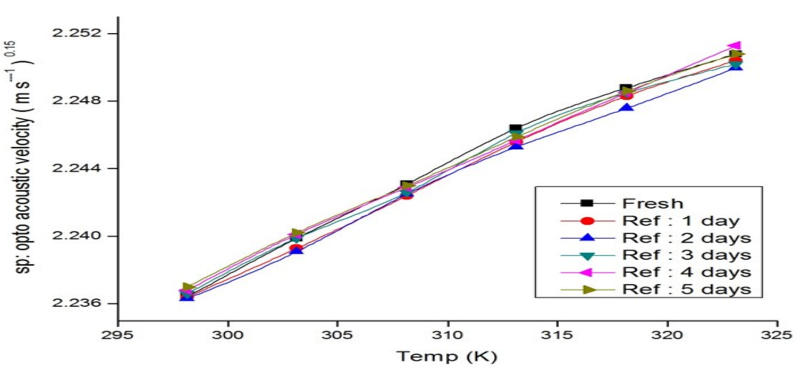

Figure 1(a) . Variation of η with temperature for fresh and refrigerated coconut water samples

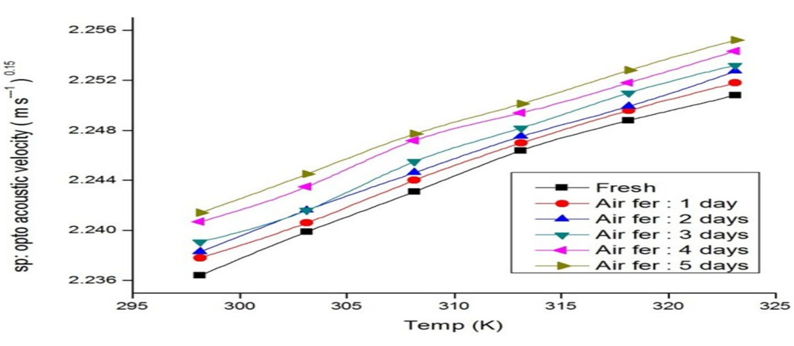

Figure 1(b). Variation of η with temperature for fresh and air – fermented coconut water samples

Table: 1 Variation of U, n and η with temperature for fresh, refrigerated, air – fermented and yeast – fermented coconut water samples.

Parameters	298 K	303 K	308 K	313 K	318 K	323 K
Fresh Sample						
U	1527.5	1536.4	1546.6	1553.3	1559.8	1563.4
n	1.3429	1.3420	1.3414	1.3403	1.3397	1.3390
η	2.2364	2.2399	2.2431	2.2464	2.2488	2.2508
Refrigerated 1 day						
U	1529.8	1539.0	1547.9	1555.8	1561.9	1568.1
n	1.3432	1.3427	1.3420	1.3411	1.3403	1.3398
η	2.2364	2.2393	2.2424	2.2456	2.2483	2.2504
Refrigerated 2 days						
U	1529.8	1539.7	1548.5	1555.9	1562.9	1567.7
n	1.3433	1.3429	1.3420	1.3413	1.3408	1.3400
η	2.2363	2.2391	2.2425	2.2453	2.2476	2.2500
Refrigerated 3 days						
U	1530.1	1539.6	1548.3	1557.2	1562.3	1567.1
n	1.3431	1.3424	1.3419	1.3410	1.3402	1.3398
η	2.2366	2.2399	2.2426	2.2461	2.2485	2.2502
Refrigerated 4 days						
U	1529.9	1539.1	1547.8	1555.6	1561.7	1567.3
n	1.3430	1.3422	1.3417	1.3410	1.3401	1.3392
η	2.2368	2.2401	2.2429	2.2457	2.2485	2.2513
Refrigerated 5 days						
U	1529.4	1539.3	1548.5	1556.3	1561.3	1566.8
n	1.3428	1.3422	1.3417	1.3410	1.3400	1.3394
η	2.2370	2.2402	2.2430	2.2459	2.2486	2.2508
Air fermented 1 day						
U	1529.0	1538.4	1547.8	1554.5	1561.3	1567.4
n	1.3423	1.3418	1.3410	1.3401	1.3394	1.3389
η	2.2378	2.2406	2.2440	2.2470	2.2496	2.2518

Air fermented 2 days						
U	1528.6	1537.6	1546.8	1553.9	1560.4	1565.3
n	1.3419	1.3411	1.3405	1.3397	1.3391	1.3381
η	2.2383	2.2416	2.2446	2.2475	2.2499	2.2527
Air fermented 3 days						
U	1527.6	1536.5	1546.8	1554.0	1559.9	1565.3
n	1.3413	1.3410	1.3400	1.3393	1.3384	1.3378
η	2.2391	2.2416	2.2455	2.2482	2.2510	2.2532
Air fermented 4 days						
U	1529.4	1537.8	1548.4	1553.4	1560.6	1564.8
n	1.3406	1.3400	1.3392	1.3385	1.3380	1.3371
η	2.2407	2.2435	2.2472	2.2494	2.2518	2.2543
Air fermented 5 days						
U	1526.5	1535.6	1543.8	1551.6	1558.0	1562.7
n	1.3398	1.3391	1.3383	1.3379	1.3371	1.3363
η	2.2414	2.2445	2.2477	2.2501	2.2528	2.2552
Yeast fermented 1 day						
U	1526.4	1536.4	1545.4	1554.1	1560.2	1565.2
n	1.3413	1.3409	1.3401	1.3392	1.3386	1.3380
η	2.2388	2.2417	2.2450	2.2484	2.2507	2.2528

Figure 1 (b) shows the variation of η with temperature for samples of coconut water kept in air (air – fermented samples) for 5 consecutive days along with the fresh sample. A perusal of the graph shows that there is an upward shift for the air – fermented samples. In other words, the η values increase with fermentation period and the shift is maximum for the one kept for maximum number of days. The shape of the graphs also shows variation from fresh sample for higher and higher fermentation period. These observations indicate that both physical and chemical changes takes place in air – fermented samples. A close examination of figure 1 (b) shows that the curves for 4^{th} day and 5^{th} day samples deviate much from that of fresh sample. This may be due to the conversion of reduced sugars in coconut water into alcohol by fermentation. But such a conversion is not observed in refrigerated samples because the micro organisms which are responsible for fermentation cannot survive at very low temperature. The increase in η values with fermentation period of air – fermented samples indicates the reduction in concentration of sugar content in the samples as it is converted into alcohol. A similar observation has already been established by Mohanan *et al* that a

Yeast fermented 2 days						
U	1527.6	1538.4	1545.8	1552.9	1559.7	1564.1
n	1.3399	1.3391	1.3385	1.3378	1.3371	1.3361
η	2.2415	2.2452	2.2478	2.2505	2.2532	2.2558
Yeast fermented 3 days						
U	1525.9	1536.1	1544.0	1551.4	1558.6	1561.8
n	1.3388	1.3380	1.3373	1.3367	1.3360	1.3351
η	2.2429	2.2465	2.2494	2.2520	2.2548	2.2570
Yeast fermented 4 days						
U	1523.8	1532.4	1540.9	1548.1	1554.0	1558.9
n	1.3387	1.3379	1.3373	1.3367	1.3360	1.3351
η	2.2426	2.2459	2.2487	2.2513	2.2538	2.2564
Yeast fermented 5 days						
U	1522.6	1532.1	1540.4	1547.5	1553.6	1558.5
n	1.3388	1.3380	1.3374	1.3368	1.3361	1.3352
η	2.2422	2.2456	2.2485	2.2510	2.2535	2.2561

decrease in concentration of sugar increase the value of η. (Mohanan *et.al* 2001).

Figure 1 (c) shows the variation of η with temperature for coconut water fermented with yeast (yeast – fermented samples) for 5 consecutive days along with fresh coconut water. It is observed that there is an increase in relative shift when compared to the normal fermented sample showing enhanced fermentation on addition of yeast. Again it is found that in air - fermented samples [Fig : 1 (b)] , there is a regular upward shift for η values whereas in yeast – fermented samples [Fig: 1 (c)], the η values first increase till the 3rd day and thereafter decreases for 4th and 5th days. Moreover the relative shift in the curves decreases for 4th and 5th days and the graphs get crowed together. This may be due to a state of saturation acquired on fermentation by yeast and certain other chemical reactions takes place with higher fermentation period. Such an abnormal behaviour of yeast – fermented samples has to be studied further.

Conclusion

It is well – known that refrigeration is an effective means for storage of food stuffs. In the present paper, using the technique “ Thermo Opto – Acoustic Analysis”, we have scientifically arrived at the conclusion that the physical characteristics of tender coconut water are not altered due to refrigeration whereas there is change in physical and chemical properties due to fermentation. Moreover the fermentation effect is enhanced on addition of yeast in coconut water.

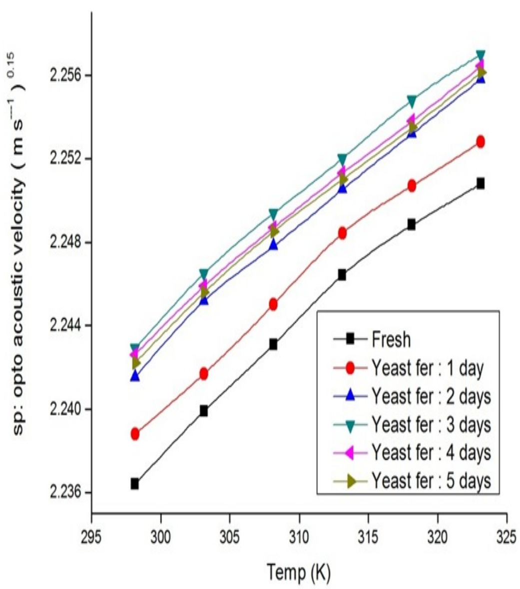

Figure 1(c) . Variation of η with temperature for fresh and yeast – fermented coconut water samples

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