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Non Thermal Processing of Coconut Water

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Abstract—*The product, Coconut water (Cocos nucifera L.) is usually found in tropical regions. Its functional properties draws the attention of manufacturers to process this. Coconut water is very sensitive as water starts to decompose as soon as it comes in the contact of environment. Processing, Thermal processes with chemical additives are usually used by the manufacturers for its processing. But due to these thermal treatments product obtained is not of good quality in terms of taste, aroma, and color. So there is need to use some non thermal treatments not only to maintain its sensory properties but also for nutritional content. Like high pressure processing, high pressure carbon dioxide technologies can be used for its processing. Discussion, the results came out from various former and recent investigations are mentioned here. And finally, conclusion is made to vast the knowledge for further research in this respective field.*

1. INTRODUCTION

Coconut water is generally consumed as fresh where it is abundantly found. But to be consumed in other regions it needs to be processed because of its low shelf life. Processing of coconut water not only maintains the quality attributes but also generates jobs and facilitates its consumption in other regions also. Even though, India is the third largest coconut growing country in the world, still its contribution to international market remains insignificant. The reason behind that food processing sector has not paid due attention to diversification and value addition to coconut, its products and by products. Therefore, coconut processing remained confined to only copra production, manufacturing of desiccated coconut, oil extraction, coir and coir products.

1.1 Need of non thermal treatment

Coconut water is sterile until it is not in direct contact with environment but it started to deteriorate when it comes in contact due to the presence of oxidative enzymes. So there is need of treatment for its preservation or for long shelf life. Pasteurization process is generally used for its preservation and microbial safety. Thermal processed coconut water shows a fouling effect. Formation of white, greasy deposits on the top of the processed coconut water shows the fouling. The deposits on the top layer are of proteins such as albumins and globulins, fats, and minerals. This fouling is not at all desirable and it makes the product unacceptable. Also these deposits cause the loss of minerals in the coconut water. The nutritional value of the product also gets affected due to the thermal treatment. Also shows a negative effect on the sensory properties. Coconut water loses its delicate fresh flavor and some of its nutrients during heat treatment.

So a non-thermal process is needed to protect the fresh flavor and nutrient content of coconut water. Non thermal processing of coconut water would increase marketability of this healthy drink and availability to consumers throughout the world. Some of the non thermal treatments discussed below can be used for coconut water processing.

2. HIGH PRESSURE PROCESSING (HPP)

It is kind of cold pasteurization technique. In this processing the coconut water is processed by already packing it in to the final package and then pressure is applied. Isostatic pressure is applied, due to which every molecule get equal pressure and adiabatic heating of the product is there. Due to adiabatic heating all the molecules are exposed to heat treatment, thus uniform quality of the product is there. In this the coconut water is exposed to high pressure, generally in the range of 100-800 MPa. The pressure is transmitted by a medium which is usually water, placed between the product and container.

2.1 Working

In HPP processing, the coconut water is packed in a flexible packaging material like pouch or plastic bottle and then the product is placed into high pressure chamber containing pressure-transmitting or hydraulic fluid. The hydraulic fluid used is usually water, and pressure is applied on this by means of pump. The pressure applied is further transmitted by means of hydraulic fluid to the coconut water through the package. There is certain retention time usually 3 to 5 min for the pressure application. After that pressure is removed from the product. As the uniform pressure transmittance is there, thus the shape and quality of the product does not get affected. Pressure applied inactivates the vegetative flora thus increasing the shelf life and also guarantee the food safety. Life raw coconut water brand is HPP processed coconut water.

2.2 Advantages

Due to this non thermal type treatment the product quality is good in terms of nutrition and sensory qualities. In HPP there

is retention of colors, flavors and nutrients, thus increasing the aesthetic value of the product. Also due to HPP the need for additives for the retention of original flavors and preservatives get reduced. Also very less energy required for the process.

2.3 Disadvantages

It is very expensive process than the thermal process. Not suitable when the large volume of the coconut water needs to be processed because of the batch style performance. Also the product does not show the shelf stability as time passes. The reason is that HPP processing is not always capable to inactivate the enzymes which are responsible for browning and other degredative effects.

3. MEMBRANE FILTRATION

Membrane filtration are interesting alternatives to stabilize delicate aromatic fruit juices. The original flavor of coconut water is sensitive to temperature and microfiltration (MF) could help to pasteurize the product at ambient temperature while preserving its aroma. Moreover, ultra filtration (UF) is used for the extraction of small molecules from a solution and enzymes, such as PPO and POD, are small molecules of, respectively, 73.8 kDa and 49.2 kDa [15]. Ultra filtration retained 92% and 91% of PPO and POD activity thanks to a 10 kDa cut-off membrane [14]. Hence, from a microbiological point of view, microfiltration appears to be a satisfactory way to stabilize coconut water but has no effect on enzyme activity since the enzymes cross the membrane. Ultra filtration retains PPO and POD enzymes. The discoloration of coconut water is still not completely elucidated [13].

Microfiltration did not significantly influence pH, acidity, total soluble solids or total solids of clarified coconut water but increased clarity (measured as luminance *L* with a Hunter-Lab system), decreased turbidity and protein content by 24%. With different equipment and membranes, a similar increase in clarity, and a decrease of 13% in protein content and turbidity were also observed in clarified coconut water [13]. Furthermore, microfiltration caused a significant decrease in the ash content of permeate. K, Mg, Ca, Fe and Cu concentrations decreased by, respectively, 10 %, 16%, 19%, 20% and 22% [13]. Only calcium concentrations remained stable. Physical properties such as surface tension and viscosity changed, whereas the specific gravity was not affected.

Microfiltration obviously did not stop the pink coloration of the clarified coconut water. The taste of the micro filtered coconut water was found to be very similar to that of fresh coconut water but the aroma was lost during processing. Ultra filtration retained PPO and POD enzymes. Retention percentages of protein of, respectively, 25 %, 38% and 43% for the 100, 50 and 20 kDa cut-off membranes were confirmed [16, 17]. The assessment of the effect of three different processes ultra filtration, pasteurization and freezing on the mineral composition of young coconut water showed that the ultra filtration membrane retained most of the minerals present in coconut water. In contrast, pasteurization tended to increase Cu, Fe and Zn concentrations, whereas freezing completely changed the mineral distribution. Ultra filtration was able to retain PPO and POD enzymes but also retained minerals.

4. HIGH PRESSURE CARBON DIOXIDE TECHNOLOGY (HPCD)

In this technique incorporation of CO2 in coconut water is done. This leads to the micro-organisms destruction in the coconut water. There are following reasons which cause the preservation of coconut water due to the use of high pressure carbon dioxide technology. The preservation of coconut water is due to:

- **pH lowering effect:** CO2 helps in lowering the pH of the coconut water due to the formation of carbonic acid.
- **Inactivation of enzymes:** enzymes get inactivated due to the presence of CO2 and bicarbonate ions. Weder (1990) and others (1992) claimed that, "under a low pH environment, arginine could interact with CO2 to form a bicarbonate complex, and inactivate the enzyme containing this amino acid".
- **Physical disruption of cells:** It occurs due to the bursting of cells. As during depressurization, pressure applied is instantly released and the gas expansion is there with in the cells.
- **Modification of cell membrane and extraction of cellular components:** When gas is applied to the cells, CO2 penetrate into cell membrane and stored there, as the inner layer of cell is lipophillic. There is increase in fluid content of the membrane due to the accumulation of CO2. Increasing fluidity also leads to increase in permeability. Thus cause the inactivation of micro-organisms.
- **Inactivate the vegetative cells:** HPCD technology shows a good effect on killing of the vegetative forms of pathogenic and spoilage bacteria, molds and yeasts.

Formulation of coconut water beverage is done by acidification with malic acid. The pH of coconut water is around 5 and it is reduced to pH around 4.3 by use of malic acid. Then it is sweetened with Splenda (0.7% w/w) and carbonated at 1.82 atm CO2 at 4°C [2]. Microbial reduction was quantified as a function of pressure, temperature and % CO2 level. Optimum DPCD treatment conditions for microbial inactivation were determined to be **13% CO2, 25°C, 34.5 MPa for 6 min** [13].

Quality attributes such as pH, °Brix, % titrable acidity (%TA) and color of HPCD treated, fresh and heat pasteurized (74°C for 15 s) coconut water beverages were measured and compared throughout refrigerated storage (4oC for 9 weeks). HPCD treatment did not cause a change in pH or °Brix. The color of coconut water eventually turned pink during storage,

in all the 3 samples. Sensory panels showed that HPCD treated coconut water was liked as much as fresh coconut water; whereas heat pasteurized coconut water was significantly less liked at the beginning of storage. This study showed that a fresh-like tasting coconut water beverage can be produced by HPCD technology with an extended shelf-life of more than 9 weeks at 4°C [2]

HPCD treatments systems

HPCD systems are available in batch, continuous, and semi-continuous systems. In batch type system, treatment solution and CO2 are not continuous. They are fit in a container thus stationary during the treatment. In continuous HPCD system there is continuous flow of both treatment solution and CO2 in the system whereas in semi-continuous system only the continuous flow of CO2 in the treatment chamber is there.

5. FREEZE DRYING

Freeze drying or lyophilisation**,** is dehydration processing technique. Usually used for the preservation of a perishable product. In freeze-drying the coconut water is firstly freeze and then surrounding pressure is reduced so that the frozen water in the product get sublimate.

Freeze drying is completed in four stages i.e. pre-treatment of the product, freezing, primary drying, and the last secondary drying.

- **Pre-treatment of the product:** Pre-treatment means any method used for treating the product before the freezing. Like concentration of the product, product formulation, increasing in the surface area of the product.
- **Freezing:** It is accomplished by utilising a freeze-drying machine. In this stage, it is necessary to cool the product lower than its triple point i.e. the lowest temperature where the solid and liquid phases of the product can exist together. It ensures the sublimation of the product and prevents melting.
- **Primary drying:** In this step, pressure is reduced and heat is given to the product for sublimation. In this step around 95% of water in the product gets sublimated. The phase of this can be slow, because if large amount of heat is applied to the product then that can alter the structure of the product.
- **Secondary drying:** Its main objective is to remove the water molecules which are unfrozen. The temperature used is higher than that is used in the primary drying phase. The temperature is increased for the breakage of any physico-chemical interaction which may be occurred between the unfrozen water molecules and the frozen product.

5.1 Freeze drying of coconut water

It is under research. No commercial utilization of this process for the processing of coconut water is there. The freeze-drying of coconut water is done by temperature and time variation. It is found that, "1 ton of fresh coconut water produced 63.8±2.7 kg of freeze-dried coconut water powder and also results showed that all nutritional properties of freeze-dried coconut water is nearly the same as the fresh coconut water" [6]. The freeze-dried coconut water powder processing was done by temperature and time variation with the temperature programming by using SPC Freeze dryer Model 40Kg**.** The optimum condition of this processing process was done by pre-freeze at -20ºC for 3 hours with first drying step at -20ºC for 4 hours, second drying step at -10ºC for 7 hours and third step at 0ºC for 6 hours and heat up to 30ºC [6].The product formed is of very good in nutritional quality. It is not a commercial product but all its research parameters make it feasible to be commercialized

6. CONCLUSION AND FUTURE PROSPECTS

The demand of coconut water is increasing due to increase in health awareness. It becomes necessary to preserve the coconut water for future use. So, that people not belongs to tropical area can also consume this product. It is becoming popular due to its medicinal and nutritional benefits. People are becoming more conscious about their health these days. Furthermore development of new technologies also facilitates the preservation of coconut water. Nowadays non thermal treatments are used for its processing so that people can get original flavor and color. In 2012, the estimated demand for coconut water was around 100 million litres and which is expected to 350 million litres in 2020. So, there is a wide scope for this product. Its global increase in demand made it a good export product. Also the increasing market demand not only profits the companies but also serve as a source of income to the farmers in one end of supply chain. But before this, coconut water is simply a waste to them with no profit but the processing made it a highly profitable beverage. So there is a good future scope of this product. It is becoming a popular drink today among the beverages and increasing rapidly. Popular beverage giants like Coca-Cola Co. and PepsiCo plays a significant role in the coconut water market.

In India, there is very less processing of this good gifted product. So manufacturer needs to pay more attention towards the processing as well as value addition of this product. Technological advancement should be done to preserve its flavor, aroma and nutrients. So this is the time to pay attention towards the processing and preservation of coconut water. There is need to develop cost effective non thermal treatments for its processing, which will provide good quality and nutritive product to the consumer.

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