An overview of dealcoholization of beverages

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Alcoholic beverage is a beverage/ brew or liquor containing more than 0.5% alcohol by volume (FSSAI). At the heart of all alcoholic beverage is fermentation, basically alcoholic fermentation in which the sugars are converted into alcohol and other minor products by utilizing agricultural produce as the raw material. Varied flavor profile of alcoholic beverages is obtained by using different type of media culture along with distinct type of raw material. This varied profile contributes to rich diversity of drinks. Alcoholic beverages fall under the category of psychotropic substance. Examples of alcoholic beverages are wine, beer, cider etc.

Beer is an alcoholic beverage produced from malted barley grains or other malted cereal grains with or without the addition of adjuncts, in combination with hops or hop extract that imparts a bitter taste whereas wine is manufactured from complete or partial fermentation of grapes or other fruits. A recent improvement in paradigm aiming for a healthy lifestyle, have led to an increase in global demand for alcohol free beer or dealcoholized wine (Mangindaan *et al*., 2018). Once the ethanol content in alcoholic beverages is reduced, anyone can consume it without restrictions and one could enjoy the benefits of bioactive compounds that are present in the fermented beverages. Beer contains a good quantity of vitamin B and phenolic compounds. Even wine has been used as a cardioprotective, diabetic and anti- aging agent.

The other benefit of dealcoholization is that, it can easily eradicate the ill effects caused by heavy alcohol consumption such as dementia, cirrhosis, cancer, high blood pressure and high crime rates. Hence, dealcoholization is a process of ethanol removal up to certain limit in order to obtain low alcoholic beverage or alcohol-free beverage. Low alcoholic beverage generally contains more than 0.5% and less than 7% alcohol by volume. But according to FSSAI, alcohol free beer should possess 0.0% abv. Therefore, the range of alcohol-free beverages vary from country to country. When the alcohol content is reduced more than 20% of its initial alcoholic concentration, then only it is said to be dealcoholized beverage (Liguori *et al*., 2018). Either pre- production or post- production methods is employed for obtaining dealcoholized wine or beer. But each dealcoholizing method has its own pros and cons.

Pre- production methods restrict the production of ethanol during fermentation. The various pre-production methods are selection of yeast with lower sugar/ ethanol transformation ratio, reduction of fermentable fraction in the raw material, changed mashing

process (by inactivation of amylases), arrested fermentation (either by temperature inactivation of removal of yeast from wort). However, these processes have a negative result on the taste and aroma of the beverages, worty off flavors may be produced in beer, that is usually unacceptable by the consumers. Therefore, considerable efforts are put into the post production methods of dealcoholization in which high alcoholic beverages are manufactured by fermentation and then the ethanol content is reduced. Various post- production techniques are spinning cone column, osmotic distillation, solvent supercritical extraction, reverse osmosis, pervaporation.

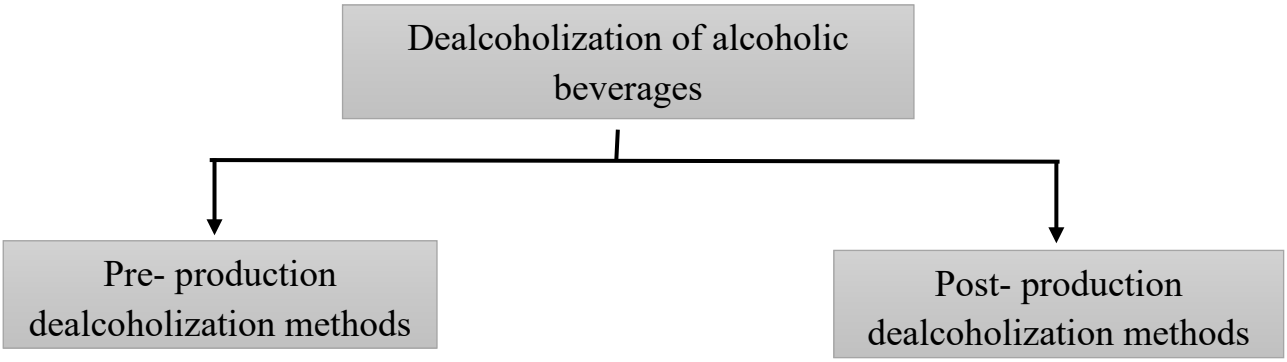

Figure 1. Methods for production of dealcoholized beverage

Spinning cone column is an advanced method of distillation. It is a multi-stage strip column developed in 1930 in USA, for separation of liquid mixtures. It consists of a vertical column with countercurrent flow of alcoholic beverage and stripping agent. The column comprises of alternate rotating and stationary cones with a rotating shaft. The column operates in vacuum. The liquid flows down by the action of applied centrifugal force. It is an energy extensive process that extract the aromatic compounds from the alcoholic beverages. Belisario-Sánchez *et al*. (2012) optimized the spinning cone column conditions for dealcoholization of red, white and rose wine. They dearomatized the wine at 26° C and then extracted ethanol from the dearomatized wine. At the end of the process, the aromatic compounds were added back to dearomatized- dealcoholized wine in order to provide the similar properties, in terms of aroma as that of original wine as shown in Fig. 2.

Osmotic distillation is a separation process in which microporous hydrophobic membrane is used. Only volatile substances can migrate to the opposite side of the membrane where stripping agent is present. This process operates at ambient temperature. Difference in vapor pressure acts as the driving force. Liguori *et al*. (2013) used a polypropylene based hydrophobic membrane for dealcoholization of red wine. In 5 cycles, the alcoholic content of red wine was reduced from 13% to 0.19%. The first and second cycle was of 60 mins each and the alcoholic content was halved in both the cycles whereas 3rd, 4th, and 5th cycle was of 45 minutes each with less reduction of alcoholic content. At the completion of this process, only

1.2% total aromatic compounds were left in the dealcoholized red wine as compared to the original wine.

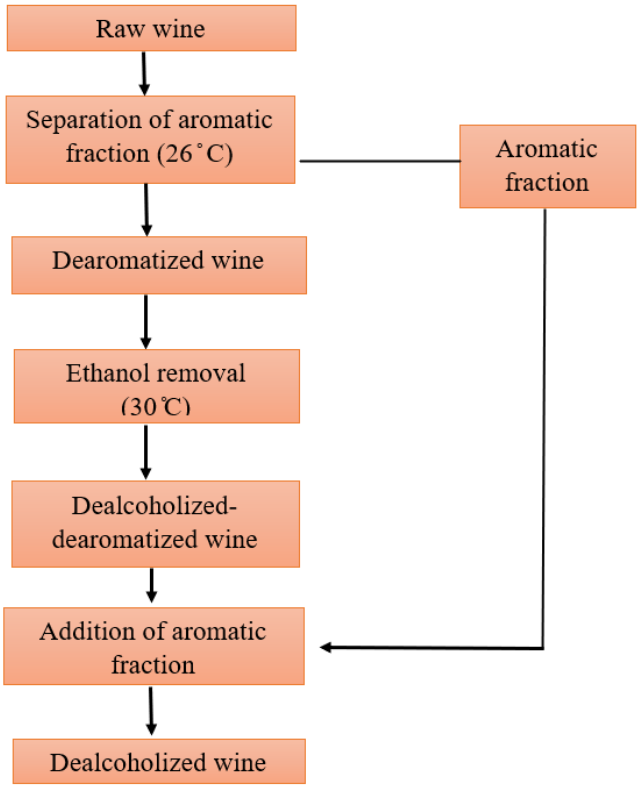

Figure 2. Dealcoholization by spinning cone column

Pervaporation is another post fermentation technique in which mixtures are separated by partial vaporization through a membrane. The vapors that cross the membrane were condensed due to the presence of vacuum on other side of the membrane. Olmo and his co-workers (2014) pervaporated a special beer (5.5% abv) and a reserve beer (6.5% abv) in order to recover aromas that was added back to improve their sensory qualities.

Membrane technology such as the reverse osmosis method could be performed for production of dealcoholized beverages. The semi- permeable membrane used in reverse osmosis allows only the small molecules such as water, ethanol, to pass through whereas larger molecules are retained. Ramsey *et al*. (2021) worked on dealcoholization of lager and stout beer and assessed the sensory and physicochemical impact on dealcoholized beers. The significant reduction was observed in sensory properties of dealcoholized lager and stout beer.

More research is still awaiting in this field. During dealcoholization, it is a cumbersome task to preserve the aromatic compounds. Most of the aromatic compounds are removed during this process that results in low-quality beer or wine in terms of taste/ aroma. Therefore, existing techniques should be improved for maximum retainment of organoleptic and sensory properties. Furthermore, various functional drinks can be developed from these dealcoholized beverages.

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