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Potential Microencapsulation of Barley Beer by β –Cyclodextrin - A Review

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ABSTRACT

Beer, an alcoholic beverage made from barley, hops, yeast, water and sometimes with adjuncts such as sorghum, rice, maize and more is a favourite drink for many people around the world. Beer is a drink for both happy and sad moments. In this review work, the potential of microencapsulating barley beer with spray and freeze drying techniques were assessed. Spray and freeze drying techniques have been employed in drying other products including wine. The carrier agent, β-Cyclodextrin which has been used in both food and pharmaceutical industries could serve as the wall material to protect the polyphenol-rich barley beer from thermal degradation of the nutrients during the drying process. Barley beer powder could result from the microencapsulation which could serve as a drink or added to other drinks or foods.

KEYWORDS: *Beer, Microencapsulation, spray drying, freeze drying, β-Cyclodextrin, beer powder*

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1. INTRODUCTION

Beer is one of mankind's oldest beverages. It has a long history and has accompanied human progress since the dawn of agriculture and sedentism. Brewing was prevalent in the Near East(Zarnkow, 2014) and the creation of beer brewing technique can be traced back to the Neolithic period. China provides the first evidence of fermented beverages with modern techniques such as mass spectrometry(Clarebel et al., 2020).

Beer, aside from water and coffee or tea, is one of the most popular beverages. Beer is made from cereal grains, most frequently malted barley, but it can also be made from wheat, corn, or rice (Stewart, 2016). Beer is typically sold in bottles and cans, but it is also accessible on tap at pubs and bars(Buiatti, 2008). Beer's percentage of alcohol is calculated using the density of alcohol; normally, beer has 4.7–5.0 percent alcohol by volume (abv) (Spedding, 2016).

Beers with an alcohol content of less than 0.5 percent abv are known as nonalcoholic beers (Ambrosi et al., 2020; Blanco et al., 2016). Due to its widespread consumption, a great deal of research has gone into developing various beer processing procedures. The historical manufacturing procedures mostly concentrated on physicochemical features like flavor and aroma, but current studies include a wider range of aspects of beer processing.

A. Bottled Tsingtao beer

B. Canned Tsingtao beer

Figure 1: Liquid beers in cans and bottles

Factors, such as transportation, carriage changes, and storage conditions, might result in the loss of flavor, nutrition, aroma, and color (VenuGopal & Anu-Appaiah, 2017). As a result of the drink being heavy and takes up greater volume and space, these problems arise during carriage and transportation. However, it has been found that beverages such as wine (Alvarez Gaona, Bater, et al., 2017; Wilkowska et al., 2017), pomegranate juice (Ghalegi Ghalenoe et al., 2021; Jafari et al., 2017), fruit juices (S. Wang et al., 2011), strawberry juices (Balci-torun & Ozdemir, 2021) and bovine lactoferrin (B. Wang et al., 2016). Figure 2 shows examples of some dried food made into powder.

Red wine powder

Apple powder

Strawberry powder

Figure 2: Dried food powders

2. BRIEF INTRODUCTION TO ENCAPSULATION PROCESS

Encapsulation technology has advanced dramatically during the last few decades, and its uses in the food, pharmaceutical, and nutraceutical industries have made it deeply embedded in our daily lives. The process of encapsulating active materials in a capsule made of other immiscible materials is known as encapsulation (Ahmad, 2012; Gibbs et al., 1999; Nedovic et al., 2011; Woo & Bhandari, 2013).Many food active components, such as oils, flavors, antioxidants, polyphenols, minerals, pigments, vitamins, and enzymes, can now be microencapsulated thanks to advancements in microencapsulation technology (Taghinezhad et al., 2020).

Microencapsulation techniques have a number of useful and desirable properties, including improving active ingredient handling (by converting liquid to solid), stabilizing labile active ingredients during processing, preserving bioavailability, extending the shelf life of final products, and masking flavors and tastes(da Rosa et al., 2013; Furuta & Neoh, 2021; Keven et al., 2016; Saifullah et al., 2019).

Microencapsulation of active substances is routinely performed in food application settings using a variety of processes such as freeze drying, fluidized bed coating, spray drying, and many more. (Furuta & Neoh, 2021). Figure 3 gives some processes under microencapsulation technologies.

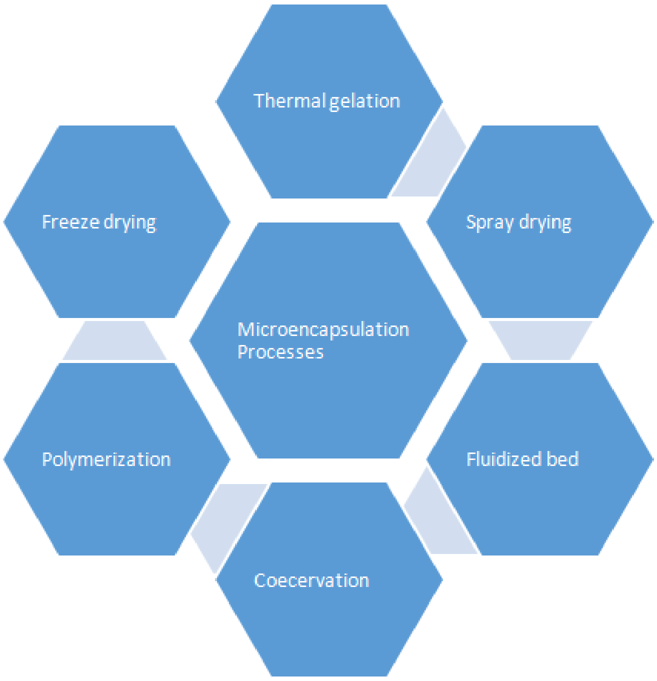

Figure 3: Microencapsulation processes

3. BRIEF INTRODUCTION TO DIFFERENT DRYING TECHNOLOGIES

Drying has been used to make powdered products in the wine and fruit juice industries.

This technique could lower the water activity of the items to less than 0.6, extending shelf life, increasing stability, and reducing microbiological elements and chemical reactions (Bhandari, Bhesh R. and Adhikari, 2008; Wilhelm et al., 2013)·

Overall, high-quality food drying is a distinct drying technology that safeguards the look, nutrition, color, taste, rehydration, and uniformity of foods during the drying process.

Some drying procedures may result in unsuitable food products. Food deterioration (e.g., oxidation, color loss, and nutritional loss) and structural changes may occur as a result of the incorrect drying method (e.g., texture loss, shrinkage, and microstructure variation). Such chemical and physical alterations may cause the client to reject the food product(Chitrakar et al., 2019; Osae et al., 2019).

Designing drying procedures for food and agro-products is particularly critical. Expanding the availability of food goods and broadening markets necessitates consumer-friendly and high-quality dried foods. (Mujumdar & Law, 2010; Osae et al., 2020).

A dry food product's consistency is usually determined by six key criteria.

1. The retention of flavoring ingredients has a considerable impact on the organoleptic consistency of dried items (Chin et al., 2008).
2. Nutritional retention, particularly for heat and oxygen-sensitive compounds like thiamine, vitamins A and C (Zhang et al., 2017).
3. Browning inhibition to maintain a pleasing color is linked to aspects such as attractiveness, freshness, and food safety (Boateng & Yang, 2020).
4. Rehydration, which refers to the possibility of recovering new product qualities as the dry material is rehydrated (Ambrosi et al., 2020; Antal, 2015; Omolola et al., 2017)·
5. It's also important for dried products that can be evaluated based on color differences, temperature, moisture content, shrinkage, and other factors (Caglar et al., 2021; Gokhale & Lele, 2012).
6. Food components interact at both the microstructural and macrostructural levels, resulting in complex look and texture (Boateng et al., 2022; Lao et al., 2020).

Due to its heat-sensitive, easy-to-degrade properties, and high moisture content, the examination of high-quality drying processes is critical to retaining certain quality food qualities. Fast-drying nutrients, such as vitamin C, are more heat-sensitive and should be considered.

Spray drying and freeze drying techniques are widely used in both the food and pharmaceutical industries for varying reasons, cost, quality and type of product (Çopur et al., 2019; Furuta & Neoh, 2021)·

3.1. Spray drying

When "active" components are encased in a protective matrix, spray drying can be utilized as an encapsulation method. The quick evaporation of water from the droplets makes spray-drying a suitable method that has been widely employed for drying foods and pharmaceuticals(Ziaee et al., 2019). It has the appealing benefit of manufacturing microcapsules at a lower cost than freeze drying, in a simple and continuous operation, when compared to other standard microencapsulation procedures (Alvarez Gaona, Bater, et al., 2017). The technology has been used in other researches to produce products such as tomatoes, wine, milk, pomegranate juices and other powders (Alvarez Gaona, Bater, et al., 2017; Ćujić-Nikolić et al., 2019; Maury et al., 2005; Shishir & Chen, 2017)

Figure 4: Spray dryer

3.2. Freeze drying

Freeze-drying has been shown to be a very effective method for drying thermo-sensitive materials while reducing thermal degradation processes. It's also been used to encase fragile biological materials during microencapsulation (Pavan, 2010). As a result, freeze-drying could be utilized to protect polyphenols from oxidation while also making them easily transportable through easy handling (Gustavo V. Barbosa-Canovas, Enrique Ortega-Rivas, Pablo Juliano, 2005). Freeze drying is a gentler method that is especially good for fragrant and/or heat-sensitive items. Water is removed from the frozen product using this technology by exposing it to a very high vacuum, which is based on a direct phase transition from ice to vapour(Alvarez Gaona, Rocha-parra, et al., 2017; Ratti, 2013). The technology has been used in both food and pharmaceutical industries (Balci-torun & Ozdemir, 2021; Çopur et al., 2019; Hnin et al., 2019; Huang & Zhang, 2013; Mphahlele et al., 2016; Pellicer et al., 2019). Products such as wine, drugs, bovine lactoferrin and many more.

Figure 5: Freeze dryer

4. THE USE OF CARRIER AGENTS OR WALL MATERIALS

Gelatin, gum arabic, cyclodextrin (CD), starch, paraffin, dextrin, and other carrier agents have been widely employed in the food and pharmaceutical industries to improve the drying process because they can change the viscosity, solid concentration, and surface tension of the fluids (Coimbra et al., 2021). They can be natural or synthetic carrier agents or wall materials.

Dehydration of wine removes both water and practically all of the alcohol, leaving a concentrated wine dry extract containing the polyphenols. However, dehydration of wine is a difficult task. The freeze-drying technique was used by (Sanchez et al., 2013) to remove alcohol and water in a research of the health effects of wine polyphenols without the influence of alcohol without the use of carrier agent. According to their findings, this process produced an amorphous rubbery mass of wine dry extract that is difficult to handle. When 20 percent (w/w) maltodextrin DE-10 (MD) was added to wine before freeze-drying, it resulted in an amorphous microstructure with a glassy appearance that was easily milled into a free-flowing powder with a color similar to that of a typical red wine. From their research, it could be deduced that, the physical stability of wine powder is linked to its glass transition temperature (Tg). Freeze-dried materials may exist in an amorphous state with time-dependent physical properties, affecting their storage stability. At the glass transition temperature, amorphous materials transform from an extremely viscous glass to a rubber, causing structural changes such as stickiness and collapse. (Sanchez et al., 2013) also found that following freeze-drying, the total polyphenol content in the powder remained at 97.8%. This wine powder proved microbiologically stable at room temperature due to its low water activity (a_w less than 0.25).

4.1. Cyclodextrin

Cyclodextrins are widely available, cheap and very useful carrier agent. Their capacity to form inclusion complexes with organic host molecules suggests that they could be used to create supramolecular threads (Torres-alvarez et al., 2020). From a microscopical perspective, each guest molecule is micro-encapsulated since it is individually surrounded by the carrier agent. This can lead to beneficial modifications in the guest molecules' chemical and physical properties (Lien et al., 2015; Webber et al., 2018).

1. The stabilization of highly volatile chemicals.

2. Changes in the chemical reactivity of visitor molecules.
3. The transformation of liquids into powders.
4. Increased solubility of substances and organisms
5. Masking of unpleasant odors and tastes.

Cyclodextrin and their derivatives have these properties, making them appropriate for use in, pharmaceuticals, food industries and many more (Mufioz-ruiz & Paronen, 1997). Cyclodextrin act as molecular encapsulants, safeguarding the flavor of foods during the freezing, thawing, and microwaving processes. In food compositions, cyclodextrin are employed to protect or convey flavors. They create inclusion complexes with lipids, flavors, and colors, among other compounds. When compared to other encapsulants, cyclodextrin permits the flavor quality and quantity to be kept to a larger extent and for a longer period of time, providing life to the food item (Valle, 2004).

HP- β-CDand inulin were used to spray dry polyphenols from several fruit wines (chokeberry, blackcurrant, and blueberry). The spray-dried wine powders' physicochemical and biological properties were investigated during the course of a 12-month storage period in darkness at 8 °C and the cyclodextrin was discovered to have a good influence on anthocyanin retention throughout storage (Furuta & Neoh, 2021).

5. THE IMPACT OF MICROENCAPSULATION ON THE CHEMICAL COMPOSITION OF FOOD PRODUCTS

Consumers are becoming more conscious of the importance of maintaining overall health and wellness, as well as improving heart and maintaining a healthy bodyweight (Pallottino et al., 2016). Basic nutrition (carbohydrates, proteins, and fats), bioactive components (vitamins, minerals, amino acids and peptides, and phytochemicals), and sensory appeal compounds all contribute to these advantages (e.g. organic acids, flavours and pigments).

Food components, particularly bioactive components, are prone to degradation or destruction by exposure to harsh surrounding conditions during food production, storage, distribution, and consumption, resulting in a reduction in their functionality and availability. Many food components are extremely reactive to one another, which can cause functionality to be altered or lost (e.g., protein and polyphenol interactions, and mineral and fatty acid interactions). Even in their natural state, several bioactive components of food have an unpleasant taste and flavor. As a result, they must be protected throughout their shelf life without affecting their sensory qualities. Their bioactivity must also be maintained so that it is available when taken and has a physiological function when transported to the body's specific target spot (Furuta & Neoh, 2021).

Microencapsulation has been utilized in food ingredients and nutraceuticals to protect and deliver food components. It is the process of encasing, packing a core ingredient in a more stable, protective wall material that can be released at controlled rates under certain conditions (Maia et al., 2020; Taghinezhad et al., 2020). Drying techniques, such as spray drying and freeze drying, have been widely used among these encapsulation methods due to their ease of use, wide availability of equipment, significant benefits in terms of product volume, storage space, and transportation costs, ease of handling, and high stability due to their low moisture content. The finished powdered goods can be easily reconstituted (dissolved) or combined with other prepared substances. The drying process is used in most encapsulation procedures to turn the substance into a more stable dried state (Li et al., 2019).

Spray drying was used to encapsulate red wine in a maltodextrin matrix, according to (Alvarez Gaona, Rocha-parra, et al., 2017). The encapsulated wine had a 5 times higher concentration of total anthocyanin than liquid wine after being made with a mix of red wine (Cabernet sauvignon) and 13.5 percent (w/w) maltodextrin DE_{10} (MD DE_{10}). (Alvarez Gaona, Bater, et al., 2017)employed outlet air temperatures in the range of 75-79°C and got a free-flowing powder with water activity (a_w) of less than 0.20 in all drying batches. Depending on the inlet air temperature (135 - 170°C), the retention of Total Monomeric Anthocyanin (TMA) in the wine powder was found to be over 83 %. The destruction of biologically active substances at high temperatures as a result of thermal, enzymatic, chemical, or breakdown is linked to the decline in antioxidant activity caused by drying (Kamiloglu et al., 2015). Some drying procedures have, nevertheless, enhanced the overall antioxidant capacity of dried nuts and fruits. Because partially oxidized polyphenols have higher antioxidant activity than non-oxidized polyphenols (Nguyen et al., 2014; Zhang et al., 2017).

Furthermore, improvements in antioxidant potential after drying may be linked to Maillard reaction products, which are often created as a result of heat treatment or extended storage and have high antioxidant capabilities (Kamiloglu et al., 2015).

6. CONCLUSION

Beer, a popular beverage, has seen numerous technological advances. These innovations are aimed at generating a nutritious product with a flavor that consumers enjoy. As a result, several types of packaging have been used to entice customers. Various advanced drying processes, such as freeze, spray, and diverse hybrid drying technologies, have been developed around the world to successfully transform various food ingredients into powder employing microencapsulation techniques. The findings of current literature research that have identified the impact of drying on the food properties are also presented in this review.

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