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APPLICATIONS OF DIACYLGLYCEROL (DAG) RICH MICROENCAPSULATED VITAMIN-C IN FOOD PROCESSING -A REVIEW

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Abstract

Oils enriched with fat soluble vitamins are of plenty in market but oils with less calorie and enriched with water soluble vitamins and their use in food processing are still not in a practice. Water-soluble vitamins such as vitamin C can also be added to oils through the process of microencapsulation.The present study deals with DAG rich microencapsulated Vitamin-C oil. DAG (diacylglycerol) is devoid of one fatty acid than TAG(triacylglycerol) gives less calories in foods. On the other hand, vitamin–C is an well known antioxidant because of its ability to stabilise free radicals. Rice bran oil also contains oryzanol naturally which prevents cholesterol absorption. Therefore, combination of duo can serve as a duel nutraceutical in food industry and use of such oils (vitamin-C enriched DAG oil) in fortification of various food products like butter, yogurt, Nutella mix will be very beneficial (less calorie containing vitamin enriched foods) in our day to day life.

Keywords: *Microencapsulation, Ascorbic acid(vit-C), diacylglecerol, food-processing*

Introduction:

Microencapsulation is a method that involves enclosing tiny solid particles, liquid droplets, or gas molecules within a protective layer or incorporating them into a consistent or diverse matrix. This technique serves to protect the enclosed active substance from external factors and releases it when a specific trigger is applied, typically when its functional properties are needed. Essentially, microencapsulation is a technology for packaging solids, liquids, or gases in a way that allows controlled release under specific conditions (Picot and Lacroix, 2003) (Shahidi, 1933). The size of microcapsules can range from as small as 1 micron to a few millimeters but is generally less than 200 microns (Dunn, 2008).

Ascorbic acid (AA) functions as a potent antioxidant by supplying hydrogen atoms to counteract harmful free radicals (Bendich, A, 1990). Upon neutralizing free radicals, ascorbic acid transforms into dehydroascorbic acid, which can regain its antioxidant activity by accepting hydrogen atoms.

Davey *et al*.'s comprehensive review delves into the chemistry, function, metabolism, bioavailability, and the impact of processing on plant L-ascorbic acid (Davey, M.W.; Van Montagu, M.; Inzé D.; Sanmartin, M.; Kanellis, A.; Smirnoff, N.; Benzie, I.F.F., 2000)

In Ball's discussion (Ball, 2004), various potential roles of ascorbic acid are explored. These roles include its participation in the absorption of inorganic iron, prevention of the formation of carcinogenic compounds, coenzyme functions, synthesis of carnitine and noradrenaline, stimulation of collagen production, regulation of brain neurotransmitter systems, and reinforcement of immunity against diseases. Additionally, vitamin C is noteworthy for its potential to reduce the risk of severe illnesses like cancer, heart disease, cataracts, and elevated lead levels. It is also believed to enhance the immune system's defenses against common colds (Blake, S., 2008) (Hamilton, I.M.J.; Gilmore, W.S.; Benzie, I.F.F.; Mulholland, C.W.; Strain, J.J., 2000).

The reactivity and stability of ascorbic acid are compromised due to its high reactivity, resulting in substantial losses during food processing. It degrades quickly in the presence of oxygen through oxidative processes mediated by free radicals, especially when transition metal ions like iron and copper catalyze these reactions, leading to the breakdown of ascorbate. The degradation process is accelerated when the pH is neutral or higher. Additionally, enzymes like ascorbate oxidase and ascorbate peroxidase can contribute to its degradation (Kirby *et al*., 1991).

Dietary oils containing diacylglycerols (DAGs), which are known for their beneficial fatty acid composition, have gained attention for their anti-obesity properties. Many modified lipids, including structured and bioactive lipids, have been developed to combat obesity, with DAGs being one such innovation. This study focuses on the controlled release of microencapsulated vitamin C in DAG-rich rice bran oil. While this vitamin C-enriched oil is not suitable for frying, it performs excellently as a cooking oil. Because vitamin C is water-soluble, encapsulation is essential. Among the various microencapsulation techniques, popular options include spray drying, spray cooling, spray chilling, fluidized bed coating, extrusion, centrifugal extrusion, lyophilization, coacervation, centrifugal suspension separation, cocrystallization, liposome entrapment, interfacial polymerization, inclusion complexation, molecular inclusion, and nanoparticulate delivery systems.

Microcapsule Preparation Procedure:

To create the microcapsules, method inspired by Comunian *et al.* (2013) was followed. Once freeze-dried, the samples were placed in glass vials with aluminum foil lining and stored in a desiccator.

Spray-drying - Spray drying is the primary method used for large-scale encapsulation of food ingredients, as noted by Desai and Park (2005) and Gharsallaoui *et al*. (2007).

This technology is well-established, cost-effective, straightforward (Gouin, 2004), continuous, and easily scalable. However, it's important to be aware that using higher air inlet temperatures, ranging from 150 to 205°C, even for a short period, may potentially result in the degradation of heat-sensitive compounds (Gharsallaoui *et al*., 2007).

The key steps in the spray drying process include creating an aqueous emulsion with core and wall materials, homogenizing this emulsion, atomizing it inside the drying chamber, and lastly, dehydrating the resulting spray-dried particle(Desai *et al*., 2005) (Gharsallaoui *et al*.,2007).

Fluidized Bed Coating - In the fluidized bed coating process, an active ingredient is suspended in a controlled upward airflow, and simultaneously, a spray of hot molten substances like fat, wax, or polymers is used to coat these particles, as described by Schrooyen and Madene (Schrooyen *et al*,2001 and Madene et al.,2006).

Liposomes-

Liposomes are commonly produced by combining lipids with organic solvents and subsequently drying them through processes like a rotary evaporator, spray drying, or lyophilisation. A thorough examination of liposomal structure, characteristics, manufacturing methods, and potential uses concerning food ingredients has been carried out. The encapsulation of substances within liposomes provides distinct benefits, particularly in safeguarding water-soluble bioactive components, and presents several advantages compared to alternative techniques. The popularity of liposome encapsulation is attributed to its adaptability in customizing liposomes to specific needs, its capacity to encapsulate both hydrophilic and lipophilic bioactives, and its ability to regulate release rates (Augustin *et al*, 2007).

Furthermore, liposome technology excels at preserving the stability of water-soluble bioactives in high-moisture food systems compared to other techniques, thanks to its superior controlled-release properties (Ramon *et al.*, 2008). From an industrial perspective, liposome encapsulation holds significant importance as it provides a continuous and scalable approach suitable for large-scale production.

Melt Extrusion - Extrusion is an encapsulation method where a core material is dispersed within a molten coating material, and this blend is pushed through an opening in an extruder die head. This process utilizes an extruder, which continuously melts the carrier material, while the materials to be encapsulated are mixed or injected into the molten carbohydrate carrier (Shefer *et al*., 2003). After extrusion, the product goes through cooling and particle size reduction.

Development of yogurt, butter, nutella spread, containing vitamin- C enriched DAG-rich oil

The development process includes the production of yogurt, butter, and Nutella spread infused with vitamin-C enriched DAG-rich oil (Dhara *et al*.,2012) .For yogurt preparation, a mixture of 10% sugar, 0.075% strawberry essence, and 0.05% encapsulated vitamin-C is added to heated milk at 90ºC for 30 minutes. This mixture is then cooled to 45ºC over 3 hours. Encapsulated vitamin-C is introduced and mixed at 4ºC for varying durations of 0, 7, 15, 21, and 30 days. There are three categories: control yogurt without vitamin-C, experimental category (I) with 6% non-encapsulated bioactive compounds DAG-rich oil and 2% non-encapsulated vitamin-C, and experimental category (II) containing 2% microencapsulated vitamin-C.

Nutella, a chocolate spread, is made from hazelnuts, sugar, cocoa, skimmed milk powder, whey powder, lecithin, and encapsulated vitamin-C. Butter, with an 80% butter fat content, is produced by churning cream and can also be fortified with encapsulated vitamin-C. All the prepared food products could be evaluated for control sample (I), non-encapsulated vitamin-C (II) and experimental category with microencapsulated vitamin-C(III) will be morphologically characterized (SEM, pH, viscosity).

Discussion - The technique of microencapsulation offers numerous advantages, making it a valuable method for protecting sensitive compounds and ensuring the effective use of active materials known as "core materials." This process effectively shields these materials from external environmental factors. Due to its track record of delivering successful outcomes, microencapsulation has made significant and costly contributions to both the food and pharmaceutical industries. It plays a crucial role in preserving and enhancing the effectiveness of various sensitive ingredients in a wide range of applications. Further examination of its applications and effectiveness can provide more insights into its potential benefits and contributions.

A study conducted by Coumanian, Gomez-Estaca, *et al*. (2016) documented the process of chitosan-based gelation, involving a renewable amino carbohydrate obtained by deacetylation of chitin, through pH inversion. In this research, the mean particle size will be determined.

The prepared microspheres will undergo comprehensive characterization, including assessments of loading efficiency, particle size analysis, scanning electron microscopy (SEM), transmission electron microscopy (TEM), Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), zeta potential, and in-vitro release studies.

Additionally, the stability of ascorbic acid microencapsulated using this method will be evaluated by subjecting it to dissolution in a phosphate buffer for up to 60 days. This evaluation will be conducted using a UV spectrophotometric method to assess the integrity and performance of the microencapsulated ascorbic acid over an extended period.

The development of encapsulation technology has been significantly propelled by the functional food industry. Within this context, a wide array of functional food components has been effectively encapsulated. These components encompass flavors, vitamins, enzymes, acidulants, colors, microorganisms, and minerals (Dziezak *et al*., 1988; Shahidi *et al*., 1993; Schrooyen *et al*., 2001; Dezarn *et al*., 1995; Madene, *et al*.,2006; Bakan et al., 1973; Jackson *et al*., 1991).

To fully tap into the potential benefits of this technology, several crucial factors must be taken into account. These factors involve assessing the functionality of the encapsulated ingredient in the end product, selecting the appropriate encapsulating material, ensuring stability under diverse processing conditions, defining the release mechanism, determining the optimal concentration of bioactive substances within the microcapsules, specifying capsule size and density, addressing concerns related to storage stability, and managing production costs (Desai *et al*.,2005).

Conclusion:

This study underscores the importance of creating and examining novel food products using the food fortification process, which holds a central role in the field of food science and technology. The introduction of innovative food items like vitamin C-enriched butter, Nutella spreads, and fortified yogurt has the potential to deliver significant advantages to people in their everyday routines. These fortified products are positioned to boost nutritional value and provide valuable health benefits, ultimately contributing to the overall well-being of individuals**.**

Future Scope:

Food fortification is a vital aspect of enhancing the nutritional value of food items. The creation of new food products, such as vitamin C-enriched butter, Nutella spreads, and fortified yogurt, holds great promise for improving the daily lives of individuals. These fortified products have the potential to provide essential nutrients and health benefits, contributing to the overall well-being of consumers. Consuming Vitamin C along with food not only supplements its intake but also enhances the stability and overall appeal of the food products.

Conflict of Interest: The authors of this paper declare that there is no conflict of interest associated with its publication.

Author's Contribution: Soheli Dutta conducted the complete literature review, created all the figures, and managed the references for this paper. Dr. Rupali Dhara Mitra conceptualized the paper's idea and title, in addition to providing extensive editing for the entire manuscript.

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