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**Research Article**

# Microencapsulation of Vitamin C through Extrusion Process

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**Abstract**

A healthy diet and consumption of a variety of foods should ensure adequate supply of vitamin C to the body. A study was carried out to develop of microcapsules for vitamin C by extrusion process. Sodium alginate used as a coating material. 2g of sodium alginate with 0.2N of $CaCl_2$ solution was better to develop the microcapsules and load the core material of Vitamin-C (L-ascorbic acid). Encapsulation efficiency was noticed higher in 100mg of Vitamin C beads. The average efficiency rate is 74%. Vitamin C microcapsules were stored for 15 days at room temperature and refrigerated conditions. When compared to room temperature stored capsules which lost the maximum amount of vitamin C (average range of loss 175%) with refrigerated stored capsules during the storage period of $10^{th}$ day onwards.

**Keywords:** microencapsulation, vitamin C, extrusion, microcapsule beads, encapsulation efficiency

## Introduction

Microencapsulation is the creation of a barrier to avoid chemical reactions and/or to enable the controlled release of the ingredients. It involves mass transport behaviour in some way between the core (the ingredient) and the shell (capsule or coating) (Madene, 2006). Vitamin C (Ascorbic Acid) is a water-soluble antioxidant. It is common in fruits and vegetables such as guava, orange, capsicum, apple, pawpaw, brussel sprout, strawberry, kiwi fruit and cauliflower. Unlike animals humans cannot synthesize vitamin C, rendering its ingestion from exogenous supplement or diet necessary. It is essential for the manufacture of collagen protein, wound healing, healthy immune and nervous systems and as an antioxidant to help prevent diseases (Reavley, 1998). And also it helps in the formation of neurotransmitters and increases the absorption of iron in the gut. Being an antioxidant, it protects the body from the harmful effects of free radicals and pollutants (Khalid lqbal et.al., 2004). Vitamin C is stable as a powder but this stability decreases when dissolved in water.

Environmental factors such as temperature, pH, oxygen, metal ion, UV and x-ray affect the stability. Ascorbic acid is highly oxidative which can cause a problem in food systems. In the processing stage, it can change colour from white to yellow which affects food colours. Also, it can react with other ingredients and bring about undesirable changes in the colour and taste of the food. Even though, it is this oxidative effect that makes vitamin C such a good antioxidant. Vitamin-C are essential more and more nutritious across the many nutritive ingredients. Unfortunately, vitamin-C is an unstable substance at the time of heat processing and storage. Encapsulating this vitamin-C provides higher shelf life. Microencapsulation can help to stabilize vitamin C. The objectives of this work were to optimize the level of sodium alginate for encapsulation of vitamin C for develop the vitamin C microcapsule beads and to extend the shelf life of the vitamin C in comparison with refrigerated stored beads and also to examine the physical quality of microencapsulated beads.

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## Materials and Methods

### Materials

Sodium alginate, Calcium chloride, Vitamin C (Ascorbic acid) was purchased from Hi-Media Laboratories Pvt. Ltd. Mumbai – 400086**)**

### Solution preparation

The calcium chloride was prepared 0.2% molar i.e., 10.0 g of Calcium chloride and dissolved in 500 ml of distilled water and shake well. And the coating material as sodium alginate was prepared 1 molar size i.e., 2 g of sodium alginate dissolved in 100 ml of water.

### Production of vitamin C microcapsules by extrusion technique

Sodium alginate was slowly added to distilled water with constant stirring on magnetic stirrer followed by mild heating, while stirring, until the solution became clear (Rojas-Grau et al., 2006, 2007 a,b). After the preparation of coating material, added the vitamin C @ 10% level to the above the solution and allowed it to mix. Calcium chloride solution was taken in a beaker and put it on a magnetic stirrer at mild stirring for extrusion of microencapsulated vitamin C beads. Fixed / perforated beaker on a stand and put the sodium alginate + vitamin C solution into it. Height of the syringe was maintained in such a way that shape of the drop in sustained and tailing was avoided. Drops of alginate will fall into the Calcium chloride solution and beads were formed. Beads were kept in Calcium chloride solution for one hour for hardening. After hardening beads was sieved through a strainer. Collected microcapsules were washed with distilled water to remove unencapsulated materials. Dried vitamin C microcapsule was prepared by the stabilizer of sodium alginate @ 0.2% for vitamin C fortification (Narsaiah.K, 2013).

### Encapsulation Efficiency

Content of Vitamin C was measured using 2, 6 dichlorophenol indophenols method. Microcapsules were macerated in phosphate buffer and centrifuged at 10000 rpm for 30 min. Vitamin C content of supernatant was estimated. Vitamin C content in hardening water 0.2M $CaCl_2$ (Calcium chloride) was also estimated. Encapsulation efficiency (EE) was calculated using following formula:

$$\textbf{EE} = \frac{\text{Vitamin C content in capsules}}{\text{Vitamin C content in hardening solution}} \times 100$$

### SEM (Scanning Electron Microscope) for vitamin C microcapsules

Morphology of Sodium alginate based dried microencapsulated vitamin C beads were examined through Scanning Electron Microscopy in Centre for Nanoscience and Nanotechnology, Gandhigram Rural Institute - Deemed University, Gandhigram.

### Estimation of vitamin C

This analysis was based on the method of described by AOAC, volumetric method (1975).

## Results and Discussion

### Optimization of Sodium Alginate Powder for Microcapsule (Beads) Formation

The ratios for optimization of sodium alginate powder with calcium chloride ($CaCl_2$) solution for development of microcapsule beads are presented in the table 3.1. In this optimization study 0.5 to 2.5g of sodium alginate powder with 0.1 to 0.2N of $CaCl_2$ was carried out.. The results indicated that optimization process the 0.5g sodium alginate powder no beads was appeared (microcapsule) in both 0.1N and 0.2N $CaCl_2$ solution. Then the 1g and 1.5g of sodium alginate the beads were noticed with loose texture in 0.2N $CaCl_2$ solution. With 2g sodium alginate in 0.2N $CaCl_2$ was observed hard (tough) nature of microcapsules, but with 2 .5g the beads were very hard. From the table 4.1 it could be concluded that, the optimization of 2g of sodium alginate with 0.2N of $CaCl_2$ solution was better to develop the microcapsules and load the core material of Vitamin-C (L-ascorbic acid).

### Evaluation of microencapsulation efficiency

The encapsulation efficiency was expressed in the Figure 3.1. Encapsulation of vitamin C was done by using sodium alginate as wall material. As per the result, Encapsulation efficiency was noticed higher in 100mg of Vitamin C beads. Which was followed by

250, 500, 750, and 1000mg of Vitamin C, got the encapsulation efficiency percentage of 75.6, 71, 68, 65.2 respectively. In this results showed that descending of encapsulation efficiency. When compared with the 750 and 1000mg of Vitamin C added matrix the 100 to 500mg vitamin C encapsulation had highest efficiency. The average efficiency rate is 74%. It could be concluded that 2g of sodium alginate matrix has carried maximum 355mg of Vitamin C out of 500mg.

**SEM (SCANNING ELECTRON MICROSCOPE)**

Surface characteristics of the sodium alginate coated Vit-C microcapsules were studied through SEM on different nanometers (500µm to 5µm) at Centre for Nanoscience and Nanotechnology, Gandhigram Rural Institute - Deemed University, Gandhigram.

Among the SEM photograph of microcapsules appeared as a crystal like structure. The agglomerated appearance might be due to the thickness of wall of the microcapsule.

**Determination of storage stability for vitamin C in microcapsules**

For assessment of the stability of Vitamin C in capsules, the capsules were kept both in the room temperature and refrigerated conditions. The stability was assessed by the aspects of oxidation level through colour intensity and presence of Vitamin C percentage, which was indicated in the table 3.2 and depicted in Figure 3.3. As per the table 3.2, Vitamin C microcapsules were stored for 15 days at room temperature and refrigerated conditions. The result shows that under refrigerated conditions (beads) microcapsules lost their vitamin C content at the average of 45% throughout the 15days of storage period. When compared to room temperature stored capsules which lost the maximum amount of vitamin C (average range of loss 175%). Regarding the colour, the beads stored at room temperature was noticed the dark yellow colour from white colour microcapsules during the storage period of $10^{th}$ day onwards. Ascorbic acid is highly oxidative which can cause a problem in food systems. In processing stage, it can change colour from white to yellow which affects food colour (Wilson,N and Shah,N.P, 2007).

**Table. 3.**1 Development of Microcapsule Beads by different proportions of sodium alginate

| **Requirements** | **Level of sodium alginate beads** | | | | |
|---|---|---|---|---|---|
| | **0.5g** | **1g** | **1.5g** | **2g** | **2.5g** |
| **Water** | 100ml | 100ml | 100ml | 100ml | 100ml |
| **$CaCl_2$ (0.1N)** | Not Appeaed | Not Appeared | Not Appeared | Not Appeared | Not Appeared |
| **$CaCl_2$ (0.2N)** | Not Appeared | Appeared | Appeared | Appeared | Appeared |
| **Beads Texture** | - | Loose | Semi hard | Hard | Very hard |

**Table-3.2** Stability of vitamin C in microcapsules during storage period

| | **Storage under Room temperature** | | | | **Storage under Refrigerated** | | | |
|---|---|---|---|---|---|---|---|---|
| **Days** | **$1^{st}$** | **$5^{th}$** | **10th** | **$15^{th}$** | **$1^{st}$** | **$5^{th}$** | **10th** | **$15^{th}$** |
| **Vitamin C (mg)** | 355 | 352 | 282 | 180 | 354 | 348 | 330 | 315 |
| **Colour** | White | white | Slight white | Yellow | White | White | white | White |

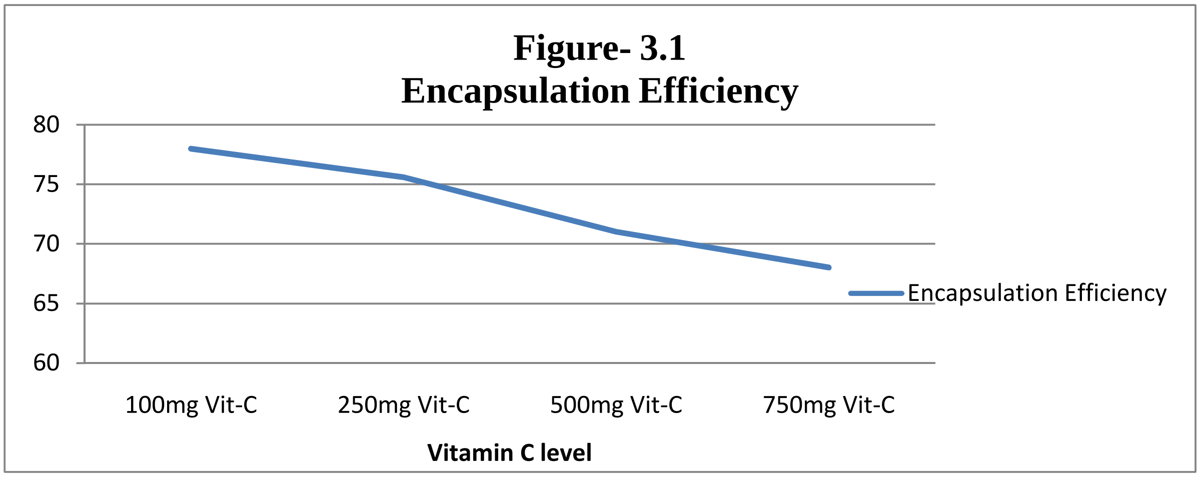



**Figure - 3.2** (Scanning Electron Microscope)

**Figure- 3.2- A**

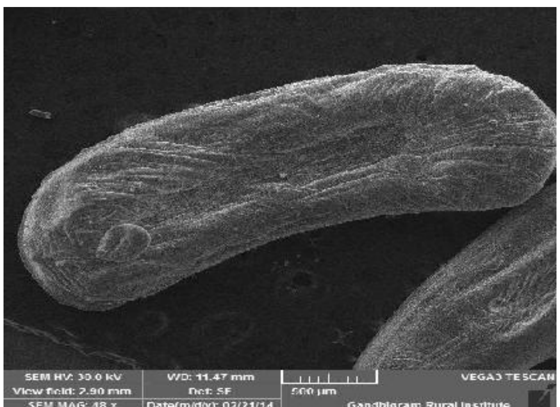
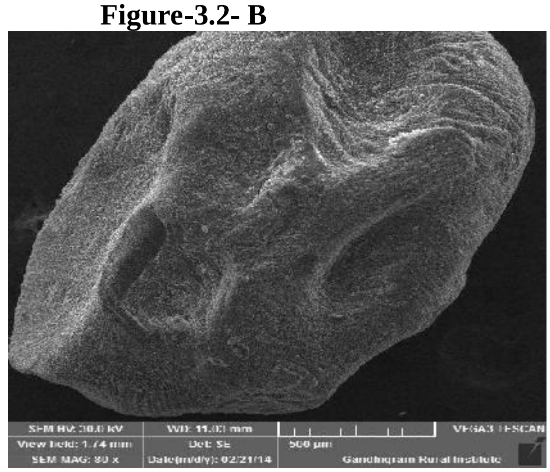


**Figure-3.2- B**



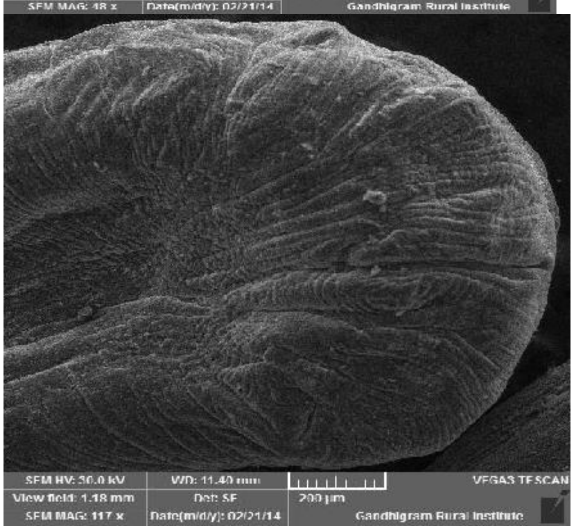


Figure- 3.2-C

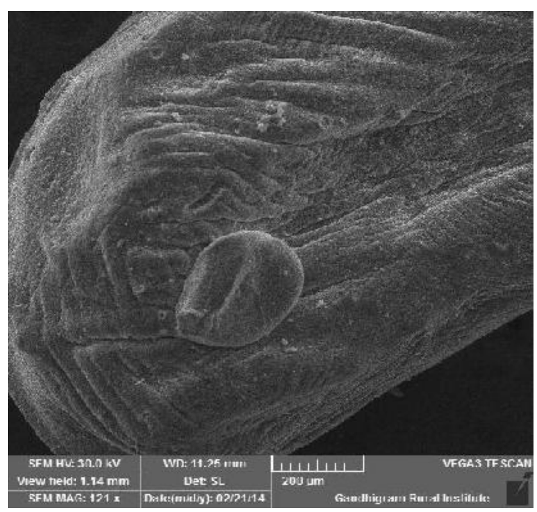


Figure- 3.2-D

Figure (A and B= sodium alginate coated vit-C bead magnified at 500µm) and (Figure C and D = sodium alginate coated vit-C bead magnified with 200µm) at an accelerated voltage of 30kv.

Figure – 3.2-E

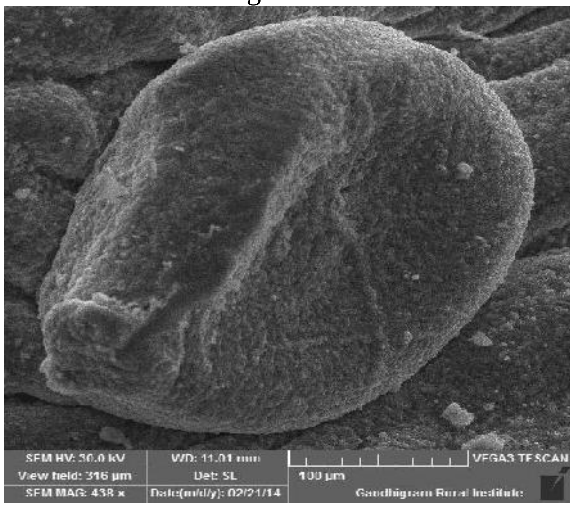



Figure – 3.2-F

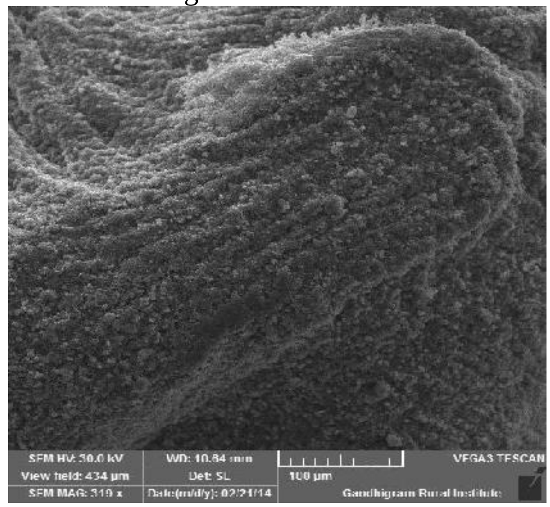



Figure – 3.2-G

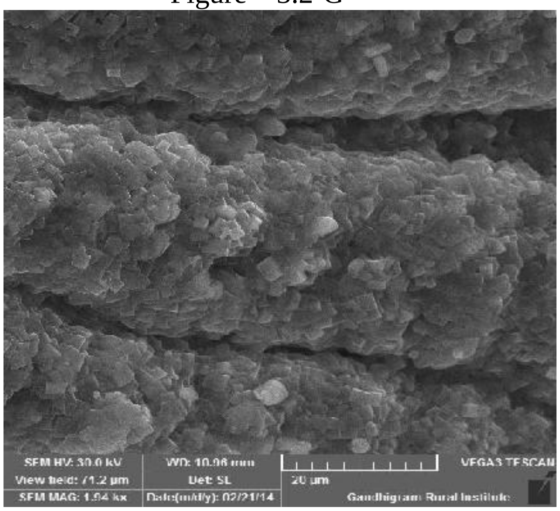



Figure – 3.2-H

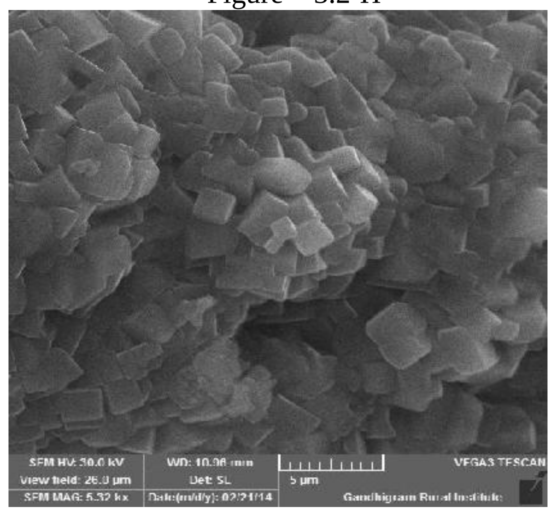
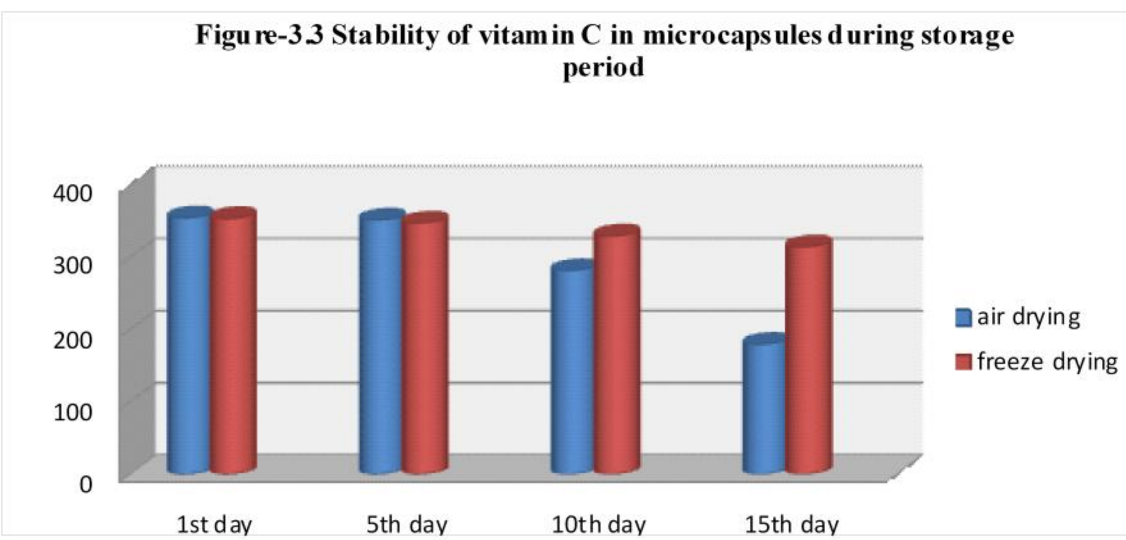



Figure (E and F = sodium alginate coated vit-C bead magnified at 100µm), (Figure G= sodium alginate coated vit-C bead magnified at 20µm) and (H= sodium alginate coated vit-C bead magnified at 5µm) ) at an accelerated voltage of 30kv.



## Conclusion



Use of microencapsulation technologies for protection of health ingredients achieved high ingredient efficiency. It could be concluded that, the optimization of 2g of sodium alginate with 0.2N of $CaCl_2$ solution was better to develop the microcapsules and load the core material of Vitamin-C (L-ascorbic acid). Increase of the wall material will improve the encapsulation efficiency. But this will harden the texture of capsules and also it leads to discomfort for fortification into dairy products. Hence for further study 500mg vitamin C encapsules were used. Since it carries 355mg vitamin C, Which will meet to (RDA) Requirement of daily allowances.

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