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Calcium Extraction from Waste Egg Shell: A Novel Approach

Miss. Durvakshi Mahajan,
Department of Zoology
Dr. D. Y. Patil ACS College Akurdi, Pune

Mr. Satish Thakar
Assistant Professor
Department of Zoology

ABSTRACT:

As we all know how calcium is important for human body as it helps in formation of teeth & bones. Calcium plays an important role in blood clotting, muscle contraction, nerve function etc. The eggshell was demineralized using lactic acid and vinegar and the kinetics of demineralization was studied. The amount of demineralization was determined by measuring the calcium concentration that remained after the acid treatment. The extracted calcium will be used for making calcium tablets, toothpaste, dairy products and other food products. The eggshells contain 70% to 80% calcium. The process of extraction involves acid reaction. The conventional demineralization process of eggshells using HCL is very costly, causes environmental problems and deteriorates the quality and quantity of calcium. Use of this strong acid harms the physio-chemical properties of eggshells using vinegar to demineralized eggshells is a more convenient, cost-effective, and user-friendly method. This process can be used by layman to get a bio business opportunity.

Key Words: Calcium, Vinegar, Eggshell, Bio waste.

INTRODUCTION:

The eggshells are composed of calcium carbonate crystals, with small amounts of matrix proteins. For more than 50 years, they have attracted attention for their unique mechanical and biological properties. Despite the fact that matrix proteins make up less than 5% of the weight of the shell, researchers have only lately started to understand that they are responsible for controlling the production of calcium carbonate crystals and are crucial to their exceptional qualities. This article reviews the matrix proteins identified to date from the eggshells, their structural characteristics and their roles in shell formation. Some suggestions are given for further investigations based on the summary and analysis. Eggshells are generally found in poultry farms, hotels, restaurants and household waste. In India, approximately 2, 50,000 tons of eggshells are produced every year and it requires minimum 1 year for degradation. These eggshells are rich source of calcium and are essential for living organisms in particular cell physiology. It is a major material used in mineralization of bone & teeth in human. We used these waste eggshells for calcium extraction which will help to control the waste of eggshells & useful products can be produced from this waste. Calcium has numerous applications such as food agriculture, cosmetics, bio-medicines, textiles, water treatment and in pharmaceutical industries. The extraction of calcium from eggshells has been proposed not only to solve environmental problems but also as an alternative to the disposal of shell waste. Calcium is a naturally occurring material that exists in shell and rocks and can be used for agricultural purposes. It is a chemical element with symbol Ca and atomic number 20. It is a soft grey alkaline earth metal and is fifth most abundant mass in the earth's crust. The Ca^{2+} ion is also the fifth most abundant dissolved ion in seawater by both molarity and mass, after sodium, chloride, magnesium and Sulphur free calcium metal is too reactive to occur in nature.

Calcium is essential for living organisms in particular cell physiology, where movement of the calcium ion into and out of the cytoplasm functions as a signal for many cellular processes. In many species, calcium is the most prevalent metal by mass and is a crucial component in the mineralization of teeth, bone, and shells. Eggshells consist mainly of 30-40% protein, 20-30% chitin and 30-50% calcium carbonate which is a semi-permeable membrane and through which air and moisture can easily pass. Composition of eggshells differs according to different species. The utilization of eggshells waste has been proposed not only to solve environmental problems, but as a waste treatment alternative to the disposal of shell waste. Conventionally, isolation of chitin from eggshell involves acid treatment to dissolve calcium carbonate i.e., Demineralization followed by alkaline extraction to solubilize proteins i.e., Deproteinization. The conventional demineralization process of eggshell is costly and causes environmental problems. Hydrochloric acid is the most commonly used chemical in the demineralization process.

The use of this strong acid harms the physiochemical properties of calcium and results in a harmful effluent wastewater and increases the cost of calcium purification process. Percot *et al.* reported that using HCL for the demineralization results in detrimental effects on the molecular weight and the degree of acetylating that negatively affects the intrinsic properties of the purified chitin. The significance of optimizing the parameters of the extraction process (pH, duration, temperature, and solids to acid ratio) was expounded upon, with the aim of minimising chitin degradation and reducing impurity levels to an appropriate level for certain applications. Mahmoud *et al.* reported that the effectiveness of using lactic acid or acetic acid for

demineralization of shells was comparable to that of using hydrochloric acid and other benefits may include organic acids that are less harmful to the environment can preserve the characteristics of the purified chitin and can be produced from low cost biomass such as cheese whey the resultant organic salts from the demineralization process that can be used as a food preservative and/or an environmentally friendly de-icing or anti-icing agents. Fermentation of crustacean shell biowaste using microorganisms, which results in the production of lactic acid and protease, has been used in the demineralization of eggshells. Ameh *et al.* reported that the demineralization of deproteinized shell using dilute hydrochloric acid was a chemical reaction controlled process.

Occurrence:

The elemental form of calcium is not found in nature. Calcium occurs most commonly in the sedimentary rocks in the minerals calcite, dolomite and gypsum. It also occurs in igneous and metamorphosis rocks chiefly in the silicate minerals: plagioclases, amphiboles, pyroxenes and garnets.

Geological Sources: These include materials recovered from earth such as arganite, marbles, limestone, calcite, chalks and travertine.

Biological Sources: Some of the biological sources in which calcium occurs include egg shells, sea shells, and shells of snail, oyster, krill, shrimp and many others. Calcium is a mineral that is essential to life and a crucial part of a balanced diet. According to the National Osteoporosis Foundation, "building stronger, denser bones early in life and keeping bones strong and healthy later in life are important functions of calcium." The bones and teeth contain 99 percent of the calcium in the body. Other crucial functions of the remaining calcium in the body include exocytosis, which is particularly useful for the release of neurotransmitters and the contraction of muscles. Dairy products, such as milk and cheese are a well known source of calcium. Some individuals are allergic to dairy products and even more people; in particular those of Non Indo-European descent are lactose intolerant, leaving them unable to consume non-fermented dairy products in quantities larger than about half a liter per serving. Others, such as vegans avoid dairy products for ethical and health reasons. A variety of vegetables, such as seaweeds like kelp, wakame and hijiki; nuts and seeds like pistachios, almonds, hazelnuts and seasame; blackstrap molasses; beans (particularly soy beans); figs; quinoa; okra; rutabaga; broccoli; dandelion leaves and kale, are good sources of calcium. Tofu, orange juice, soy milk, breads, and morning cereals are among the other foods and beverages that are frequently fortified with calcium. While oxalic acid, which binds calcium and decreases its absorption, can be found in various amounts in many vegetables, including spinach, chard and rhubarb, which are high in calcium. The same problem may affect degree of calcium absorption from amaranth, collard greens and chicory greens. This process may also be related to the generation of calcium oxalate. An overlooked source of calcium is eggshell, which can be ground into powder and mixed into food or a glass of water. The calcium content of most foods can be found in the USDA National Nutrient Database.

Dietary supplements:

500 milligram calcium supplements are made from calcium carbonate and these supplements re used to prevent and treat calcium deficiencies. Office of Dietary Supplements (National Institutes of Health) recommends that not more than 600 mg of supplement should be taken at a time because the percent of calcium absorbed decreases as the amount of calcium in the supplement increases. It is therefore recommended to spread doses throughout the day. Recommended daily calcium intake for adult ranges from 1000 to 1300mg. Some people may experience constipation and bloating as side effects from calcium supplementation. It has been claimed that consuming the supplements with food could help to mitigate these adverse effects. Certain calcium supplements contain vitamin D in addition. A healthy level of vitamin D is crucial because the body uses vitamin D to produce a hormone that in turn triggers the manufacture of intestinal proteins that are necessary for the absorption of calcium. The majority of foods and frequently used dietary supplements both absorb calcium very similarly. This runs counter to what a lot of producers of calcium supplements say in their marketing brochures.

MATERIALS:

Waste eggshells were collected from restaurants, household wastes and poultry farms (damaged eggs), and mortar pestle was used to crush the eggshells in powder form and strainer. At the time of collection of eggshells there is no wastage or damaging of any completely developed egg.

Chemicals Used:

- Vinegar solution.
- Aqueous Ammonia.
- Ammonium Oxalate.
- Distilled Water.

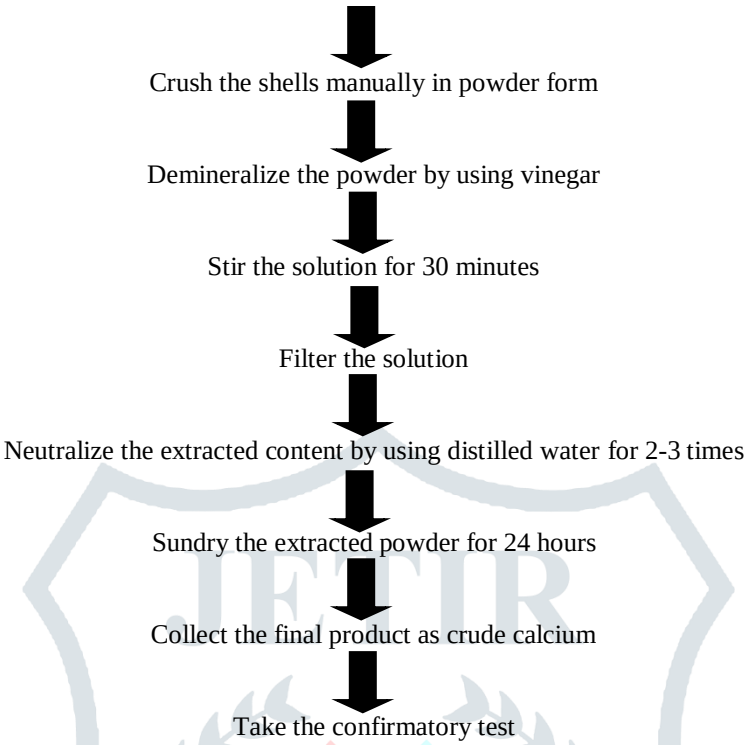
Glassware Used:

- Conical flask
- Beaker
- Petri dish
- Test tubes
- Stirrer
- Strainer

METHODOLOGY:

We collected eggshells from restaurants, household waste and poultry farms. Then washed the shells and boiled it by using tap water. After boiling, we kept it to dry for few minutes and manually crushed the eggshells in powder form by using mortar pestle. The powder was weighing 65.102 grams. Then demineralized the powder and for that ml of vinegar solution was introduced into conical flask. The powder of eggshells was quickly added in the vinegar solution. We stirred this solution for 30 minutes at room temperature by using glass stirrer. Then the content in the flask is filtered through the filter paper. After filtration, we neutralized the extracted content for 2-3 times by using distilled water to makes it pH neutral then keep the extracted powder for sun drying for 24 hours. After 24 hours, the water content evaporated and we collected the final product as crude calcium. Later, took the confirmatory test of crude calcium by using aqueous ammonia and ammonium oxalate.

Flowchart of the Procedure of calcium extraction:



Washing process of Eggshells

Boiling Process of Eggshells

Cleaning and Drying of Eggshells

Crushing of Eggshells

RESULT:

After sun drying, we took confirmatory test of the extracted crude calcium by using aqueous ammonia and ammonium oxalate. The test which we performed is as follow:

SAMPLE + AQUEOUS AMMONIA + AMMONIUM OXALATE (Drop Wise) = WHITE PPT.

Positive Confirmatory Test

Extracted Crude Calcium

DISCUSSION:

In this study, we extracted calcium from waste eggshells by using vinegar solution as it is cheap, easily available and maintains the quality and quantity of calcium. Various studies suggested to use hydrochloric acid but it deteriorates the quality and quantity of calcium and also shifts its pH to acidic. This extracted crude calcium has various applications, such as it can be used for making calcium tablets, dairy products, tooth paste and many other food products. It is a cheap method and can provide an employment source to the laymen's. The extracted calcium can be used as a soil fertilizer in agriculture. We can even sell the crude calcium to pharmaceutical companies. This project has some environmental benefits as it helps in reducing the disposal of eggshell waste helps reduce the environmental impact associated with waste disposal. It can be a source of revenue for business engaged in the extraction and processing of calcium from waste eggshells. Calcium is an important mineral in our body and it helps in building and maintaining strong bones and to carry out numerous important functions. It plays a vital role in muscle contraction, blood clotting, nerve function etc.

CONCLUSION:

In conclusion, the extracted calcium from waste eggshells can be used to produce calcium derived products. This study showed that the great volume of discarded eggshells, with great economic and nutritive potential, can be used as excellent nutritional components in future in health and food sectors. Extraction of calcium was successfully carried out by chemical method using vinegar which is cheap and easily available in local market.

The extracted calcium from waste eggshells exhibits tremendous pharmaceutical, industrial and medical applications. The positive side of calcium is that it is highly biocompatible and biodegradable material. It is the most commonly found mineral in body, in some foods and medicines.

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