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Sustainable Sources and Extraction Methods of Calcium for Expanding Dietary Supplement Sector

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KEYWORDS

Calcium, Eggshell, Seashell, Megalobrama Amblycephala bone, limestone, fish bone, animal bone, waste material.

ABSTRACT:

Introduction: Calcium is a critical mineral essential for various physiological functions, including blood coagulation, nerve transmission, and skeletal health. While dairy has traditionally been the primary source of calcium, recent research emphasizes the importance of diversifying calcium sources through diet and supplements. This study aims to explore different techniques for extracting calcium from natural sources other than dairy source.

Objectives: This study seeks to consolidate knowledge on calcium extraction methods from a range of natural sources. It specifically investigates various sources rich in calcium, such as seaweed, mollusc shells, marine organisms, fish bones, animal bones, eggshells, and limestone.

Methods: The study conducts a comprehensive review of literature on calcium-rich sources and extraction techniques. It examines existing methods and technologies utilized for extracting calcium from different natural sources, providing insights into the effectiveness and practicality of each approach.

Results: By analyzing various extraction techniques, this study contributes to advancing efficient and eco-friendly methods of obtaining calcium from different natural sources. The findings aim to expand our understanding of available calcium sources and optimize extraction processes for practical applications, including nutraceutical production and broader environmental and agricultural uses.

Conclusions: To conclude, the study aims to promote innovative approaches to calcium extraction that support health, sustainability, and economic viability.

1. Introduction

Many body functions, including the proper functioning of the nerves and teeth, the mineral content of bones, and the cofactor of numerous enzyme reactions, rely upon calcium. It is also necessary for the modulation of sodium ion permeability across cell membranes, especially nerve cell membranes, and for the contraction of muscles. The calcium content of blood plasma in a given individual is almost stable and barely varies over time. In the marine environment, calcium is widely distributed and is primarily found as calcite ($CaCO_3$) or the divalent cation calcium (Ca^{2+}).

Additionally, calcium has a wide range of physiological functions in a number of marine microorganisms, invertebrates, and vertebrates, such as fertilising eggs, producing shells, and producing nutritional metabolites [1,2].

Calcium formulations often contain carbonate, citrate, or gluconate molecules, none of which are particularly helpful. As a result, the use of natural sources of vitamins and minerals is becoming a growing trend. As an alternative, since eggshells are more soluble than oyster shells—which are already in use—they can be used as a naturally occurring calcium source. The remaining 3.5% of the eggshell is composed of glycoproteins and proteoglycans, with calcium carbonate making up the remaining 95%. Glucosamine, chondroitin sulphate, hyaluronic acid, type I collagen, and a significant number of proteins and microelements in the inner shell

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membrane, such as magnesium, strontium, zinc, barium, and fluorine, may all help to improve bone metabolism [3].

Due to growing consumer awareness of dietary supplements and the advantages of nutrition for health, consumers now prefer them; 43% of Americans these days use calcium supplements. Two forms of absorbed calcium are calcium carbonate and calcium citrate. The amount of food ingested, especially meals high in protein during the day, controls the rate of absorption, which is about 30–40%.

Calcium is an important mineral necessary in body for proper growth and formation of bones and many other functions. Calcium could be extracted from many food products like: milk, cheese, salmon, sardines, and some vegetables. Other than food sources calcium could be extracted from animal or agriculture waste which includes oyster shells, egg shells, snail shell, bones of fish and animals, etc. The shells and bones of animals end up as waste material and is thrown away in huge quantity; this bio waste has sufficient amount of calcium in it and could act as alternatives for calcium extracted from food sources. Thus, production of calcium supplements from the bio waste having higher calcium concentration has the ability to reduce the strain on waste management and to provide cheap alternatives for source of calcium. This can lead to more sustainable business of converting waste materials into value added product and can lower the dependency of calcium extraction from food sources. This investigation of calcium extraction techniques from various natural sources offers insights into sustainable business practices for the expanding nutraceutical sector.

Calcium in Human Body

Calcium has a significant impact on blood clotting, contraction of muscles, cardiac movements, nerve function, and calcium is required for strong teeth and bones. The body attempts to keep an even supply of calcium in the systemic circulation so that these essential daily activities can be performed. Parathyroid hormone also known as PTH instructs the bones to release calcium into the blood vessels when blood calcium levels drop too low. In order to enhance the absorption of calcium, PTH may activate vitamin D; and PTH also instructs the kidneys to release less calcium in urine. Another hormone calcitonin acts in the opposite way when the body has adequate calcium. Calcitonin lowers blood calcium level by blocking the release of calcium from bones and instructing the kidneys to excrete more calcium in the urine.

There are two methods the body can get the required calcium. The first is by consumption of calcium-containing foods or supplements, and the other is by consuming the body's stored calcium. Insufficient consumption of foods rich in calcium content might cause the body to eliminate calcium from bones [4].

Calcium is found in many foods. The recommended amounts of calcium are obtained by eating a variety of foods.

Table1: Food source that provide calcium

Source	**Product**	**Amount of calcium**
Dairy	Milk, yogurt, and cheese	130mg to 300mg
Fish	Sardines and salmon with bones contain calcium.	170 to 370 mg
Vegetables	Kale, broccoli, and Chinese cabbage (bok choi)	40mg to 200mg
Meats	Beef, shrimp, crab, trout, pork, chicken, anchovy, and canned tuna.	53mg to 250mg
Seeds	Poppy, pumpkin, sesame, celery, and chia seeds.	80mg to 150mg
Fruits	Orange, figs	3000mg

Certain kinds of tofu and packaged cereals, as well as a number of fruit juices and milk alternatives including soy milk and almond milk, have added calcium in them.
The majority of grains, including breads, pastas, and cereals without added nutrients, are low in calcium. But because they're consumed frequently, the impact raises up [5].

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- **Calcium Absorption**

In teeth and bones, calcium hydroxyapatite ($Ca_{10}[PO_4]_6[OH]_2$) comprises up more than 99 percent of the overall calcium in the body. The intestinal mucosa allows for both passive diffusion (paracellular) and active transport (transcellular) absorption of calcium [6].

The intestinal vitamin D receptor (VDR) and calcitriol are required for the active transport of calcium. Most of the calcium absorbed at low and moderate intake levels is accounted for by this transcellular process, which is triggered by calcitriol. Transcellular transport mainly occurs in the duodenum, which also happens to be the organ where VDR expression is highest [6].

The transfer of calcium across mucosal cells, also called as passive diffusion or paracellular uptake, is reliant on luminal:serosal electrochemical gradients. Passive diffusion can happen anywhere along the length of the gut and is more likely to occur during higher calcium intakes, especially when luminal concentrations are high. On the other hand, passive diffusion rates are influenced by the permeability of each intestinal section. Calcium diffuses most readily in the ileum, jejunum, and duodenum [6].

It has been documented that mean calcium absorption, also known as "fractional calcium absorption," or the percentage of a particular calcium dose that is absorbed, is roughly 25% of calcium intake in males and non-pregnant women over a broad age range. With small losses from sweating, skin, hair, etc., the mean urinary and stool loss of the entire calcium intake amounts to 22% and 75% of the total [6].

There are differences in fractional calcium absorption during important life stages. It is highest in early childhood, at around 60%. As the neonate gets older, calcitriol-stimulated active intestinal calcium absorption becomes more significant, while passive absorption decreases. Fractional calcium absorption has been shown to decrease with ageing and postmenopausal by 0.21 percent year generally after age 40 [6].

- **Factors Affecting Calcium Absorption**

Vitamin D: When vitamin D is available, the small intestine actively absorbs calcium. Hydroxyapatite crystals are generated by calcium and phosphorus to mineralise and build bones. Therefore, for healthy bone mineralisation, a diet full of calcium and vitamin D is crucial. The conventional function of vitamin D is to enhance intestinal calcium absorption capacity. Optimal vitamin D levels are necessary for an increase in the efficiency of calcium absorption. Only 10% to 15% of the calcium that is ingested is absorbed by the body due to inadequate vitamin D levels. When there is adequate vitamin D in the body, 30% to 40% more calcium is absorbed through the digestive tract [7].

Calcium intake: The amount of calcium consumed regularly determines how much is absorbed in the intestine. Due to the low calcium intake and uncontrolled active transcellular calcium transport in the duodenum, a higher percentage of calcium is absorbed. According to Yin et al. (2010), Chinese boys' efficiency of absorbing calcium grew to 665 mg/day when their daily calcium intake varied from 352 to 1323 mg/day [8].

Hormones: The two main hormones that make up calcium absorption are 1,25-dihydroxyvitamin D and parathyroid hormone. Calcitonin, a third hormone, has a restricted function. Parathyroid hormone (PTH) indirectly regulates the gastrointestinal system. According to Widmaier et al. (2004), the extracellular calcium concentration regulates the production of parathyroid hormone (PTH), which in turn directly stimulates the generation of 1,25-dihydroxyvitamin D, which increases intestinal absorption of calcium. Parathyroid hormone release is stimulated by a decrease in plasma calcium concentration, but the opposite is true when the concentration of plasma calcium is raised. It makes sense that increasing small intestine absorption of calcium will raise blood calcium levels [8].

Age: In new-borns and early children, when the body needs calcium to form strong bones, net calcium absorption can reach 60%. In adulthood, absorption gradually drops to 15-20% and then even more as one grows. Adults of 51 years of age and older are advised to consume increased dietary intakes of calcium due to the fact that calcium absorption decreases with age [8].

Lactose: Lactose is a disaccharide that the small intestine is unable to break down. Strong evidence that the disaccharide lactose improves intestinal calcium

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absorption had been found in animal experiments. Rather than combining with the calcium ion to form a complex, lactose interacts with the tissue to let the calcium ion enter the tissue or stay in solution [8].

- **Daily Calcium Intake**

The amount of calcium required each day depends on the age and sex. Amount of calcium required in early stages of life is lower and it keep on increasing as age increases; and it decreases again during old age. Maximum amount of calcium is required by teenagers and pregnant women. Average daily recommended amounts of calcium are listed below in milligrams (mg) [5].

Table 2: Daily recommended amounts of calcium

Age	**Amount of calcium**
0 to 6 months	200 mg
7 to 12 months	260 mg
1 to 3 years	700 mg
4 to 8 years	1,000 mg
9 to 13 years	1,300 mg
14 to 18 years	1,300 mg
19 to 50 years	1,000 mg
51 to 70 years (men)	1,000 mg
51 to 70 years (women)	1,200 mg
More than 71 years	1,200 mg
Pregnant and breastfeeding women	1,300 mg

Calcium Supplementation

- diet calcium or supplement calcium

Calcium is required in day to day life for many activities. It is one of the main elements required in body for various physiological functions, including bone health, blood clotting, and nerve transmission. Although foods containing high calcium are best rather than supplementation Calcium but unless it is sufficient, supplementation is needed for variety of reasons. Calcium supplements are often taken orally for low level calcium symptoms. Calcium supplements are taken with meals for higher absorption. Calcium supplements can be recommended in the following conditions:

Osteoporosis

Osteoporosis poses a major risk to public health due to its high rates of morbidity and mortality. It is common for both patients and healthcare professionals to overlook the significance of calcium and vitamin D consumption in preserving ideal bone health. Furthermore, getting enough calcium and vitamin D into one's diet is an essential part of the effective osteoporosis treatment plan. An aging-related skeletal disease is referred to as osteoporosis. It is characterised by a decline in bone mass and quality, which raises the risk of fracture, especially at the hip, forearm, and vertebrae, and decreases bone strength. It has been suggested that vitamin D plus calcium supplementation, whether in the form of tablets or dietary calcium, helps prevent osteoporosis in people of all ages and genders [9].

Calcium requirement in pregnancy

During pregnancy calcium supplements are recommended for the following reasons:

- The demand of calcium increases during pregnancy.
- Difficulties in the foetal skeletal development are avoided by calcium.
- Pregnancy-induced hypertension can be avoided with calcium.
- Increased resorption of calcium from the mother might plant the first seeds of osteoporosis.

Thus, calcium supplements are necessary to satisfy the increased need of calcium during pregnancy [10].

Pregnant and lactating women

For expecting or nursing mothers, the benefits of calcium supplements on the mother's and the fetus's bone health are debatable. Pregnant women in the Gambia, West

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Africa, who had poor calcium intake during their 12-month lactation period demonstrated significantly decreased bone mineral content, bone area, and BMD for hip. After taking calcium supplement the women's bodies underwent biochemical changes that suggested enhanced mobilisation of bone mineral, and their lumbar spine and distal radius displayed greater lactation-induced losses in bone mineral. It is recommended that women who ingest inadequate quantities of calcium during pregnancy or nursing take supplements [10,11].

Postmenopausal women

Bone remodelling, which is amplified in the perimenopausal and postmenopausal periods and causes a discernible loss of bone density, is characterised by a decrease in oestrogen production and an increase in the absorption of calcium from bone. Calcium supplements may be given for postmenopausal women who have a medical history of osteoporotic fractures, an osteoporosis diagnosis, a vitamin D deficiency, or who are at high risk of developing osteoporosis [12,13].

In Children

Growing kids need more calcium because bone modelling, or the creation of new bone over resorption, is the primary skeletal process that requires mineralisation. This is particularly valid throughout physical growth spurts that take place throughout childhood and adolescence. For children, there is no acknowledged prescription for routine calcium supplements [14].

Cardiovascular System

A study on the elderly Chinese population found that consuming adequate foods high in calcium can lower the risk of heart issues and death from all causes. Another study on postmenopausal women found a correlation between a lower death rate from ischemic heart disease and high dietary and supplemental calcium intake [15,16].

Bone and Teeth Health

Calcium is one of the primary building blocks of teeth and bones. It maintains their authenticity and strength and provides structural support [17].

Muscle Function

Muscle contraction requires the mineral calcium. Calcium ions are released throughout an animal's muscular contraction and are vital for the process [18].

Nerve Function

Nerve impulses cannot be transmitted without calcium. It promotes the release of neurotransmitters, which are vital to nerve cell-to-nerve cell communication [19].

Blood Clotting

Calcium is a necessary component of the blood coagulation process. Wounded animals have to generate blood clots in order to prevent further bleeding; this demands calcium ions [20].

Cell Signalling

Calcium is the secondary messenger in several biological signalling pathways. It is involved in a number of biological processes, including hormone secretion and cell division [21].

Enzyme Activation

For several enzymes, calcium serves as a cofactor, assisting the enzymes in carrying out their respective tasks. This is essential for a number of animal metabolic activities [22].

Regulating Heartbeat

Calcium ions are required to maintain a regular heartbeat. They participate in the contraction of the heart's muscle cells [23].

2. Discussion

Calcium as a Supplement

Calcium can be obtained in different forms- elemental calcium is obtained as mineral form and natural calcium can be obtained in different compound form after extraction from natural sources.

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Table 3: Types of Calcium in supplements

Salt of calcium	Uses
Calcium Phosphate	This calcium source, which is essential for strong bones, is commonly available in daily supplements. Tricalcium phosphate and dicalcium phosphate are the two common forms.
Calcium Gluconate	This type of calcium can be added to liquid supplements and is occasionally injected into people to rapidly restore calcium levels, particularly in cases of hypocalcemia.
Calcium Lactate	Some specialised animal supplements contain calcium lactate, which the body absorbs quicker than calcium carbonate.
Calcium Carbonate	Calcium carbonate is one of the most often used forms of calcium. Usually, unprocessed marble or limestone is used for creating it. Since calcium carbonate is easily absorbed by the majority of animals and people, it is frequently found in commercial calcium supplements.
Calcium Citrate	Moreover, calcium in the form of citrate is easily absorbed by the body. Supplements for animals, particularly those intended for people and animals like cats and dogs, typically have it.
Eggshell Powder	Eggshells that have been crushed can be utilised as an organic calcium source for animal nutrition. They serve quite effectively for reptiles and birds. An efficient way to use waste is to turn it from trash into valuable products. Eggshells from chickens include a potentially useful mineral called calcium carbonate, which can be processed to make biomaterials for use in biomedical applications.
Bone Meal	Animal bones, usually from cattle, are ground and crushed to create bone meal. It is a naturally occurring source of phosphorus and calcium that is utilised as supplements for a range of animals, humans, livestock, and other species.

Mineral and Biowaste as Sustainable Source of Calcium

Calcium for supplement can be extracted from many sources. The sources included extraction from limestone, fish, eggs, bones etc. Calcium phosphate and calcium citrate are two major types of calcium extracted from bones of animals and fish.

Limestone

The primary source of lime is limestone, or calcium carbonate ($CaCO_3$), a kind of carbonate sedimentary rock. Majority of its composition is made up from calcite and aragonite. When these minerals calcite and aragonite split from water which contains dissolved calcium, limestone is formed. It is possible for both biological and nonbiological mechanisms to cause this. Scientists can often learn about the evolution of life from fossils found in limestone. The typical colour of limestone is white to grey. The colour of limestone can vary from off-white to yellow to red depending on the presence of iron or manganese elements. Limestone that is exceptionally rich in organic matter can have an almost black shade.

Fish Waste

The major solid fish waste or by-products that are high in calcium include fish heads, bones, and scales. After appropriate processing, the calcium derived from these fish by-products can be utilised in food, feed, therapeutic, and biological materials. To extract calcium, one might utilise marine creatures like sardines, anchovies, clam, shrimp, crab, and even fish bones [24].

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Table no:4 amount of calcium present in various fish waste

Name	Calcium (mg)
liver	1.123 g/kg
gills	63.09 g/kg to 70.24 g/kg
fish's scales	3246.93±18.98 mg/100g to 7930.42±60.02 mg/100g
Fish bone.	90%

Snail Shells

Although they are pests in rice fields, snails are typically fed to animals like ducks. About 95% of the shell's weight is made up of crystalline $CaCO_3$ and 5% is organic stuff. Shells of molluscs and snails contain a lot of calcium. Snail shells are widely available globally, and although the meat is removed, the shells are discarded. Nevertheless, the shell waste can be utilised as a valuable source of bio-calcium for many purposes, such as creating hydroxyapatite (HAp), or $Ca_{10}(PO_4)_6(OH)_2$). In the tissue, HAp can be utilised as a dental composite material. HAp is the calcium phosphate (CaP) chemical that is most frequently employed. Because of its similarities in structure and function to human bone, HAp is significant for biomaterial applications. HAp can be used on solid or porous ceramics, coatings and composites [25].

Freshwater snail calcium concentration: The concentrations of calcium carbonate ($CaCO_3$) (mean %/dry weight) of the shells are as follows: Helisoma trivolvis 97.0%; Physa sp. 97.8%; Biomphalaria glabrata 98.8% [26].

Oyster Shell

Many distinct families of salt-water bivalve molluscs that reside in brackish or marine environments go by the common name "oyster". Certain species have heavily calcified valves, and many of them have rather asymmetrical shapes. Certain varieties of oysters are widely eaten, either raw or cooked, and are considered a delicacy in some regions. A few varieties of pearl oysters are collected for the pearls that are formed inside the mantle. Others are taken for their shells, such the transparent Windowpane oysters. Mussels and oyster shells have a high calcium carbonate concentration that can be utilised as a filler in polymer materials, in building, or in medicinal product formulation. Oyster shell contains 39% calcium out of which calcium carbonate is 97% [27].

Table no:5 amount of calcium in snail shell, and oyster shell

Shell type	Amount of calcium
snail shells (land)	95%
snail shells (Freshwater)	97%-98%
Oyster shell	39%

Seaweed

Seaweed, often known as macroalgae, is the collective term for thousands of species of macroscopic, multicellular marine algae. Some varieties of the macroalgae are Rhodophyta (red), Phaeophyta (brown), and Chlorophyta (green). Certain seaweed species like kelps safeguard food sources by acting as key nursery habitat for fisheries and other marine animals. Other seaweed species such as planktonic algae are crucial in absorbing carbon dioxide and generating at least half of the oxygen on Earth.

Ocean seaweed, particularly green algae, is a great source of minerals like calcium. For instance, the common calcium-rich supplement Aquamin contains up to 31% of its weight in calcium. It is made from the calcified skeletal remnants of the red seaweed species Lithothamnion. In animal models of osteoporosis, calcium derived from marine algae was also found to have a positive anabolic effect on bone skeletal calcification. Seaweed has 70 mg of calcium per 100 g serving [28].

Chicken Egg Shell

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An egg's hard shell is its outermost layer. The most frequent form of calcium found in it is calcium carbonate. Protein and other minerals make up the remainder. A plentiful mineral in many foods particularly dairy products is calcium. For many years, humans have used eggshell powder, which is derived from hen eggs, as a natural calcium supplement. About 40% of eggshells contain calcium, containing 381–401 milligrams per gram. One of the most affordable and efficient sources of calcium is eggshells. Calcium carbonate together with trace amounts of protein and other organic components make up eggshells. Eggshells are a good source of calcium, as confirmed by studies conducted on rats and piglets [29].

Animal Bones

Many eateries raise bone waste, which is worthless economically. Naturally the disposal of this garbage in a landfill may have negative environmental effects. But it's important to remember that animal bones have a lot of advantages, one of which is that they're the ideal way to obtain calcium for biological development and human growth. The primary structural component of the body, bones are made of both organic and inorganic materials. Calcium phosphate makes up to 85% of all the salts found in bones, with calcium carbonate making up the remaining 10%. Bones contain about 46% of salt and 97% of calcium in the body. Animal bones are among the elements of animals that offer numerous advantages [30].

Beef bones have a high calcium content, which is 85.84%. Cow bones 723.16mg/100g; goat bones 610.53mg/100g; pig bones 647.64mg/100g [31].

Animal bone	Amount of calcium
Beef bones	85.84%.
Cow bones	723.16mg/100g
goat bones	610.53mg/100g
pig bones	647.64mg/100g

Table no:**6** calcium content in cattle's

Methods of Calcium Extraction from Different Sustainable Sources

Extraction of calcium from limestone

Limestone is a sedimentary rock that is primarily composed of calcium carbonate. It is found in natural deposits or quarried from mines. Crush limestone into small pieces and then heat it in a kiln or furnace at temperatures above 900 degrees Celsius. This process produces calcium oxide (also known as quicklime) and carbon dioxide gas. Mix calcium oxide with water to produce calcium hydroxide. The calcium hydroxide is then reacted with hydrochloric acid to produce calcium chloride and water; following is the reaction that takes place: $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$. Then solution of calcium chloride containing water is heated to remove the water, leaving behind calcium chloride [32].

Mix calcium chloride ($0.18mol \cdot L^{-1}$) with sodium citrate ($0.12mol \cdot L^{-1}$) to achieve molar ratio of 3:2. stir the mixture at 25°C, add ethanol until a white slurry is formed. After that, the slurry is centrifuged, cleaned, and collected as a pure slurry of calcium citrate [33].

Extraction of Calcium Phosphate from Fish Waste

Millions of tons of fish waste are produced annually by fishing operations, and an equivalent quantity is thrown away and returned as unwanted captures into the ocean. Although fish bones aren't utilized very often, they can serve as a biological source for a variety of novel, high-value goods. Examples include hyaluronic acid from fish eyeballs and collagen derived from fish skin. Calcium phosphate can be produced using aquaculture by-products (salmon heads and trimmings, salmon salar), as well as the leftovers of Atlantic horse mackerel (Trachurus trachurus) and scorpionfish (Scorpaena scrofa) [34].

Extraction of Calcium from Tilapia bone

The bones of the tilapia are immersed in hot water and an alkaline solution at 1:2 (w/v) ratio for an hour. Clean the bone samples with tap water, and autoclaved for one hour at 121°C, and then dry in an oven dryer overnight at 105 °C. Filter the powdered dehydrated materials through a 38 µm sieving mesh to produce alkaline and water-treated powders, respectively [35].

Extraction of Calcium from the Megalobrama Amblycephala bone

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Mix powdered dry fish bones and solution made up of citric and malic acids together. Stir this mixture using a magnetic stirrer at constant temperature (60 °C). Then centrifuge it for 20 minutes at 3000 rpm. Collect the supernatant, neutralise it, dry, and crush into powder. Another name for this powder is milk white active calcium powder [36].

Extraction of Calcium from Snail Shells

Clean the shells with distilled water and then dry them at room temperature for two weeks. The snail shell calcination is carried out in an oven for 90 minutes at a temperature rise of 5 °C per minute, with increasing temperatures of 400 °C, 700 °C, and 1000 °C in order to monitor the evolution of the material's crystallization. The temperatures at which the materials are calcined has an impact on their final form and crystalline properties. Only particles with a diameter of less than or equal to 25 µm are retained after sifting, following variations in the temperature of each substance. The non-calcined and calcined materials are labelled as escN (pale white powder), esc400 (grey powder), esc700 (grey powder), and esc1000 (white powder) at 400°C, 700°C, and 1000°C, respectively. Mix esc1000 (white powder) and 0.1M EDTA to get 0.1 M Ca-EDTA complex. Stir the mixture continuously for 120 minutes and add Na_2HPO_4 gradually while maintaining a PH at 13. Dry the mixture for 12 hours, white colour powder is obtained [37].

Extraction of Calcium from seaweed

Seaweed from the ocean, especially green algae, is an excellent supply of minerals like calcium. For example, the calcium content of Aquamin, a popular calcium-rich supplement, can reach as high as 31% by weight. Aquamin is manufactured from the calcified skeletal remnants of the red seaweed species Lithothamnion. A recent study found that marine algae gives horses a higher calcium supply than supplements containing calcium carbonate. Additionally, in animal models of osteoporosis, it is demonstrated that calcium from marine algae has a beneficial anabolic effect on bone skeletal calcification. Compared to calcium carbonate, calcium that is obtained from seaweed and oyster shell powder has a better bioavailability [38,39].

Extraction of Calcium using the oyster shell

Bake oyster shells for 1 hour at 200ºC. Once the shells are brittle enough grind them with water for 15 minutes in a high-speed planetary mill. Heat the granules at 500 ºC for 2 hours. Crush the dried clusters without water to obtain powder [40].

Extraction of Calcium carbonate from chicken egg shell

The calcination process is used in extraction procedure of calcium carbonate from eggshells. Wash chicken eggshells under running water, dry them in the sun, and then soak them in sodium hypochlorite solution to generate $CaCO_3$. Dry the eggshells, crush the eggshells using a stainless-steel mortar and pestle. sieve the eggshell powder through a 200-mesh sieve [41].

Extraction of Calcium chloride from chicken egg shell

Combine crushed eggshells with hydrochloric acid solution to create eggshell calcium chloride, then stir periodically until no gas bubbles are visible. centrifuge the mixture for 10 minutes, remove the supernatant and dry it at 110–115°C. This produced calcium chloride crystals, are also known as eggshell calcium chloride [42].

Extraction of Calcium Phosphate from Animal Bones

Break the bones into tiny fragments. Submerge them in hydrochloric acid for few days so that following reaction can occur; $2HCl + Ca_3(PO_4)_2 \rightarrow 2CaCl_2 + Ca(H_2PO_4)_2$. After that, add hydrochloric acid, and apply heat to a predetermined temperature. Then filter the solution using vacuum pump. Next, add NH_3 with varying PH to the filtrate to cause precipitation. The following reaction occur $Ca(H_2PO_4)_2 + 2NH_3 \rightarrow Ca(HPO_4) + (NH_4)_2(HPO_4)$ the calcium triphosphate is precipitated. The filtered precipitate is dried and quantified [43].

3. Conclusion

Calcium stands as one of the most crucial minerals for human body, constituting 98% of the skeletal system. Deficiency in calcium can lead to various health issues such as osteoporosis, rickets, epilepsy, and anaemia. The body absorbs calcium from diet or supplements, maintaining a dynamic equilibrium between blood and bone calcium level. The review explores various sources

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of calcium other than regular food sources. it has been found that several natural materials in the form of minerals and waste from agriculture or fisheries can become good source of calcium

Mineral limestone is an abundant source of calcium but it is crucial to accept the potential presence of heavy metals and other harmful compounds in natural calcium carbonate minerals. Animal bone also pose a risk of microorganism especially prion transmission. In recent years, calcium supplements sourced from marine environments have gained recognition due to their vast reserves, safety, and biological activity. Leveraging marine derived calcium represents a significant strategy to enhance the utilisation of biological resources and to develop sustainable source of calcium for supplementation. The paper has outlined the process for extraction of calcium and most follows green pharmacy concept

To achieve commercial viability in various applications, further research is needed to conduct toxicology and calcium uptake studies. This would contribute to both addressing calcium deficiency and reducing waste. Developing calcium supplements from calcium-rich waste material not only alleviates the burden on waste management but also offers a more affordable alternative to conventional supplements for the calcium deficient population.

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Conflict of interest

The authors declare no potential conflicts of interest to the respect to the review research, authorship and/or publication of this article

Ethical approval

The work does not need any ethical approval

Data availability

All the data pertaining to the manuscript has been provided in the manuscript.

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