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THE NEW TREND OF ADDING EGGSHELL POWDER TO FORTIFIED FOODS

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ABSTRACT

Fortification of food products is a way to reduce dietary deficiencies in the masses. It includes the addition of some essential nutrients to support good health in the consumers. This term denotes incorporating micronutrients like essential vitamins into food products to improve their levels in the consumers. This paper focuses on various food products in which eggshell powder can be added for fortification. The uses of eggshell powder in various fortified foods, the composition of eggshell powder, and the benefits of fortification using eggshell powder have been discussed in this study. In the last, a suitable conclusion is made keeping in mind the various aspects of eggshell powder. The main reason behind the study is to discuss the new trend of fortification in food products and various new products launched in the market with eggshell powder fortification that can benefit consumers on a nutritional level.

Keywords: Chicken Eggshell Powder, Waste Disposal, Fortified Foods, Eggshell Powder Application.

I. INTRODUCTION

Chicken eggshells are one of the major contributors of waste received from food industries and outlets, restaurants, hotels, households, and similar places. As reported, chicken eggshells are the fifteenth source of food pollution, and because of being non-biodegradable, a key source of environmental pollution (Awogbemi et al. 2021). After collection, these eggshells are dumped to cover the landfills where they facilitate a habitat for mosquitoes, flies breeding, and fungal, and bacterial growth, which results in the development of various diseases (Ajala et al. 2018, Faridi et al. 2018). According to the reports, in the ten years from 2009 to 2019, the production of chicken eggs hiked by more than 30% globally. This situation resulted in more waste generation out of eggshells (). Hence, the utilization of these eggshells for their value is essential to manage waste worldwide (Arnold et al. 2022). One of the best waste disposal and utilization methods for eggshell waste is the conversion of these into valuable products. It is the most eco-friendly, cost-effective, and safe means of waste management and disposal (Awogbemi et al. 2021).

Several essential components/nutrients like sulfur, zinc, copper, iron, boron, calcium, molybdenum, and other related elements are present in the eggshells making them a suitable option for the production of value-added products (Waheed et al. 2019, Sembiring et al. 2021).

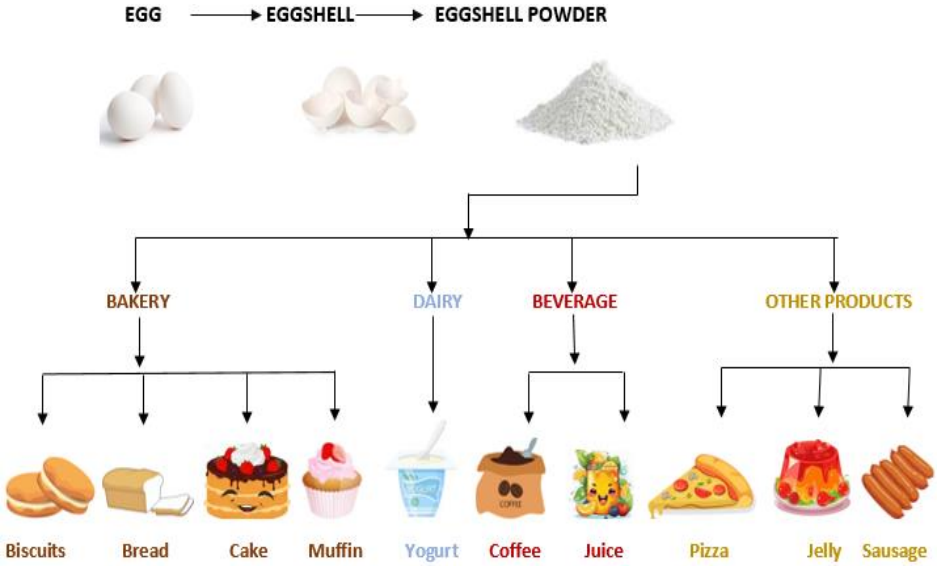

Figure 1.0- Applications of eggshell powder in the food industry (graphical abstract)

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1.1 Composition of eggshell powder-

As this powder is formed from the eggshells, it has the chemical and nutritional composition same as that of eggshells. According to Shahnila et al. (2022), eggshells are the major source of dietary calcium with approximately 39% elemental calcium, 94% calcium carbonate, 1% calcium phosphate, and 1% magnesium carbonate.

Chart 1.0 depicts the composition of eggshells. About 2.7g (half of an eggshell) can provide enough calcium for the daily requirement of adult consumers (Milbradt et al. 2015). Furthermore, according to Arnold et al. (2021), studies conducted in the past state the availability of calcium in chicken eggshells ranges from 35,000 mg/100 g to 40,000 mg/100 g. According to Jony et al. (2021) in their study, duck eggshells contain a higher amount (52.8 mg) of calcium content than chicken eggshells, along with 3.68 mg magnesium, 0.18 mg lead, 1.4 mg zinc, and 0.15 mg arsenic. Chart 2.0 show the composition of duck eggshells as per Jony et al. (2021).

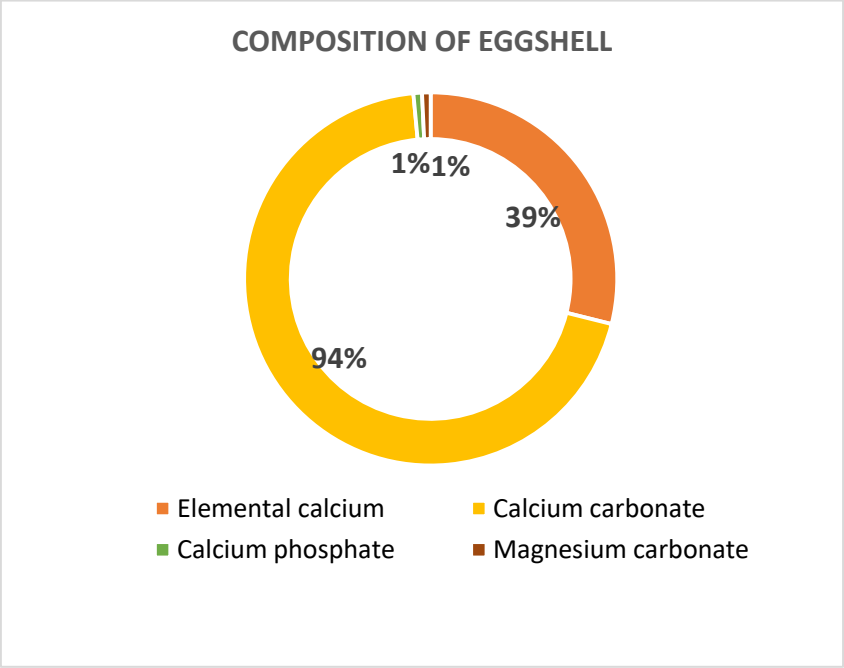

Chart 1- Composition of eggshell as per Shahnila et al. (2022)

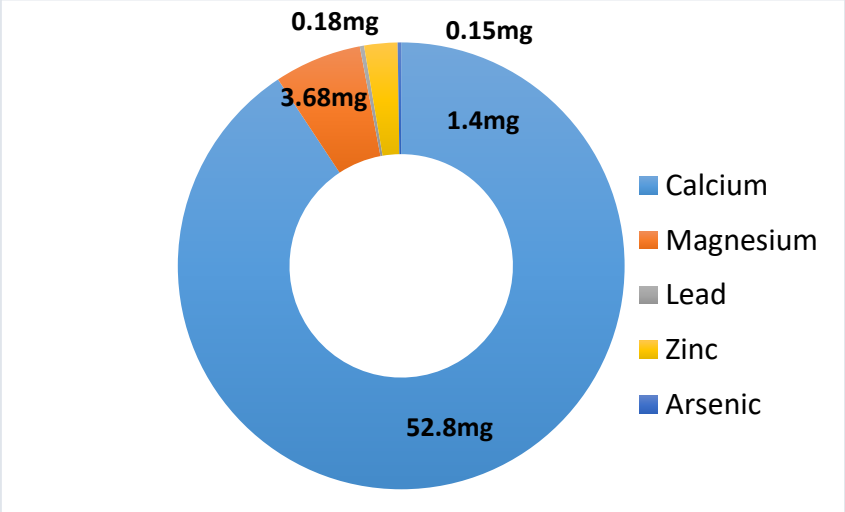

Chart 2- Composition of duck eggshell as per Jony et al. (2021)

1.2 Production of eggshell powder-

Eggshell powder as the name suggests is produced from the egg shells by the means of drying or heating the eggshells followed by grinding or crushing which results in these shells turning into fine powder. Recently, apart from conventional means of heating, new methods of heat treatment like microwave and infrared heating are also regarded for eggshell drying at an industrial level (Therdthai et al. 2023). After the proper heat

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treatment, the egg shells are crushed and ground to form powder with fine particle size (Hama S.M. 2017). This fine eggshell powder obtained can be used in various industries and products for value addition.

II. APPLICATION OF EGGSHELL POWDER

This powder can be beneficial in engineering, environmental, biomedical, chemical, and other related fields. For instance, it can be used for the production of health-oriented products, and chemicals like calcium phosphate and calcium lactate. Also, it can be used in biodiesel oil catalysis, the food manufacturing industry, and the construction industry (Ahmed et al. 2021).

This study, however, discusses the use of eggshell powder in the food processing and manufacturing industry. This powder can be incorporated in calcium-fortified (supplemented) food products to increase the nutritional value of these food products.

2.1 Application of eggshell powder in the food industry-

Calcium is one of the most vital, abundant nutrients required in the human body for proper growth and development. It is useful for forming and maintaining strong bones, teeth, blood pressure, muscular tissues, and other related functions.

The high availability of calcium in the chicken eggshell makes its powder a suitable raw material for food fortification. In the past years, various fortified foods with added eggshell powder and higher calcium content have been introduced in the market. In this study, we are identifying the use of eggshell powder in fortified food products. Popular food items like biscuits, bread, pork sausage, yogurt, juices, pizza, and other related products are willingly consumed by children and the elderly, therefore, fortifying them can provide essential calcium for healthy bone growth and overall body development. In addition, it has been shown that the absorption of calcium into the body is facilitated by vitamin D, inulin as well as further indigestible oligosaccharides, magnesium, or brief chain fatty acids (Arnold et al. 2021; Kozakai et al. 2002; Weaver et al. 2015). A food product containing these essential elements and added, higher calcium content can help in avoiding the risk of diseases caused by calcium deficiency in the body like osteoporosis. Therefore, this study is designed to assess the essential composition, processing, overall properties, and applications of eggshell powder and highlight the foods made by fortifying the powder.

According to a blog by dietitian Shikha Mahajan, on a small scale level, consumers can add eggshell powder to their day-to-day homemade beverages and food products to get the benefits of nutrients and calcium content present in the eggshells. It's further discussed in the blog that hyaluronic acid present in the eggshells can make our skin glow, and elements like chondroitin and glucosamine can aid in reducing joint stiffness and pain associated with them. Eggshell powder mixed in water can help in the removal of toxic elements in our bodies. And everyday intake of eggshell powder mixed with lemon juice is said to treat thyroid problems while the powder mixed with hot milk is said to reduce gastric ulcers. The most obvious benefit of eggshell powder intake is the strengthening of bones and teeth due to the more calcium content present in it. These benefits are shown in the figure 2.0.

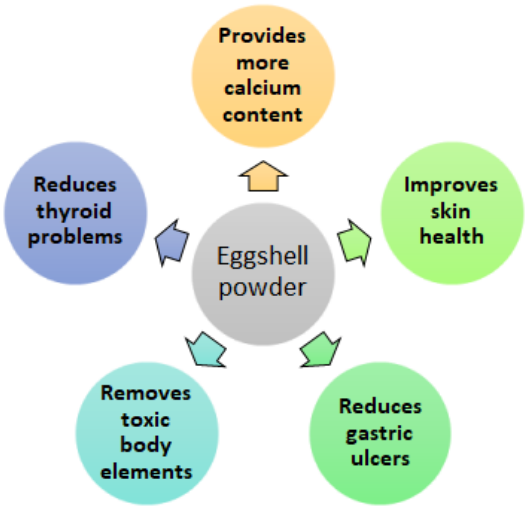

Figure 2.0- Benefits of eggshell powder intake (blog by dietitian Shikha Mahajan, Lybrate 2021)

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2.1.1 Bakery Products

One of the major applications of eggshell powder is in the bakery industry in the production of bakery products like different types of breads, biscuits, cakes, muffins, and other related products. This powder can be incorporated into these bakery products leading to the increased calcium content in the food, preservation of bakery products, reduction of waste accumulated out of egg shells, and overall waste recycling (Platon et al. 2020). According to the study conducted by Ray et al. 2017, to manufacture calcium-enriched bakery products out of eggshell powder, chicken eggshells are firstly rinsed and cleaned to remove unwanted particles and impurities, and then boiled with water for 30 minutes duration to kill the germs on the surface. Thereafter, the boiled chicken eggshells are dried in a hot oven before grinding to a fine powder. Higher drying temperatures may lead to the loss and reduction of the calcium content in the eggshell powder (Leonte, 2007; Ali et al. 2017). This eggshell produced is then added to the bakery products in the appropriate concentration while they are processed and manufactured. The proportions of the eggshell powder and mix are maintained to follow the Recommended Dietary Allowance (RDA) and obtain the desired texture. Over addition of the powder can affect the texture, and other sensory and nutritional characteristics of the food products therefore, the determination of the suitable quantity of addition is essential. Eggshell powder is a cheap source of calcium, which can be exploited for an increase in its content and does not affect the quality characteristics of bakery products (Hassan, 2015). According to a study by Platon et al. 2020, the addition of eggshell powder can improve consistency, humidity, elasticity, and overall physico-chemical properties of bread crust and crumb. The final fortified product obtained is better developed and fresh, with pleasant sensory characteristics like smell and taste. Similar to bread, a cupcake with higher nutritional availability can be manufactured with eggshell powder added to the main ingredients. (Giango et al., 2017).

2.1.2 Dairy Products:-

Dairy products are widely available in the market and preferred for consumption by children and the elderly. They are a good source of calcium and other essential nutrients. However, their overall calcium absorption and retention of the total calcium fraction can be enhanced by the addition of eggshell powder with minute particle size. According to a study conducted by Al Mijan et al. 2014, eggshell powder with very small particle size (Nano-powdered) can be added to form calcium-enriched yogurt. As per the results of the aforementioned study, such yogurt is earthy in taste, firm, and grainy in texture, showing less to no indication of contamination and more shelf life. Also, there is no bad effect on the quality of such yogurt due to the addition of eggshell powder.

According to a patent 1995/000396 by Anne Schaafsma Cornelis Glas, these calcium-enriched dairy products have higher relative calcium density which gives way to the possibility to enhance calcium concentration in the whole milk to such an extent that to fulfill the daily calcium intake for the proper functioning of the body, adults consume just 500-700 ml of milk each day rather than the recommended 1-1.25 liters of the same. According to the invention in the patent, 3 grams of fine aseptic eggshell powder can be added per 40 grams of dry matter to manufacture calcium-fortified dairy products. The quantity of eggshell powder that can be used depends on the consistency and required mouthfeel of the product to be formed. Higher powder addition might lead to a drier mouthfeel of the product. More viscous and structured dairy products like yogurt, spreads, cheese, and others will prevent the settling of the eggshell powder added. Also, the mouthfeel of whole milk can change considerably more than in the fresh cheese, when eggshell powder is introduced to it. This parameter is furthermore affected by the particle size of the powder. The patent further explains that the addition of vitamin D, vitamin D-rich fish liver oil, lactose, and vitamins A, K, and C to the other raw materials while manufacturing calcium-enriched dairy products can further enhance the good calcium retention of these products.

2.1.3 Beverages:-

Eggshell powder can be added to beverages like juices, sodas, health drinks, and other options to form calcium-fortified beverages. According to the study by Lachowicz et al., 2020, a 1% addition of eggshell powder to a juice sample has a slight betterment in the taste and doesn't show any significant color or precipitate changes.

In the case of coffee, calcium citrate powder prepared from eggshells (calcium carbonate) by the addition of citric acid, can be mixed with roasted and ground coffee to obtain calcium-fortified coffee powder. This doesn't alter the taste characteristics of coffee but rather increases the bioavailability of calcium (de Paula et al., 2014).

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In brewed coffee, cold plasma techniques can also improve the solubility of calcium for enhanced fortification (Aditya et al., 2020). In the case of wine beverages or any other fruit-based beverage, clean fine eggshell powder can be added to fruit peels, crushed rice, and other ingredients to produce calcium-fortified alternatives (Wang et al., 2016).

2.1.4 Other Products:-

The fine, clean, disinfected eggshell powder can be added to some other food products to enhance their calcium content and manufacture a calcium-fortified version. According to the study by Xie, 2018 and Zeng, 2019, eggshell powder with minute particle size can be added to noodles to form calcium calcium-enriched version. To form calcium-enriched sausages, eggshells are cleaned, dried, disinfected, and grounded to form a fine powder. This powder is added to a solution including acetic and citric acids to form a composite calcium precipitate which is dried and added in the process to form sausages (Liu et al., 2018). Calcium propionate can be formed from eggshell powder by solubilizing it in propionic acid and filtering and drying the product formed. Calcium propionate can be used as a preservative due to its antimicrobial property (Wang, 2015b).

Various snacks like Pizza, Jellies, pudding, and others can also be made using eggshell powder to manufacture the fortified version. Tay (2024) mentions in his study that calcium-fortified jellies can be prepared by boiling the ingredient mixture with added well-grinded and sieved eggshell powder to form candy syrup. Then the syrup is put in the molds and frozen for three hours. Later, a proper analysis of the manufactured jelly is done. This research brought forward the potential of candies and jellies in providing nutrition and acting as a vehicle for nutritional supplementation. Novelina (2020) in her study finds that the higher amount of eggshell addition in the formation of soy milk jelly candy increases the pH of this product and also decreases the strength of soy milk jelly gel. The former is due to a higher amount of calcium carbonate which increases the pH of this candy and the latter is due to the increase of the candy's water content due to more addition of eggshell powder. Furthermore, the eggshell powder incorporation might impart a little chalky taste to the candy resulting in the reduction of the sweetness of this jelly candy. Therefore, the incorporation of eggshell powder in varying amounts can affect the water content, strength, Ph, ash content, saccharose amount, reducing sugar levels, and calcium levels of the jelly candy while having no noticeable impact on the protein and aw values (Novelina, 2020).

Similarly, milk pudding can also be made with added eggshell powder. According to Suci (2023), the eggshell powder can be obtained by collecting eggshells, cleaning, boiling them for 30 minutes, and soaking them for 3 hours in 0.5% lime solution followed by draining, drying in an oven at 60°C for 3 hours, and finally grounding the treated eggshell using blender and sieving the powder using an 80 mesh size. Then this obtained powder can be added to the pudding ingredients at specific concentrations. In the final stage of baking, the mixture can be put into a 60 ml plastic mould followed by steaming for 15 minutes over medium heat. Post-cooking, the pudding is drained and stored in the refrigerator. The study also finds that there can be a significant increase in the overall ash and calcium content of the pudding due to the addition of eggshell powder.

III. CONCLUSION

Recycling of eggshell waste using eggshell powder-incorporated food products ensures waste recovery, provides nutritionally better food products, and enhances food preservation. Food products manufactured by adding eggshell powder are found to have better sensory, physicochemical, and nutritional characteristics with a higher acceptance rate by consumers. Food security can be attained by cheaper, veritable food supplementation containing calcium derived from eggshell powder. However, less research has been conducted to find the deployment of eggshell membrane powder for the fortification of food products.

IV. REFERENCE

[1] Aditya, S., Gnanasekaran, S., Stephen, J., & Radhakrishnan, M. (2020). Enhancing the properties of eggshell powder by cold plasma for improved calcium fortification in black coffee. Journal of Food Process Engineering, 43(8), Article e13450.

[2] Ahmed TAE, Wu L, Younes M and Hincke M (2021) Biotechnological Applications of Eggshell: Recent Advances. Front. Bioeng. Biotechnol. 9:675364. doi: 10.3389/fbioe.2021.675364.

[3] Ajala, E., Eletta, O., & Oyeniyi, S. (2018). Characterization and evaluation of chicken eggshell for use as a bio-resource. Arid Zone Journal of Engineering, Technology and Environment, 14(1), 26-40.

[4] Al Mijan, M., Choi, K. H., & Kwak, H. S. (2014). Physicochemical, microbial, and sensory properties of nanopowdered eggshell-supplemented yogurt during storage. Journal of Dairy Science, 97(6), 3273–3280.

[5] Ali, M., Badawy, W.Z., (2017) Utilization of eggshells by-product as a mineral source for fortification of bread strips, J. Food and Dairy Sci., 8(11), 455-459.

[6] Arnold, M.; Rajagukguk, Y.V.; Gramza-Michałowska, A (2021). Functional Food for Elderly High in Antioxidant and Chicken Eggshell Calcium to Reduce the Risk of Osteoporosis—A Narrative Review. Foods, 10, 656.

[7] Arnold, M., Rajagukguk, Y. V., & Gramza-Michałowska, A. (2021). Functional food for elderly high in antioxidant and chicken eggshell calcium to reduce the risk of osteoporosis—A narrative review. Foods, 10(3), 656.

[8] Arnold M, Rajagukguk YV, Sidor A, Kulczyński B, Brzozowska A, Suliburska J, Wawrzyniak N, Gramza-Michałowska A (2022). Innovative Application of Chicken Eggshell Calcium to Improve the Functional Value of Gingerbread. Int J Environ Res Public Health. 1;19(7):4195.

[9] Awogbemi O,*, Daramy Vandi Von Kallon1 and Victor Sunday Aigbodion2,3 (2021) Pathways for Sustainable Utilization of Waste Chicken Eggshell. Journal of Renewable Materials images. DOI: 10.32604/jrm.2022.019152.

[10] De Paula, L. N., De Souza, A. H. P., Moreira, I. C., Gohara, A. K., de Oliveira, A. F., & Dias, L. F. (2014). Calcium fortification of roasted and ground coffee with different calcium salts. Acta Scientiarum. Technology, 36(7), 707–712.

[11] Faridi, H., & Arabhosseini, A. (2018). Application of eggshell wastes as valuable and utilizable products: A review. Research in Agricultural Engineering, 64(2), 104-114.

[12] Giango, W. C., Manalastas, R. D., Villaganas, A. A., Himang, C. M., and Giango, M. K. C. (2017). Formulation of Eggshell Cupcake. The Intellectual Property Office of the Philippines, PH22017000682U1. inventor; Cebu Technological Univ - Main Campus, assignee. Taguig: The Intellectual Property Office of the Philippines.

[13] Hassan, N. M. (2015). Chicken eggshell powder is a dietary calcium source in biscuits. World Journal of Dairy & Food Sciences, 10(2), 199–206.

[14] Jony, Md. Entaduzzaman & Hossain, Md & Rahman, Sharifur & Iqbal, Abdullah & Sami, Rokayya & Khojah, Ebtihal & Hashem, M. & Vivek, Kambhampati. (2021). Eggshells Calcium Extraction and the Application in Food Fortifications. Journal of Biobased Materials and Bioenergy. 15. 615-620. 10.1166/jbmb.2021.2107.

[15] Khojah, E.Y. and Sami, R., (2016). Fatty acids composition and oxidative stability of peanut and sesame oils with the sensory evaluation of mayonnaise prepared by different oils. Assiut Journal of Agricultural Sciences, 47(6–2), pp.460–472.

[16] Kozakai, T.; Uozumi, N.; Katoh, K.; Obara, Y. (2002) Dietary Magnesium Increases Calcium Absorption of Ovine Small Intestine in Vivo and in Vitro. Reprod. Nutr. Dev. 42, 25–33.

[17] Lachowicz, S., Oszmianski, ´ J., Wilczynska, ´ M., Zaguła, G., Saletnik, B., & Puchalski, C. (2020). Impact mineralization of chokeberry and cranberry fruit juices using a new functional additive on the protection of bioactive compounds and antioxidative properties. Molecules, 25(3), 659.

[18] Leonte, M.,(2007) Tehnologii, utilaje, reţete şi controlul calităţii în industria de panificaţie, patiserie,cofetărie, biscuiţi şi paste făinoase, Editura Ecozone, Iaşi.

[19] Liu, L., Xiao, F., Chen, K., Meng, Y., Zhao, S., Kang, H., et al. (2018). A Kind Of To Ferment Mutton Sausage And Preparation Method Using Industrial Egg Shell As The High Calcium Calcium Source. State Intellectual Property Office of the People's Republic of China, CN108497334A. inventor; Henan University of Science and Technology, assignee.

[20] Milbradt B.G., Muller A.L.H., da Silva J.S., Lunardi J.R., Milani L.I.G., de Moraes Flores E.M., Callegaro M.D.G.K., Emanuelli T. (2015): Eggshell as a calcium source for humans: Mineral composition and microbiological analysis. Ciencia Rural, 45: 560–567.

[21] Novelina, N., Anggraini, T., & Putri, L. N. (2020). Characteristics of Jelly Candy made from Soybean Milk and Addition of Eggshell Powder. AJARCDE (Asian Journal of Applied Research for Community Development and Empowerment), 4(1), 39-43.

[22] Platon, Nicoleta & Aruş, Vasilica-Alisa & Georgescu, Ana Maria & Nistor, Denisa-Ileana & Barsan, Narcis. (2020). White Bread Fortified with Calcium from Eggshell Powder. Revista de Chimie. 71. 299-306. 10.37358/RC.20.7.8248.

[23] Ray, S., Kumar Barman, A., Kumar Roy, P., & Kumar Singh, B. (2017). Chicken eggshell powder as dietary calcium source in chocolate cakes. The Pharma Innovation, 6(9), 1. Part A.

[24] Sembiring, H. B., Pasaribu, N., & Sitepu, J. (2021). Calcium carbonate from chicken eggshells as adsorbents. AIP Conference Proceedings, 2342(1), 070005.

[25] Shahnila, Arif S., Pasha I., Iftikhar H., Mehak F., Sultana R. (2022): Effects of eggshell powder supplementation on nutritional and sensory attributes of biscuits. Czech J. Food Sci., 40: 26–32.

[26] Suci A., Pebrianti, Yusrima S. W., Mufti G., Leny Y. (2023). Use of Chicken Eggshell Powder to Improve Calcium Content in Egg-Milk Pudding as a Food to Prevent Stunting and its Sensory Acceptability. International Journal of Current Science Research and Review, 6(11), 7366-7372

[27] S.M. Hama (2017) Improving mechanical properties of lightweight Porcelanite aggregate concrete using different waste material Int. J. Sustain. Built Environ.

[28] Tay, Hui Ling (2024) Development of Guava Jelly Candy Fortified with Eggshell Powder. Final Year Project (Bachelor), Tunku Abdul Rahman University of Management and Technology.

[29] Therdthai N, Soontrunnarudrungsri A, Khotchai W. (2023) Modified eggshell powder using thermal treatment and its application in Ca-fortified dog biscuits. Heliyon. 20; 9(2):e13093.

[30] Waheed, M., Butt, M. S., Shehzad, A., Adzahan, N. M., & Shabbir, M. A. (2019). Eggshell calcium: A cheap alternative to expensive supplements. Trends in Food Science & Technology, 91, 219-230.

[31] Wang, Y. (2015b). Method for Preparing Calcium Propionate from Eggshell. State Intellectual Property Office of the People's Republic of China, CN104262132A. Inventor; Shaanxi Synmot Petroleum Co., Ltd., assignee. Shaanxi: Shaanxi Synmot Petroleum Co., Ltd.

[32] Weaver, C.M. (2015) Diet, Gut Microbiome, and Bone Health. Curr. Osteoporos. Rep., 13, 125–130.

[33] Xie, W. (2018). A Kind of Chafing Dish Bottom Flavorings Preparation Method Containing Egg Shell Powder. State Intellectual Property Office of the People's Republic of China, CN108013360A. Inventor; Wenbo Xie, assignee. Beijing: State Intellectual Property Office of the People's Republic of China.

[34] Zeng, P. (2019). A Kind of Egg-Shell Meal Noodle Processing Method. State Intellectual Property Office of the People's Republic of China, CN109452556A. Inventor; Chongqing Dingyang Fanshu Agricultural Development Co., Ltd., assignee.

[35] FrieslandCampina Institute (2022). New review: Comparison global calcium intake. (Last accessed on 8 June, 2024). https://www.frieslandcampinainstitute.com/news/new-review-comparison-global-calcium-intake.

[36] Lybrate (2021). Egg Shell - 5 Reasons To Have It Daily! (Last accessed on 20 June, 2024)

[37] https://www.lybrate.com/topic/egg-shells-5-reasons-to-have-it-daily/62cfe1afca50af5654692d5436b9ea00

[38] Patent- Anne Schaafsma Cornelis Glas (1995). Application PCT/NL1995/000396,