Effects of Eggshell Powder Supplementation On Nutritional, Microbiological and Sensory Attributes of Cookies

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Abstract: Egg shells are an excellent source of calcium fortification in baked goods. Aside from that, the use of egg shell is aimed to reduce unused waste.Cookies are famous delicious bakery made from wheat flour that has a sweet taste, and is extremely popular. The goal of this research was to see how adding eggshell flour affected the chemical, microbiological, and sensory qualities of cookies.Three cookies samples were made: one without additions and two with eggshell powder added by replacing it with wheat flour at 5% and 10%.The samples were subjected to chemical, sensory, mineral, particularly calcium, and microbiological investigations. According to sensory evaluations, the results revealed that cookie containing 5% and 10% egg shell powder have a more sandy texture and taste, but sample of 5% concentration being more acceptable. This cookie has 5.66 % water, 6.63% protein, 24.53% fat, 2.04% ash, 61.08% total carbs, and 0.57 % calcium. The total plate count number was 7.5×10^6 cfu/g, and no colonies were discovered in the samples , according to the microbiological characteristics.

In conclusion: Strengthening cookie with egg shell powder can be an excellent source of calcium while having no substantial impact on cookie quality.

Keywords: Eggshell Flour, Cookies, Calcium, Waste Utilization.

Introduction

The rising use of chicken eggs generates a massive amount of egg shell trash, which has an environmental impact. Egg shells can be used as a source of calcium supplementation in a variety of food items in the waste valorisation node. (Raghul, 2023)

Eggshell (ES) is a low-value waste product that is not consumable. The primary components of ES are proteins, glycoproteins, and proteoglycans, which make up an organic matrix. Calcium carbonate (CaCO3) is also present. Osteopontin collagen, fibronectin, keratin, histones, avian beta defensins, ovocalyxin-36, apolipoproteins, protocadherin, chondroitin sulfate, ovotransferrin, hyaluronic acid, sialic acid, and different amino acids are found in the eggshell membrane (ESM), (Herman et al., 2023).

Large quantities of eggs are consumed in a variety of ways around the world, resulting in massive amounts of eggshells. These eggshells could end up in landfills, rivers, or coastal waterways, causing harm to people's health, contaminating water supplies, or generally harming the environment. Furthermore, in recent years, special emphasis has been dedicated to polluting industrial sectors. Although eggshells contain some organic membranes and a lot of CaCO3, they are often viewed as waste. The ES membrane's fibrils are mostly comprised of proteins, with collagen (types I, V, and X) accounting for around 10% of the total. Because of the adaptability of calcium carbonate and collagen in a variety of sectors such as medicine, pharmaceutics, and nutrition(ABBASSI, 2023)

Calcite Calicium Carbonate Nanoparticles (CaCO3NPs) were manufactured from chicken eggshell (CES) by crushing and filtering the shell.It is utilized in a variety of medical applications. (Al-Azzawi,& Al-Kalifawi, 2023).

Eggshells, which were previously considered waste food, can now be put to eggmilk pudding to create a healthy dish high in calcium to help avoid stunting. (Pebriant et al., 2023). Chicken egg shells are a

wonderful source of calcium fortification in cookies. Aside from that, the usage of chicken egg shell is intended to reduce waste that is not used (Yuliana et al ., 2022).

When eggshell was added to baked items, the calcium level increased significantly (Zerek, et al., 2022) .

Natural antioxidants obtained from agricultural byproducts have significant promise for treating oxidative stress-related disorders while also being environmentally friendly. The eggshell membrane (ESM) from hatched eggs, i.e., the hatched ESM, is a worldwide abundant agricultural byproduct with little research compared to the well-studied ESM from fresh eggs (Zhu, et al ., 2022).

When food is squandered, all resources, including nutrients and calories, are lost (TES, 2019).

Calcium, an essential element that is depleted, plays a critical part in maintaining optimum bone and tooth health, as well as other typical bodily processes. Calcium, as an organizational ingredient, interacts with phosphorus to form the mineral fraction of bone (Shang & Wu, 2019). It is essential for avoiding bone demineralization. Despite its essential role in the body, calcium deficiency is a widespread worry these days. Calcium from dairy sources is a good approach to meet the body's calcium needs (Fayet-Moore, et al., 2019).

Eggshells are the most prevalent calcium source, with a calcium concentration of 38% (Ray et al., 2017). This calcium carbonate can be transformed into a variety of calcium-containing chemicals, including calcium phosphate and calcium citrate, which have applications in the pharmaceutical and food industries (Hou et al., 2016).

Bartter et al., (2018) employed chicken eggshells to improve the nutritional condition of people in Sub-Saharan Africa and determined that adding crushed eggshell to traditional dishes is a safe and acceptable way to raise the masses' dietary calcium intake.

Natural Ca sources are appealing because they contain not just Ca but also other elements {e.g., Strontium (Sr) and Fluorine (F)} that may benefit bone metabolism (Reginster et al., 1999).With a high percentage of Ca, meaningful amounts of Sr, and controlled low levels of Pb, Cd, and Al, chicken eggshell powder should be a helpful element in human Ca enrichment efforts (Schaafsma et al ., 2020).

Globally, the amount of eggshell and eggshell membrane (ESM), by-products of the poultry and egg-processing industries, is projected to be more than 7 million tons per year, placing this waste material 15th on the list of important food sector pollution problems (Waheed, et al ., 2020 , Xiao et al ., 2021).

Strategies for osteoporosis prevention must identify which modifiable factors, particularly nutritional factors, can promote bone health throughout life. There are several nutrients and dietary components that may influence bone health, ranging from macronutrients to micronutrients and bioactive food additives (Cashman[1], 2007). Adolescence also appears to be the life stage with the highest prevalence of poor vitamin D status during the first two decades of life (Cashman[2], 2007).

Eggshell accounts for 9-12% of total egg weight and is primarily composed of calcium carbonate (94%), with some magnesium carbonate and calcium phosphate formed on the organic matrix. Eggshell calcium is an excellent substitute material for vital crustacean shells and a rich source of dietary calcium (Suguro., et al., 2000).

ES calcium has a high bioavailability and has been demonstrated to aid children and young adults with fragile fingernails, hair, lethargy, and asthma (Ahmed, et al ., 2022).

Numerous clinical studies have shown that calcium supplementation can help protect colon cells from pre-malignant alterations. The usage of calcium supplements and the development of distal colon cancer appear to be linked (Li, et al ., 2021, Younas et al ., 2021, Zhang et al ., 2022).

Minerals are essential micronutrients that are required for a variety of anabolic and catabolic biochemical activities as well as physiological functions. Minerals are required for animal production, growth, and reproduction (Durge et al ., 2022).

Calcium is not just a fundamental component of bones and teeth; it also regulates hormone release and activation, muscle contraction, neuronal transmission via ion channels, inflammatory processes, cell membrane permeability, and many other activities (Wosje& Specker 2000).

Chicken eggshell, a poultry waste product, is a promising but underutilized source of calcium that people can use to boost their dietary calcium intake by integrating it into recipes(Arif, et al ., 2022).

Cookies are flour-based bakery items that appeal to consumers due to their many flavors, long shelf life, and inexpensive cost (Manley, 2000).

The purpose of this study was to see what influence adding chicken eggshell flour on the chemical, microbiological, and sensory properties of cookies.

Materials and Methods

Materials :

Wheat flour, sugar, eggs, chocolate, butter,full cream milk, baking powder, and vanilla extract were obtained at the Super Market In Giza , Chicken egg shell was collected from household waste for this purpose, and the processing operation was carried out in a series of phases as shown in figures (1) and ratio of replacement in table (1).

Preparation of eggshell powder:

Chicken eggshells were demembraned, cleaned with distilled water, boiled in boiling water for 30 minutes to destroy germs, dried, and ground into a fine powder. The powder was oven dried and autoclaved (figer 1).

Formulation and Preparation of formulated Cookies:

(1): As stated in (table 1), eggshell was added to wheat flour at varied quantities of 5 and 10 %.

(2): Cookies were processed using the traditional creamery method described by Whitley (1970).

The dough was sheeted using a wooden roller pin, and the Cookies were cut into circular shapes before baking at 220 C for 15 minutes. The Cookies were allowed to cool for 30 minutes before being packed and stored in an airtight container for subsequent examination, as shown in (table 1).

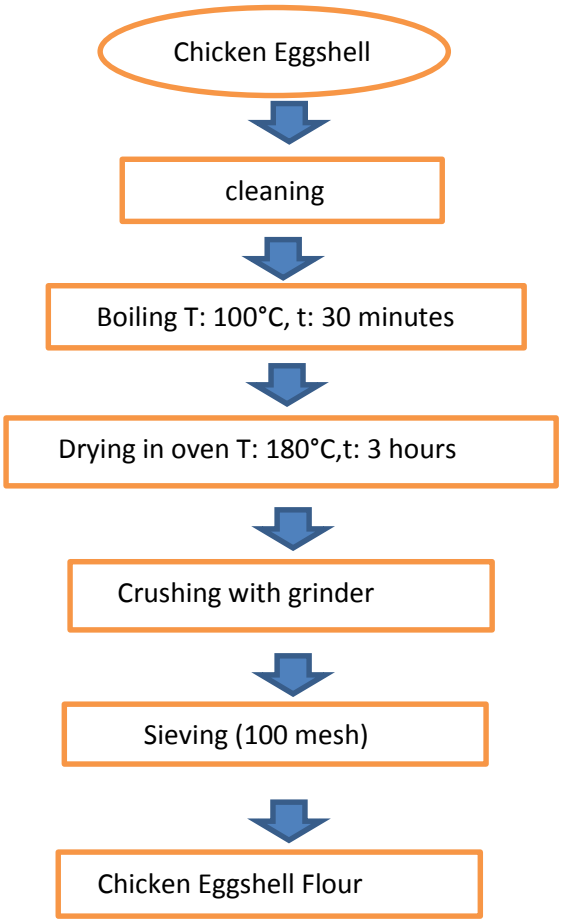

Figure 1: Flowchart of making chicken egg shell flour (Rahmawati and Nisa 2015).

Table 1. Cookies formulation with the addition of eggshell flour.

Ingredients (G)	control	Sample 5%	Sample 10%
Flour	100	95	90
Eggshell powder	-	5	10
Fresh Egg(whole)	1	1	1
Baking powder	0.25	0.25	0.25
Sugar	35	35	35
Butter	55	55	55
Vanilla	0.25	0.25	0.25
Chocolate	50	50	50
Salt	0.25	0.25	0.25
Full Cream Milk	4	4	4

Natural antioxidants obtained from agricultural byproducts have significant promise for treating oxidative stress-related disorders while also being environmentally friendly. The eggshell membrane (ESM) from hatched eggs, i.e., the hatched ESM, is a worldwide abundant agricultural byproduct with little research compared to the well-studied ESM from fresh eggs (Zhu, et al ., 2022).

Chemical Analysis:

The moisture, protein, fat, crude fiber, and ash contents of wheat flour, egg shell powder, and designed cookies were determined using the procedures given by the Association of Official Analytical Chemist (AOAC., 2016). Moisture content was assessed using the gravimetric method, protein using the Kjeldahl method, fat using the Soxhlet extraction method, ash using the dry ashing method, and fiber using the enzymatic gravimetric method. All analyses were performed in triplicates, and was done in lab of Faculty of Agriculture, Cairo University, Giza, Egypt,

Determination of Mineral Composition:

Minerals including calcium, were determined using the method described by Association of Official Analytical Chemists (AOAC.,

2016).Calcium was determined using Atomic Absorption Spectroscopy (iCE 3300), (Christian and Feldman, 1970).

Evaluation of sensory characteristics of ordinary cookies and different formulated eggshell powder (ESP) fortified cookies

Sensory properties of the formulated biscuits were evaluated by twenty five trained panellists. The panellists evaluated biscuits for its colour, odour, taste, texture, flavour, and overall acceptability. Each sensory attribute was rated on a 9 point hedonic scale: extremely liked – 9, very much liked – 8, moderately liked – 7, slightly liked – 6, neither liked nor disliked – 5, slightly disliked – 4, moderately disliked – 3, very much disliked – 2 and extremely disliked – 1 (Wichchukit, & O'Mahony, 2015).

Total Plate Count Analysis (AOAC1996)

The Total Plate Count (TPC) study is used to determine the presence or absence of total microorganisms in chicken egg shell flour cookies. The working premise of TPC analysis is the development of microorganisms after 48 hours of incubation in Nutrient Agar media at 37ºC. These bacteria will proliferate and form colonies that can be directly counted.

Analysis of Coliform Bacteria (AOAC 1996)

Coliforms are discharged from both animal and human digestive tracts. The coliform analysis is used to identify whether or not Escherichia coli bacteria are present in chicken eggshell cookie products. Eosin Methylene Blue (EMB) agar media was used for coliform analysis. This approach involves putting 1 ml of a cookie product solution that has been diluted in BPB into an empty petri dish, then pouring EMB agar liquid media over it and homogenizing it. The petri dishes were then incubated for 24 hours at 37ºC.

Statistical analysis:

Statistical analysis was carried out using one way analysis of variance (ANOVA) test followed by Duncan test through the program of statistical packages for the social science (SPSS) version 16. Results were expressed as mean± SD. The differences among means at $p \leq 0.05$ are considered significant (Snedecor and Cochran, 1989).

Results and discussion

Daily Allowance of Calcium.

Daily Allowance of Calcium was represented in table 2.
We have noted that there are no differences in calcium requirements between male and female. While there is a difference above the age of fifty, the need for females is greater than the need for males, reaching 1200 mg . Calcium requirements rise with age, with the peak level of requirements occurring between the ages of 9 and 18, reaching 1300 mg in both male and female.

Table 2: Dietary Reference Intakes (DRIs): Recommended Dietary Allowance and Adequate Intake , Elements, Food and Nutrition Board, Institute of Medicine, National Academies(2011)

Age	Male	Female
0: 6 (months)	200	200
6:12 (months)	260	260
1: 3 (years)	700	700
4 : 8	1000	1000
9 :18	1300	1300
19 :50	1000	1000
51 : 70	1000	1200
≥71	1000	1000

Ross et al .,(2011)

Dairy products are a good source of calcium, helping to meet the daily requirement. Calcium intake recommendations range from 1200 to 1400 mg/day (Raghul, 2023).

In this respect (Pebriant et al., 2023) reported that Calcium consumption was 200 mg for babies and young children, 250 mg for adults and adolescents, 650 mg for children and young adults, 1100 mg for teenagers and adults, and 1300 mg for nursing and pregnant women.

Proximate analysis of eggshell powder:

Table(3) and figre(2) show the proximate analysis of commercially available eggshell powder. The egg shell contains the most calcium (32.2%) and the least fat.

Table 3: Chemical composition of eggshell powder based on percentag:

Moisture	calcium	fat	Ash	protein	carbohydrates
1.6	32.2	0.03	91	6.3	Traces

According to the table (3) eggshells have the highest percentage of ash, reaching 91%.

These results are consistent with the findings of (Raghul, 2023) who found that the ash content of egg shell powder records highest (93.26%) and has the lowest fat content (0.03%). And also with, (Mendonça , et al. ,2023) who reported that the crude protein eggshell content shows that its presence is even greater than the mineral matter, constituting approximately 54 % of the dry matter of the eggshell of the control group

Our results indicated a decrease in the eggshell moisture content. Which was 1.6%. These results were in accordance with research by (Pebrianti et al .,2023) who found that the ash percentage of eggshell powder was 83.08%, which signified the availability of minerals in it. More than 95% of the mineral composition in eggshell powder was calcium in the form of calcium carbonate (CaCO3) and calcium phosphate (Ca (PO4)2).

In this respect Mendonça , et al ., (2023) reported that the treated groups F1, F2, GF1, and GF2 had higher dry matter and mineral matter than the control group. This finding reveals that the eggshell moisture content of the groups subjected to fipronil alone or in combination with glyphosate decreased.

In terms of chemical composition, eggshell is made up of water (2%), and dry matter (98%). The dry matter, on the other hand, is made up of 93% ash and 5% crude protein (Safitri, et al ., 2017). Eggshells are made up of a network of protein fibers that are linked to calcium carbonate, calcium phosphate, and magnesium carbonate crystals, as well as some organic compounds and water (Oliveira, et al ., 2013).

Eggshells are the most prevalent calcium source, with a calcium concentration of 38% (Ray et al., 2017). A 2.7 g serving of eggshell powder can supply almost 100% of the required dietary calcium intake for adults (Milbradt et al., 2015).

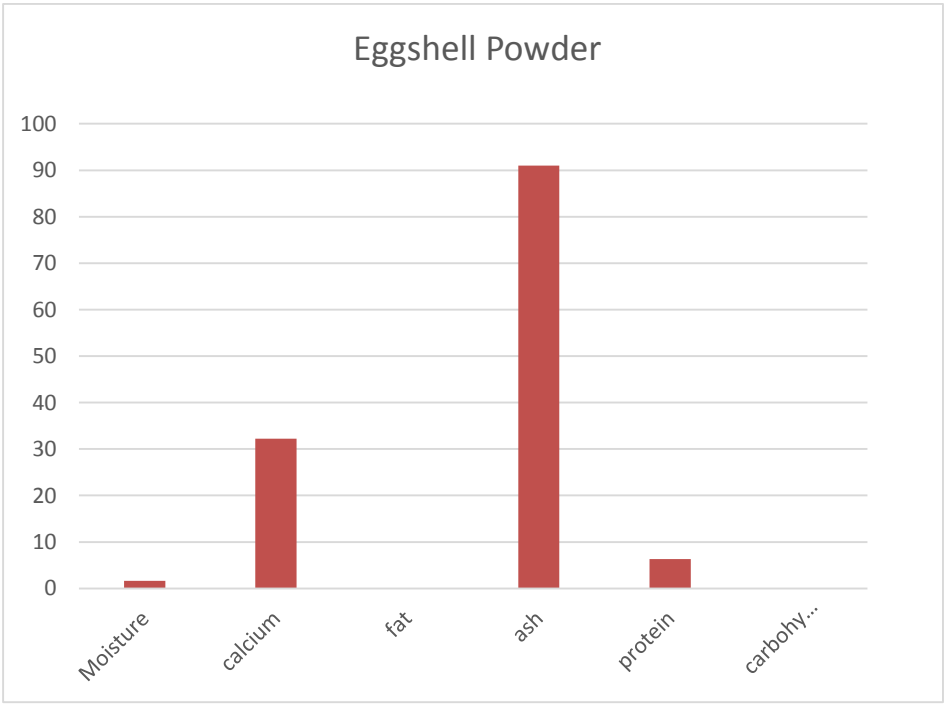

Figure 2 :Chemical composition of eggshell powder based on percentage.

Chemical Composition of Cookies:

The proximate chemical composition of prepared cookies shown in table (4) and figre(3) demonstrated that as the quantity of supplementation increased, so did the ash content of the cookies. Because the ash value controls the mineral value of the product, the addition of eggshell powder improved the mineral content of cookies, as demonstrated in this study.

The ash content of a product indicates its entire mineral composition. According to table 4, the ash content of cookies with chicken egg shell flour sample 5% and sample 10% is 2.04 % and 4.52% respectively . While the lowest ash concentration was found in control sample which was 0.35 % .

Our results are in agree with obtained by (Yuliana et al., 2022) who found that the ash content of cookies with the addition of chicken egg shell flour is 2.38%. The composition of cookies is dominated by wheat flour. The ash content of wheat flour allowed is maximum of 0.7%.

Table 4: Chemical Composition of Cookies samples (%mean ± SD)

Compounds	Control	Sample 5%	Sample 10%
Moisture	**3.52^{c} ± 0.28**	**5.66^{b}±0.2**	**6.76^{a}±0.14**
Ash	**0.35^{c}±0.03**	**2.04^{b}±0.08**	**4.52^{a}±0.07**
Fiber	**0.16^{a}±0.02**	**0.14^{ab}±0.01**	**0.13^{b} ±0.02**
Total Protein	**6.61^{a}±0.22**	**6.63^{a}±0.22**	**4.52^{b} ±0.10**
Total lipids	**24.50^{a}±1.02**	**24.53^{a}±0.69**	**24.26^{a}±0.57**
***Carbohydrate**	**64.86 ^{a}±1.02**	**61.08 ^{ab}±0.69**	**57.79^{b}±0.57**

***Carbohydrate was calculated by difference.**

The fat level of cookies made using chicken egg shell flour 5 % was 24.53 %. The addition of components such as margarine, skim milk, eggs, and chocochips contributes to the high fat content of cookies. Margarine has an average fat percentage of 80-81%, skim milk has a fat content of 14-16% (Ulfa et al., 2017), and chicken eggs have a fat content of 12% (Nova, 2014). The chemical compositions of eggshells were consistent with the analysis by (Yuliana et al .,2022)

who reported that the experiment included three tries and two repetitions of adding 5%, 8%, and 10% chicken eggshell flour to wheat flour to make cookie dough.The best attempt, according to sensory analysis, was cookies made with 5% chicken eggshell flour in addition to wheat flour. This cookie has 4.22% water, 6.73% protein, 25.14% fat, 2.38% ash, 61.53% total carbs, and 0.72% calcium.

Cookies using chicken egg shell flour have a protein level of 6.63%. This is in conformity with the Indonesian National Standard's criteria for cookie quality, which is at least 5% (BSN, 2011). According to Widiantara et al.و (2018), the composition of the elements used to make cookies, such as skim milk, eggs, powdered sugar, margarine, flour, and others, influences the high protein content.

Our resulted with in rang of protein content of cookies (Yuliana et al., 2022) which demonstrated that the addition of chicken egg shell flour 5 % to cookies was 6.73%.

In this respect Mendonça , et al. , (2023) reported that the crude protein eggshell content shows that its presence is even greater than the mineral matter, constituting approximately 54 % of the dry matter of the eggshell of the control group.

Table (4) shows that when eggshell was add for samples, larger amounts of ash and total protein were produced. These components had values of (4.52 and 4.52 g/100 g, respectively) The control has the highest amount of Carbohydrate (64.86 %) and least amount of ash compare with Sample 5% , Sample 10%. Our findings were consistent with those of (Yuliana et al.,2022), who reported that the experiment involved three trials and two repeats of adding 5%, 8%, and 10% chicken eggshell flour to wheat flour to create cookie dough.The best attempt, according to sensory analysis, was to make cookies with 5% chicken eggshell flour in addition to wheat flour. This cookie has 4.22% water, 6.73% protein, 25.14% fat, 2.38% ash, 61.53% carbohydrate, and 0.72% calcium.

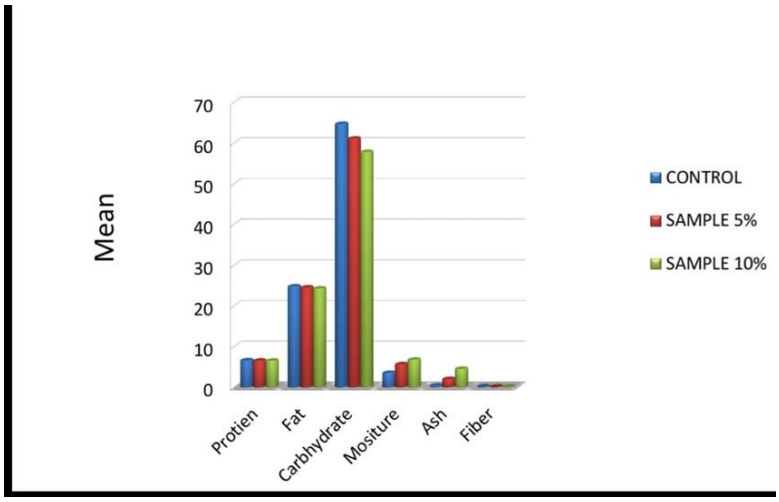

Figure 3: Chemical Composition of Cookies Samples

Calcium Content of Cookies Samples:

Calcium Content of Samples were represented in table 5 .

According to the table, as the proportion of eggshells added to the samples increases, the sample including 10% of eggshells has the highest percentage of calcium, followed by the sample containing 5%, and the control has the lowest percentage. Calcium levels in the samples varied from 0.02 to 1.11, respectively, (figre: 4) .

Table 5 : Calcium Content of Cookies Samples (g/100g)

	Control	Sample 5 %	Sample 10%
Calcium	**0.02**	**0.57**	**1.11**

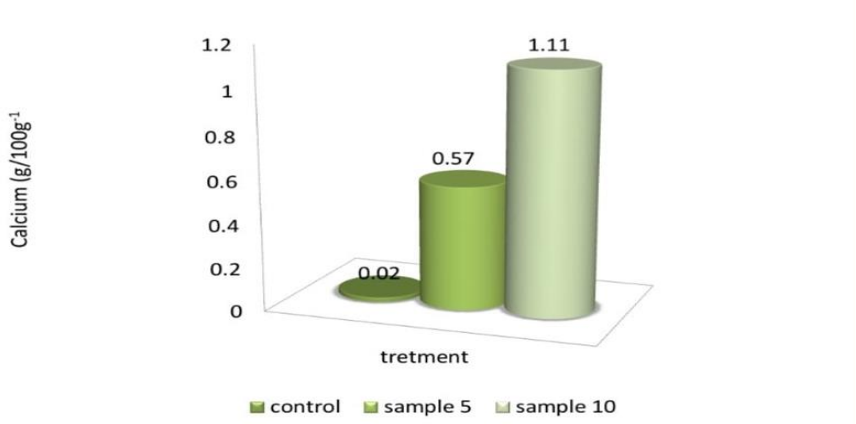

Figure 4: Calcium content of Cookies Samples

According to the statistical analysis results, as compared to the control (0%), the addition of eggshell powder considerably boosted the nutritional content of pudding in all treatments with the concentration of eggshell powder added. Ash and calcium levels were the nutrients that rose significantly. The addition of eggshell powder resulted in an increase in ash and calcium content in egg-milk pudding due to added nutrients from the eggshell powder. Eggshell powder had a high ash concentration (82.08%) in this study. As a result, the higher the ash level of the pudding created, the more eggshell powder used,(Pebrianti et al ., 2023).

Sensory evaluation of cookies samples:

Sensory evaluation of samples are shown in table(6)& Figure (5).From the consumer's perspective, organoleptic features are the key indicator of food quality. Sensory evaluation was performed in order to find the most acceptable samples. Color and aroma are the first things that attract our attention, followed by other characteristics. The acceptance test findings were comparable for the three treatments, with control and sample 5 % scoring higher than the other treatments for "Taste." We observe that there are considerable disparities across the samples, with the 10% sample being the least acceptable in terms of taste, color, and overall acceptance.

Table 6: Sensory evaluation of Cookies Samples:

Compounds	Control	Sample 5%	Sample 10%
Texture	7.94 ^{a} ±0.84	7.83 ^{a} ±0.93	7.25 ^{a} ±0.91
Taste	8.07 ^{a} ±0.93	8.06 ^{a} ±0.92	5.2 ^{b} ±0.94
Aroma	8.29 ^{ab} ±0.74	7.57 ^{a} ±0.75	7.2 ^{b} ±0.76
Color	8.5 ^{a} ±0.94	8.45 ^{a} ±0.82	5.3 ^{b} ±0.84
Overall acceptability	8.39 ^{a} ±0.88	8.43 ^{a} ±0.92	5.4 ^{b} ±0.83

In terms of "Color," (control and sample 5 %) has a higher value than the other treatments. The results suggest that (sample 5 %) has a higher acceptable value than the other treatments.

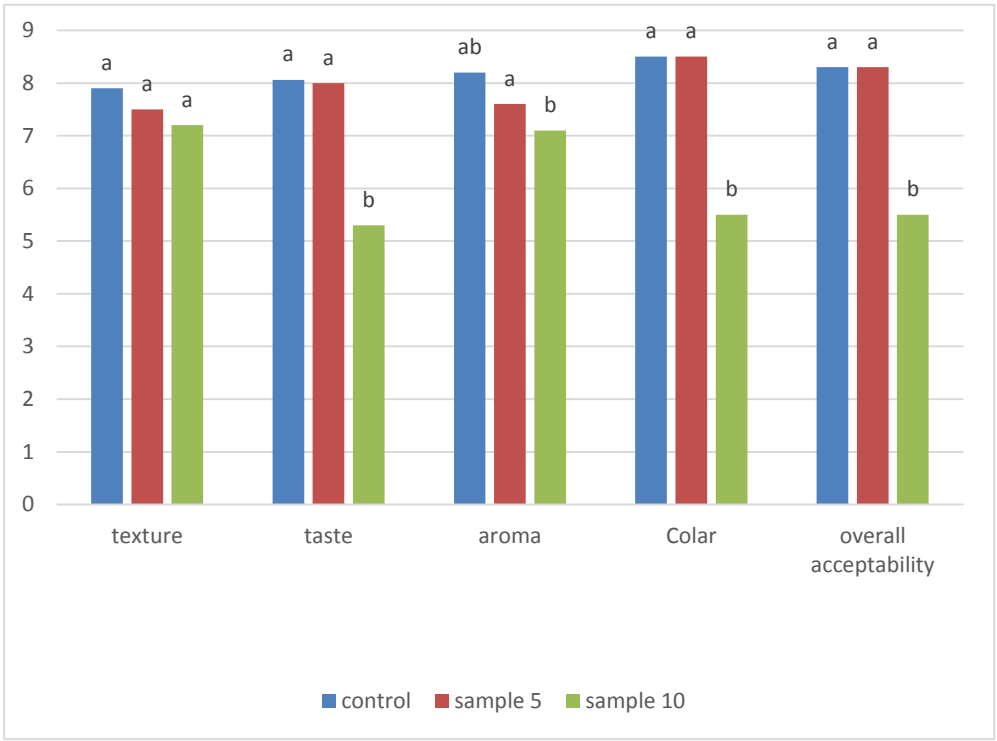

Figure 5: Sensory evaluation of Cookies samples

These findings were congruent with the findings of (Pebrianti et al., 2023) who discovered that the organoleptic color quality of cookies is important. Because the addition of eggshell powder had no noticeable impact on the panelists' color choice, there was no variance in their level of preference for pudding color.

Microbiological Study of Cookies Samples:

Microbiological study of cookies samples was presented in table 7. The total plate count (TPC) study is used to determine the presence or absence of total microorganisms in egg shell flour cookies. The working premise of TPC analysis is the development of microorganisms after 48 hours of incubation in Nutrient Agar media at 37^{o}C. These bacteria will proliferate and form colonies that can be directly counted. The lowest total plate count (TPC) was in control sample while the highest recorded for sample 10%

The coliform test can detect fecal contamination in water (Putri and Pramudya, 2018). Water is an important element in the preparation of cookies. Cookies with chicken egg shell flour yielded a negative coliform test result.

Our result was in agree with (Yuliana et al., 2022) who reported that the cookies with the addition of chicken egg shell flour showed a negative coliform test result. According to Indonesia National Standard on cookies, the maximum amount of coliform in cookies contains <20 APM/gram, so that chicken eggshell flour cookies are safe for consumption.

Table 7: Microbiological study of cookies samples:

	Control (cfu /g)	**Sample 5% (cfu /g)**	**Sample10% (cfu /g)**
T.C	5.7×10^{6}	7.5×10^{6}	11.2×10^{6}
Coliform	nd	nd	nd

Conclusion

This study shown that eggshell powder supplementation resulted in a large increase in minerals, primarily in the calcium content of cookies, with a significant decrease in calorie value. The introduction of 5% calcium in cookies resulted in a greater calcium absorption rate. Furthermore, up to a 10% supplementation dose, the eggshell powder did not cause any negative sensory changes. These findings support the potential benefits of employing eggshell powder to boost persons' dietary calcium intake by using cookies as a carrier. Furthermore, the use of eggshells in food could give another way to reduce the massive waste of created eggshells.

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تأثيرات مكملات مسحوق قشر البيض على الصفات الغذائيةو الميكروبيولوجيةو الحسية للكوكيز

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يعتبر قشر البيض مصدرا ممتازا لتدعيم الكوكيز بالكالسيوم. بالاضافة لذلك، فإن استخدام قشر البيض يهدف إلى تقليل النفايات غير المستخدمة. يعتبر الكوكيز من المخبوزات الشهيرة الشهية مصنوع من دقيق القمح وله طعم حلو، ويحظى بشعبية كبيرة. كان الهدف من هذا البحث هو معرفة مدى تأثير إضافة دقيق قشر بيض على الصفات الكيميائية والميكروبيولوجية والحسية للكوكيز. تم أخذ ثلاث عينات من الكوكيز: واحدة بدون إضافات واثنتان مع إضافة مسحوق قشر البيض عن طريق استبداله بدقيق القمح بنسبة 5٪ و 10٪. خضعت العينات للفحوصات الكيميائية والحسية والمعدنية وخاصة الكالسيوم والميكروبيولوجية. أظهرت النتائج وفقا للتقييمات الحسية، أن الكوكيز التي تحتوي على 5% و10% من مسحوق قشر البيض لها ملمس وطعم رملي أكثر،لكن العينة التي تركيزها 5% أكثر قبولا. يحتوي هذا الكوكيز على 5.66% ماء، و6.63% بروتين، و24.53% دهون، و2.04% رماد، و61.08% إجمالي الكربوهيدرات، و0.57% كالسيوم. كان العد الكلي للبكتريا 7.5×10^6 cfu/g ولم يتم اكتشاف أي مستعمرات في العينات حسب الخصائص الميكروبيولوجية.

توصي الدراسة بان تقوية الكوكيز بمسحوق قشر البيض يعد مصدرا ممتازا للكالسيوم دون أن يكون له أي تأثير كبير على جودة الكوكيز.

الكلمات الدالة : دقيق قشر البيض، الكوكيز ،الكالسيوم ، استغلال النفايات.