Valorization of Eggshell Powder: Incorporation in Scones to assess its Physicochemical and Sensory Attributes

Khadija Aijaz Siddiqui*[1], Kanza Jamil[1], Anum Liaquat[1], Rimsha Imran[1], Sara Amjad[1], Javeria Eshaal[1], Rumesa Ahmed[1]

1-Department of Food science and Technology Jinnah University for Women, Karachi Pakistan.

Authors' Contributions
All authors involve in Data Collection & Processing, Drafting of Manuscript

Article info.
Received: Sep 15, 2025
Accepted: Nov 10, 2025
Published Dec 21,2025

Funding Source: *Nil*
Conflict of Interest: *Nil*
Cite this article: Khadija Aijaz Siddiqui, Kanza Jamil, Anum Liaquat, Rimsha Imran, Sara Amjad, Javeria Eshaal, Rumesa Ahmed Valorization of Eggshell Powder: Incorporation in Scones to assess its Physicochemical and Sensory Attributes *International Journal of Trends in Food Sci and Techi. 2025;3:13-16.*

Address of Correspondence:
Email: anumfst@gmail.com

Abstract:

This research aimed to explore the nutritional composition and properties of calcium-fortified scones using eggshell powder in the ratio of 2.5, 5, 7.5 and 10% respectively. This goals of this study were to make the scones enriched with calcium from eggshell powder and to examine the product's physicochemical properties, microbiological analysis, and sensory evaluation. Eggshells are a rich and under-utilized source of dietary calcium that can be incorporated into baked goods. The eggshells have been cleaned, dried and then grinded. The scones were baked using these ratios and control sample was prepared. The scones formulated using calcium-rich eggshell powder (ESP) showed an increased ash and calcium content. The moisture and carbohydrate content showed a decreasing trend. However, there was not a significant difference between fat and protein content. Increasing the concentration showed an increase in porosity and specific volume. As the concentration increases, noticeable colour changes are observed leading to a darker hue. The results demonstrated that the springiness and cohesiveness of the scones were not much affected by the addition of eggshell powder but hardness was affected. The scones formulated with eggshell powder exhibit certain distinctive changes in their physicochemical and sensory qualities. The results suggest that upto 5% substitution gives acceptable sensory attributes and improved calcium content while, increasing the content can adversely affect the colour and reduce overall acceptability of the product.

Keywords: Eggshell, Physicochemical and Sensory Attributes"

Introduction:

One of the key macronutrients required for the human body to operate normally is calcium (Ca). In addition to being a key component of bones and teeth, calcium also plays a role in muscle contraction, release of hormones and activation, neuronal conduction via ion channels, inflammatory process regulation, cell membrane permeability maintenance, and many other processes (1). Consuming dairy products is a

suitable method of meeting calcium needs. Despite this, people typically don't take them in the dosages recommended by clinical standards. The easiest source of calcium available at our homes is chicken eggshell (2) . Tablet supplementation is expensive and occasionally causes problems with treatment compliance. The maintenance of bone tissues throughout life and a number of physiological processes depend on the mineral calcium. In addition to serving as a structural element, calcium and phosphorus combine to form the mineral portion of bone. It also plays a role in metabolic, biochemical, and physiological processes. In order to prevent and treat bone demineralization, calcium is essential(3) . Osteoporosis, or bone loss, is brought on by a diet low in calcium. Elderly people only receive 606.02±217.35 mg of calcium daily from diet. This is less than the recommended daily intake of calcium. As a result, ensuring the diet has enough calcium is crucial (4). According to the data available in Pakistan, the prevalence of osteoporosis is considerable in this region of the world, ranging from 5.6 to 17.8% in premenopausal women and 20 to 49.3% in postmenopausal women. The prevalence of osteoporosis is not well-documented(5, 6). Nearly all of the research has been published from the major cities and lacks data of rural areas. There are serious concerns over the underestimation of number of people with osteoporosis. Egg product companies and other food manufacturers who utilize eggs in their products produce tons of waste eggshell, which is a major environmental issue in many countries. Consequently, commercially accessible calcium-fortified foods have been introduced to the market in order to increase daily calcium intake(7). Numerous calcium sources, including calcium carbonate, calcium phosphate, cattle bone powder, and milk calcium, are added to these foods (8). One effective dietary calcium source is eggshell calcium. Calcium and trace levels of other microelements, such as magnesium, boron, copper, iron, manganese, molybdenum, sulfur, silicon, and zinc, are found in eggshells. Furthermore, the small intestine of the rat absorbed calcium from crushed eggshell powder more readily than from commercial CaC03 . Several researchers have been trying to figure out how to use eggshell waste as a source of calcium for human diets. Eating undercooked eggs increases the chance of contracting *Salmonella enteritidis*, which can contaminate eggs both internally and externally (9). To avoid *Salmonella* contamination, various cooking methods can be used or they can be washed thoroughly and then immersed in few drops of sodium hypochlorite solution. After this process, rinsing is required and then they can be dried with paper towels (10).

Traditional English cakes called scones are Scottish in origin. Scones are made up of flour, fat, and milk and resemble the biscuits. They are typically dense, crumbly, simple, frequently sweetened, and sometimes coated with egg

white.

Because the dough does not need to be kneaded until it is smooth, scones are a quick bread meal that is simple to prepare and requires less processing time than bread in general. The primary distinction between scones and biscuits is that the former are typically flaky and buttery, while the latter are not. While cereal proteins lack vital amino acids like lysine and threonine, wheat flour is the most significant component used to make a variety of baked goods. It is regarded as nutritionally insufficient. This has raised serious concerns about its use. Since eating a balanced diet is advised to prevent health issues including diabetes, obesity and osteoporosis, the need for safe and nourishing food is rising globally. Customers now have a strong urge to eat healthily as a result of this. Consumption of baked goods like scones is rising, yet the majority of these goods are deficient in minerals and have a higher sugar content and glycemic index, respectively (11).

Therefore, supplementation of wheat flour can be done to enhance the mineral content. The eggshell powder (ESP) can be a good strategy to utilize in the production of scones to improve its nutritional quality. The main objectives of the study were to analyze the physicochemical and sensory attributes of scones developed with the incorporation of 2.5, 5, 7.5 and 10% egg shell powder and to compare it with the control sample.

Material and Methodology:

Procurement of raw material

The study was conducted in the research lab of Department of Food Science and Technology at Jinnah University for Women, Nazimabad Karachi. The ingredients for making scones such as flour, baking powder, egg, salt, dates and vanilla essence were purchased from local store in Karachi.

Preparation of eggshell powder

The chicken eggshell was boiled in deionized water for half an hour after being cleaned twice. The eggshell was then dried for 24 hours at 60 °C using oven-drying method. A blender was used to grind the dried eggshell into a fine powder. Finally, a 120 µm screen was used to filter the pulverized eggshell powder(12)

Formulation of Scones

The scones were prepared using eggshell powder in different ratios as shown in table 1. Different treatments were prepared which included T0, T1, T2, T3 and T4 which had eggshell powder in the ratio of 0, 2.5, 5, 7.5 and 10% respectively.

Scones preparation procedure

The composition of scones is given below in Table 1. The scones were prepared according to the procedure described by Amadi & China (2022). In a big bowl, the enriched flour, baking powder, and salt were combined. In a small bowl, separate amounts of margarine and milk

were combined, then swirled into the flour mixture until moistened. After transferring the dough to a surface dusted with flour, it was briefly kneaded. After cutting the dough into eight wedges, it was baked at 200 °C for 15 minutes until golden brown. Then sprinkle some sesame seeds on it for flavour enhancing(13).

Proximate Analysis:

The moisture, ash, crude fiber, protein, crude fat and carbohydrate contents were determined according to the AOAC method (AOAC, 2000).

Determination of moisture content

The moisture content was determined by taking 5 grams of the sample that were dried at 130 °C using oven drying (InsuMax 150L) at 105±5 °C for 3 h until a constant weight was achieved in accordance with the AOAC method 934.06 method (2005). The moisture content was then calculated using the formula:

$$\% \text{ Moisture content} = \frac{(W1 - W2)}{W1} \times 100$$

Where,

W1=Initial weight of sample

W2=Final weight of sample

Determination of protein content

The protein content was determined through Kjeldahl method (AOAC 988.05). A block digestor (Gerhardt, Germany) was used to break down a finely ground sample of 1 g with 15 mL of concentrated sulfuric acid at 420°C for 1.5 hours. After cooling to ambient temperature, the digested solution was put into a distillation unit (Gerhardt, Germany) and diluted with 100 mL of distilled water before 80 mL of 40% sodium hydroxide solution was added. After the mixture was distilled, the ammonia released was collected in a 400 mL beaker with a few drops of filtered methyl red indicator solution and 50 mL of 2% boric acid. Total nitrogen was then determined by titrating this distillate against 0.1N H_2SO_4(14). The measured nitrogen content was converted to protein using a conversion ratio of 6.25.

Determination of ash content

The dry ashing method was used to calculate the ash content as per AOAC 942.05 method (2005). For 5 h, a clean silica crucible was heated to 550 Celsius in a muffle furnace. The silica crucible was weighed at a constant weight after being cooled for 1 h in a desiccator. The material was then weighed into the constant weight crucible after being finely pulverized (3–5 g). The crucible was heated on a hot plate to prepare the sample, and it was then placed in the muffle furnace at 550 Celsius for 6 to 8 hours to finish the ashing process. After cooling for an hour, the crucible's ash content was measured(15).

The semi-continuous solvent extraction method was used to determine the fat content according to AOAC 963.15 (2005). An automatic hydrolyzing apparatus (Gerhardt, Germany) was used to weigh a finely powdered and homogenized sample (1-3 g) into a hydrolyzing capsule for hydrolysis. After that, the hydrolyzed

ISSN Online 3049-7647 © 2025 Elysian Sciences Publishing House

sample was moved into an extraction thimble. An automated fat extraction machine (Gerhardt, Germany) was used to extract the fat using petroleum ether at 40–60ºC for 2-3 h while cotton was used as a lid(16). The recovered petroleum ether was dried for 3 h at 105ºC, chilled for 1 h in a desiccator, and then weighed to determine its fat content.

Determination of crude fiber content

The crude fiber content was determined according to AOAC 978.01 (2005). The beaker was filled with 2 grams of the sample and 100 mL of H2SO4 solution. Water flowed to the condensers, which were placed atop the beaker's mouth. After 5 minutes of intense heating to bring it to a rapid boil, the heating was continued for 30 minutes. After adding 50 mL of NaOH solution, the mixture was heated for an additional 35 minutes. Five minutes prior to the boiling point, 0.5g Na2 EDTA was also added. The crucible, which is connected to the filtration device, was then used to filter the solution. The hot water was used to rinse the beaker. The crucible's filtrate was rinsed with 50 mL of HCL, then cleaned twice with 50 mL of acetone and warm water until it was acid-free. After being dried overnight at 10°C in an oven, the crucible was cooled in a desiccator before being weighed. The crucible containing the dried residue was placed in a muffle furnace, burned for two hours at 55°C, cooled in a desiccator, and then weighed(17).

The following formula was used to calculate crude fiber.

Where:

W_1 = Weight of empty crucible W_2 = Weight of crucible + sample

W_3 = Weight of crucible + dried residue W_4 = Weight of crucible + ashed residue

The total carbohydrates were determined by difference according to AOAC (2000) method, by the following equation:

NFE = 100 - (moisture % + protein % + crude Fat % + ash %)

Colorimetric analysis

The color of the scones was determined using colorimeter (HunterLab, Reston, VA, USA) 24 hours after baking according to the method of Pycia & Ivanišová (2020). The CIE L*a*b* system was used to do the measurements in reflection: measuring geometry d/8°, illuminant D65, range 400–700 nm, detector inclined by 10°, and measurement slot 25 mm. The parameter L* should fall between 0 and 100, where 100 represents the brightness of a spectrum color, or monochromatic color, and 0 represents "zero" luminance, or black color. The color's chromaticity is determined by parameters a and b. The shift from green (−a) to red (+a) and from blue (−b) to yellow (+b), respectively, is indicated by the parameters a* and b*, which have values between −120 and 120 (Pycia *et al.,* 2018). The computed color difference is displayed by parameter ΔE(18) .$\Delta E = \sqrt{\Delta(L)^2}$ +

ISSN Online 3049-7647 © 2025 Elysian Sciences Publishing House

$\Delta(a)^2 + (\Delta b)^2$

Texture Analysis

The Stable Micro System Texture Analyser (Model TA.XT2 Plus Texture Technologies Corp., Scarsdale, New York and U.S.A.) was used to analyze the bread's texture profile. A 75 mm cylindrical probe was used to execute the compression, and the hardness (N), springiness (mm), gumminess (N), chewiness (N) and cohesiveness (-) parameters of the resulting deformation were examined(19). The results were obtained thrice to ensure accuracy .

Sensory Analysis

The sensory evaluation of the scones were performed according to method of Lee et al., (2024) with slight modification. Twenty trained panelists (15 females and 5 females, ages 20–40) participated in the sensory evaluation, which used a 9-point hedonic scale (1 = dislike greatly, 9 = like excessively). The scone's color, aroma, flavor, texture (hardness and crispness), and general acceptance were all assessed by the panelists. The samples were presented in a sequential order after completing evaluation of one sample. Panelists were told to rinse their palates with water in between samples during the examination, which was conducted two hours after baking(20).

Statistical Analysis

The statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software for Windows 21 (SPSS Inc., Chicago, IL, USA). Every measurement was done thrice and the results were reported as means ± standard deviation. To find significant differences between the means of each variable, one-way analysis of variance (ANOVA) was used. Tukey's Honest Significant Difference (HSD) test was used for pairwise comparisons, with a significance level of $p < 0.05$.

Results and discussion Proximate Analysis of Scones

The results of the proximate analysis of scones are presented in Table 2 and were found to be statistically significant ($P<0.05$). The scones formulated with eggshell powder showed a decreasing moisture content as the concentration of eggshell powder increased. The highest moisture content was shown by T1 and the lowest by T4. These results are similar to those reported by literature where eggshell powder was used to produce bread and brownie, respectively(21).The ash content increased with the increasing concentration showing a higher mineral content. The highest ash content was reported in T4 and the lowest in T0. The elevated mineral content of eggshell powder, which mostly comprises of calcium carbonate with traces of magnesium carbonate, calcium phosphate, and other inorganic minerals, caused an increase in the ash level of scones prepared using ESP . Previous studies have also reported an increase in ash content due to fortification of egg shell powder in making fortified bread and chocolate cake (22).Although

the values of fat content did not show much change but showed a decreasing trend as the concentration increased. The highest fat content was reported in the control sample and lowest in T4. The obtained results were similar to those reported by Afzal *et al., (23)*where muffins were prepared by the fortification of eggshell powder.The protein content was reported to be the highest in T2 and the values decreased from T3 to T4. The lowest protein content was found in T4. Furthermore, gluten, a protein present in flour, is the main protein used in baking. In the baking discipline, gluten is crucial. When mixing starts, the protein absorbs water and swells as a result. The synthesis of gluten subsequently creates a protein matrix that gives the dough its structure and support, giving it its elastic and extensible qualities (24).The fiber content increased as the concentration of egg shell powder increased with the highest value reported in sample T4 and lowest in T0. The carbohydrate content decreased from T0 to T2 and then increased again in T3 and T4.

Table 1-Composition of Scones

	T0	**T1**	**T2**	**T3**	**T4**
Flour	100	97.5	95	92.5	90
Milk	50	50	50	50	50
Baking powder	12	12	12	12	12
Salt	2.5	2.5	2.5	2.5	2.5
Sugar	15	15	15	15	15
Unsalted Butter	30	30	30	30	30
ESP*	0	2.5	5	7.5	10

Table 2-Proximate Analysis of Scones

Treatment	**Moisture**	**Ash**	**Fat**	**Protein**	**Fiber**	**Carbohydrate**
T0	26.13±0.11^{c}	3.91±0.54^{a}	1.86±0.07^{d}	14.16±0.13^{a}	1.94±0.04^{a}	52.0±0.51^{c}
T1	27.37±0.28^{e}	4.53±0.35^{ab}	1.60±0.05^{c}	14.59±0.03^{b}	2.22±0.10^{a}	49.69±0.73^{ab}
T2	26.72±0.15^{d}	5.26±0.26^{b}	1.47±0.05^{c}	14.96±0.06^{c}	2.81±0.21^{b}	48.78±0.21^{a}
T3	25.2±0.11^{b}	6.25±0.35^{c}	1.27±0.08^{b}	14.24±0.02^{a}	3.08±0.06^{b}	49.95±0.40^{ab}
T4	24.18±0.16^{a}	6.97±0.16^{c}	1.05±0.06^{a}	14.14±0.02^{a}	3.61±0.06^{c}	50.04±0.17^{b}

Textural properties of Scones

The textural characteristics of the scones are given in Table 3 and were found to be statistically significant (*P<0.05*). The hardness of the scones shows an increasing trend as the concentration of the eggshell powder increased. The highest value was reported in T4 and the lowest value was observed in T0. The substantial increase in ash content could be the cause of the enhanced hardness. The interaction between

gluten and fibrous particles may possibly be the cause of the hardness (25). The values were found to be in accordance with Chilek *et al.,* (2018). The springiness and cohesiveness decreased with increasing concentration of eggshell powder. The highest value was reported by T0 and the lowest value was reported by T4. The results were similar to those reported by scientist *(26)* utilizing eggshell powder to prepare bread.

Colour Analysis of Scones

The color characteristics of the scones are depicted in Table 4. The values for L and b were found to be statistically significant (*P<0.005*). Meanwhile, the values for a were not found to be statistically significant (*P>0.005*). The L value decreased as the concentration of eggshell powder increased. The highest L value was shown by T2 and the lowest by T4. Due to their highly textured and uneven consistency, baked goods like scones frequently make color measurement difficult. The flour particle size is the most significant of the numerous variables that affect bread whiteness, including wheat pigment, grain content, and grain fineness. The sample with the largest eggshell powder content had the lowest lightness, which could be explained by the varying amount of eggshell used.

The a* value also showed a decreasing trend where highest value was reported by T0 and lowest by T4. The b* value increased with the increasing concentration where highest value was reported by T2 and then the value started declining from T3 to T4. The lowest was depicted by T0. It can be used to assess how well the baking process is going. The physicochemical properties of the raw dough, such as its pH, moisture content and reducing sugars, as well as the baking conditions, such as temperature and relative humidity, may affect the surface color (13).

Sensory analysis

The results of the sensory evaluation of scones containing varying amounts of eggshell powder are shown in Fig1. The attributes evaluated include color, flavour, texture, aroma, crunchiness and overall acceptability. The study conducted by Esmaeili *et al.,* (2025) did not show significant change in sensory attributes of brownies on addition of eggshell powder upto 5%. The scores for color and aroma decreased with the addition of eggshell powder. The highest score obtained for T0 and the lowest for T4. The flavour was found to be highest in T1 and the lowest in T4. The texture was also found to be the highest in T2 and the lowest in T4. The crunchiness was found to increase as the concentration of eggshell powder increased. The highest was reported in sample in T4 and lowest in T0. The overall acceptability was not much affected with the addition of eggshell powder but better results for flavour and texture were obtained upto 5%. The results were found

ISSN Online 3049-7647 © 2025 Elysian Sciences Publishing House

to be in accordance with Nadeem *et al.,* where egg shell powder fortification was used to prepare muffins. Also, Bradauskiene *et al.,* utilized varying concentrations of eggshell powder in production of bread and upto 5% bread showed higher overall acceptability(27).

Table 3-Textural properties of Scones

Treatment	Hardness	Springiness	Cohesiveness
T0	20.83±0.72^{a}	0.84±0.02^{c}	0.63±0.01^{b}
T1	21.8±0.26^{ab}	0.79±0.02^{bc}	0.59±0.02^{ab}
T2	22.67±0.21bc	0.77±0.02ab	0.56±0.25a
T3	23.43±0.21cd	0.76±0.02a	0.62±0.03b
T4	23.93±0.15d	0.74±0.02ab	0.68±0.01c

Table 4-Color characteristics of Scones

Treatment	**L**	**a**	**b**	**▲E**
T0	72.56±0.25^{bc}	0.99±0.03^{b}	16.68±0.13^{a}	0
T1	72.93±0.05^{cd}	0.96±0.03^{ab}	17.48±0.09^{c}	0.88
T2	73.15±0.16^{d}	0.86±0.07^{a}	17.87±0.11^{d}	1.33
T3	71.84±0.06^{a}	0.89±0.03^{ab}	17.08±0.11^{b}	0.83
T4	72.18±0.17^{ab}	0.85±0.36^{a}	16.9±0.03^{ab}	0.46

ISSN Online 3049-7647 **© 2025 Elysian Sciences Publishing House**

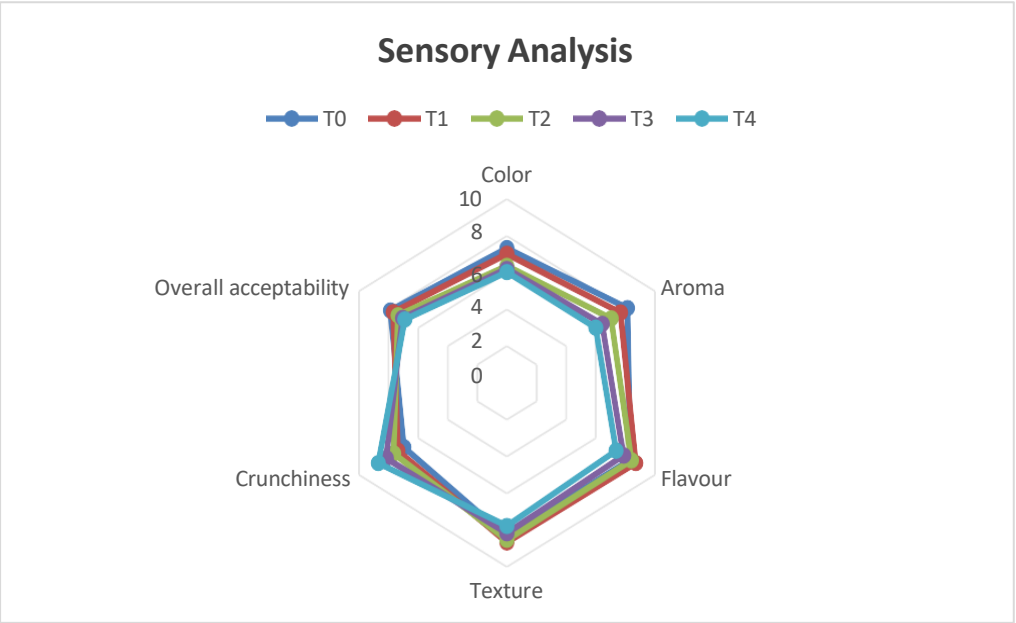


Fig 1: Sensory Analysis evaluation of scones

Table 5-Sensory Evaluation Scores for Scones

Treatment	Color	Aroma	Flavour	Texture	Crunchiness	Overall acceptability
T0	7.33±0.15^{b}	8.13±0.15^{d}	8.33±0.15^{bc}	8.37±0.15^{bc}	6.97±0.15^{a}	7.83±0.04^{b}
T1	7.01±0.10^{b}	7.67±0.20^{c}	8.40±0.15^{bc}	8.47±0.15^{bc}	7.37±0.15^{ab}	7.79±0.02^{b}
T2	6.37±0.15^{a}	7.03±0.15^{b}	8.70±0.20^{c}	8.53±0.15^{c}	7.67±0.20^{b}	7.67±0.08^{b}
T3	6.20±0.26^{a}	6.43±0.20^{a}	7.87±0.15^{ab}	8.17±0.15^{ab}	8.17±0.15^{c}	7.37±0.06^{a}
T4	6.03±0.25^{a}	6.00±0.20^{a}	7.37±0.25^{a}	7.67±0.20^{a}	8.70±0.10^{d}	7.18±0.02^{a}

Conclusion

The color analysis also revealed that the eggshell powder enhances the color profile of the scones. This study offers important information about the viability of using eggshell powder as a calcium-rich baking ingredient. Consequently, the findings imply that adding up to 5.0% ESP can supply the necessary daily calcium intake without adversely affecting the product's sensory qualities. The nutritional advantages of eggshell calcium fortification are said to promote acceptability through public awareness campaigns and education. These results highlight ESP's potential as a useful natural calcium source for enhancing baked goods. Through the efficient use of a commonly available and underutilized agricultural byproduct, this study helps to generate more

sustainable and nutrient-dense food products. However, more research is required to examine the long-term consequences of consuming ESP and evaluate its potential uses in other food products.

Conflict of Interest

There was no conflict of interest among the authors that could affect the research of the article.

References

1. Berchtold MW, Brinkmeier H, Müntener M. Calcium ion in skeletal muscle: its crucial role for muscle function, plasticity, and disease. Physiological reviews. 2000.
2. Shah R. What About My Calcium?: A Complete Plant Based Guide for Calcium Health: Notion Press; 2024.
3. Wawrzyniak A, Balawender K. Structural and metabolic changes in bone. Animals. 2022;12(15):1946.
4. Evenepoel P, Jørgensen HS, Bover J, Davenport A, Bacchetta J, Haarhaus M, et al. Recommended calcium intake in adults and children with chronic kidney disease—a European consensus statement. Nephrology Dialysis Transplantation. 2024;39(2):341-66.
5. Rehman H, Rehan SJ, Ishaq H, Shakeel S, Hashmi F, Naveed S. Hypothyroidism—a question towards quality and patient centricity. Open Journal of Endocrine and Metabolic Diseases. 2015;5(02):19.
6. Rehman H, Patrus Z, Anjum S, Altaf A, Safdar R, Shree B. Evaluation of Cough Suppressant Use Patterns and Management Practices: A Survey of Patients and Pharmacists. RADS Journal of Pharmacy and Allied Health Sciences. 2025;3(3):145-53.
7. Rehman H, Sattar A, Mustafa H, Sufyan M, Haris M, Mushtaq S. Knowledge and Beliefs of School Children Towards Medicine in Karachi, Pakistan. A Cross-Sectional Study. RADS Journal of Pharmacy and Allied Health Sciences. 2024;2(3):153-9.
8. Rehman H, Shaikh ZA, Naveed S, Latif M, Usmanghani K. Evaluation of in vitro antioxidant, reducing, lipoxygenase and ACE inhibition activity of polyherbal drug linkus. African Journal of Pharmacy and Pharmacology. 2016;10(44):945-53.
9. Rehman H, Ahmed Z. Missed opportunities in Pakistan: The never-ending struggles and challenges in clinical research. Ann Clin Lab Res. 2017;5(1):1-6.
10. Rehman H, Zahoor A, Shaikh ZA, Naveed S, Usmanghani K. Polyherbal extract based Linkus lozenges for symptomatic relief: Design, development and evaluation.
11. Rehman H, Ali SA, Naveed S, Usmanghani K. An interquartile relationship between polyherbal extract based lozenges linkus a phase IV comparative randomised control trial. Pak J Pharm Sci. 2017;30(3):961-6.
12. Nada EA, Kaddorah MEA, El Jamal M, Hamad A, Mansour FR. Eggshell waste as a sustainable resource for nanoparticle preparation; synthesis, characterization and

applications. Environmental Nanotechnology, Monitoring & Management. 2025;24:101092.

13. Jung J-W. The Quality Characteristics of Scone Enriched with Astragalus membranaceus Powder as a Medicinal Ingredient. Culinary Science & Hospitality Research. 2024;30(9):15-25.

14. Rehman H, Jamil K, Owais A, Naveed S, Usmanghani K. ANTIMICROBIAL ANALYSIS OF POLYHERBAL FORMULATION LINKUS COUGH SYRUP. 2017.

15. Rehman H, Shaikh ZA, Naveed S, Shinwari MI, Usmanghani K. Evaluation of Efficacy and Toxicity of Poly Herbal Lozenges in Experimental Animals. RADS Journal of Pharmacy and Pharmaceutical Sciences. 2018;6(1):22-32.

16. Rehman H, Naveed S, Qamar F, Ayaz S, Jamil S, Fatima S, et al. Phytochemical standardization of Vasicine in cough syrup by high performance liquid chromatography-densitometry. Pak J Pharm Sci. 2018;31(6):2679-82.

17. Alam T, Asif S, Ayaz S, Rehman H, Sana A, Alam S, et al. Total phenolic content and total flavonoid content of Embelia ribes by radical scavenging activity. Lat Am J Pharm. 2019;38(7):1467-71.

18. Khan M, Rehman H, Naveed S, Zaidi SF, Ayaz S, Owais A, et al. Chewable cough tablets with improved palatability: A comparative phase II clinical trial. Pakistan Journal of Pharmaceutical Sciences. 2019;32.

19. Khan M, Rehman H, Usman R, Ayaz S, Qamar F, Owais A, et al. Formulation development of sugar free antacid chewable tablets for diabetes induced acidity in patients. Pak J Pharm Sci. 2019;32(6):2811-6.

20. Saleem S, Naveed S, Sana A, Noor R, Rehman H, Usman R. Quantitative RP-HPLC Analysis of Gallic Acid in Polyherbal Capsules Dosage Form. Lat Am J Pharm. 2020;39(6):1187-91.

21. Shakeel S, Rehman H, Hassali MA, Hashmi F. Knowledge, attitude and precautionary practices towards COVID-19 among healthcare professionals in Karachi, Pakistan. The Journal of Infection in Developing Countries. 2020;14(10):1117-24.

22. Shakeel S, Iffat W, Rehman H, Nesar S, Bashir L, Naz S. Pharmacy students' awareness and practices concerning the disposal of household medicines in Karachi, Pakistan. Lat Am J Pharm. 2021;40(3):467-74.

23. Afzal M, Fatima M, Qamar A, Farhan M, Shah SZH. Growth, muscle proximate composition and whole-body nutrient status of Labeo rohita fed acidified and phytase pre-treated sunflower meal based diet. Pakistan J Zool. 2020;52(3):937-47.

24. Ooms N, Delcour JA. How to impact gluten protein network formation during wheat flour dough making. Current opinion in food science. 2019;25:88-97.

25. Kiumarsi M, Shahbazi M, Yeganehzad S, Majchrzak D, Lieleg O, Winkeljann B. Relation between structural, mechanical and sensory properties of gluten-free bread as

affected by modified dietary fibers. Food chemistry. 2019;277:664-73.

26. Ali M, Badawy W. Utilization of eggshells by-product as a mineral source for fortification of bread strips. Journal of Food and Dairy Sciences. 2017;8(11):455-9.

27. Arnold M, Rajagukguk YV, Sidor A, Kulczyński B, Brzozowska A, Suliburska J, et al. Innovative application of chicken eggshell calcium to improve the functional value of gingerbread. International Journal of Environmental Research and Public Health. 2022;19(7):4195.