



UTILIZATION OF CHICKEN EGGSHELL FOR DEVELOPING VALUE-ADDED PRODUCT

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ABSTRACT

Eggs of hen are very nutritious, economical and healthy food product but their shells are discarded as waste. Chicken eggshell is an excellent and commonly available source of calcium that can be used for calcium supplementation. The present work was conducted to study the effect of eggshell powder supplementation on chemical composition, physical and sensorial properties of eggshell powder supplemented biscuits. On proximate analysis, wheat flour and chicken eggshell powder showed calcium content as 18 ± 0.87 mg/100g and 35.09g/100g respectively. The biscuits were then prepared from wheat flour supplemented with eggshell powder at three levels of supplementation viz., 1.70g (provides 600mg of calcium), 2.27g (provides 800mg of calcium) and 3.41g (provides 1200mg of calcium). The addition of chicken eggshell powder led to a considerable increase in calcium content of the supplemented biscuits. The calcium content of supplemented biscuits was found to be 596.00 ± 32.05 mg/100g, 797.01 ± 40.01 mg/100g, and 1198.2 ± 42.02 mg/100g at 1.70g (ESP1), 2.27g (ESP2) and 3.41g (ESP3) supplementation respectively. ESP1 is suitable for men, women and children (1 to 9 years) because the RDA of calcium for these age groups is 600mg/d. Whereas, ESP2 is suitable for postmenopausal women, boys and girls (10 to 17 years). Eggshell powder supplementation also resulted in some change in physicochemical and sensory

properties of the biscuits. Chicken eggshell powder supplementation in biscuits increased the thickness and diameter of biscuits but reduced the spread ratio. ESP1 and ESP2 were highly acceptable by the panelists.

Keywords: Eggs, Chicken eggshell, Calcium supplementation, Supplemented biscuits

1. INTRODUCTION

Deficiency of calcium in the diet is a common problem. Calcium intake from dairy products is an appropriate way to fulfill calcium requirements. However, people do not usually consume them in the amounts established by clinical guidelines. Supplementation with tablets is costly and sometimes involves difficulties of adherence to treatment. Chicken eggshell powder is a source of calcium, which is available at home and can be used for calcium supplementation. Utilization of eggshell is an inexpensive approach to reduce the chances of calcium deficiency and other problems associated with it.

2. REVIEW OF LITERATURE

The poultry sector is growing across the globe owing to urbanization, population increase and rise in purchasing power. From the year 1961 to 2017, the global production of eggs has increased from 15 to 87 million tonnes to fulfill surge in demand. In developing countries, around 80% rural households raise poultry. A global output of more than 60% makes Asia the highest egg-producing region. With 42% of production, China is the largest egg producer worldwide,

with 7% production United States stands second and India with 6% production is third in the position. In 2018, the global egg production was 76.7 million tones [1] with China producing 26.90 million tonnes in 2018 followed by United States of America with a gross annual production of 6.46 million tones and India at a third position with annual produce of 5.23 million metric tones [2].

In India according to the department of animal husbandry, Andhra Pradesh, Tamil Nadu, Telangana, West Bengal and Haryana are the top egg producing states with a contribution of nearly 65% to the total egg production of the country. Andhra Pradesh is the major egg producer in the country with a contribution of over 19% in the total production [3].

As per Indian Council of Medical Research (ICMR), the recommended consumption of eggs per person per year is 180. The actual consumption is however very less as compared to the recommendations. In cities, the consumption is 90-105 eggs per person per year and in rural areas it is 50-70 only [3]. The continuous increase in the production of eggs is leading to a serious problem of

landfill disposal owing to generation of large quantity of eggshell waste. That is further increasing the environmental pollution and bringing several other challenges like availability of sites for disposal, presence of odor and flies [4]. In the recent years, several attempts have been made to utilize eggshell waste. Around 750-800mg of calcium can be obtained from a teaspoon of eggshell powder, which is a good amount of calcium to prepare food products fortified with calcium. The calcium from eggshell is a good natural source of calcium and is better than calcium obtained from sources like limestone and coral. The absorption of calcium derived from eggshell is around 90%. **Table 1.1** shows the nutritional status of eggshell powder.

For maintaining good health, regular consumption and proper absorption of calcium is required. Eating different foods containing calcium can provide required calcium for the body. The calcium requirement of infants, children and adolescents is higher as they need more calcium for formation and growth of bones. Pregnant women (for fetal development) and women who have reached menopause (reducing risk of osteoporosis) also need higher calcium intake [5].

Table 1.1: Nutritional status of eggshell powder [16]

Component	White eggshell powder
Moisture (%)	0.46
Protein (%)	3.92
Ash (%)	94.61
Fat (%)	0.35
Calcium (%)	34.12
Magnesium (%)	0.29
Phosphorus (%)	0.04
Potassium (%)	0.03
Sodium (%)	0.05
Copper (ppm)	<1 ppm
Iron (ppm)	22 ppm
Magnesium (ppm)	<1 ppm
Zinc (ppm)	<1 ppm

An inadequate intake of calcium results in calcium deficiency and is a very serious problem worldwide that ultimately leading to osteoporosis. The deficiency of such an important nutrient is resulting in secondary health problems, recurrence of fractures and even death in some cases [7]. As per recent reports from International Osteoporosis Foundation, the chances of osteoporotic fractures will be very high and 1 in 5 men and 1 in 3 women belonging to the age group of 50 years will experience this problem in their lifetime worldwide [8]. The calcium present in eggshells can be utilized to treat these increasing number of osteoporosis cases.

The milk and milk products contain good amounts of calcium in its most bio-available form. However, people nowadays have restricted intake of milk and milk products owing to lactose intolerance or milk allergy, high fat content [8] and also due to popularity of vegan diet [9]. The availability of calcium from plant sources like cereals, pulses, nuts

and green leafy vegetables is also limited due to presence of inhibitors [9]. In such cases, dietary modification can be used to effectively treat calcium deficiency. A shift from conventional sources of calcium rich foods to alternate foods containing good quality calcium can solve this problem to an extent. The chicken eggshell powder is a good quality economical source of calcium that is suitable for all age groups and can therefore be used in supplementation of calcium.

The Recommended Dietary Allowance (RDA) for calcium varies with different categories and age group (Table 1.2). The calcium requirement is more among children of growing age for the development of stronger and denser skeleton. During pregnancy also the requirement is higher to fulfill foetal needs and to ensure sufficient amount in milk secretions during lactation.

Table 1.2: Recommended Dietary Allowances for Calcium for Indians [17]

Group	Category/Age	Calcium (mg/d)
Men	Sedentary, Moderate, Heavy work	600
Women	Sedentary, Moderate, Heavy work	600
	Pregnant, Lactating 0-6 m, 6-12 m	1200
	Postmenopausal	800
Infants	0-6 months, 6-12 months	500
Children	1-6 years, 7-9 years	600

Some studies have been carried out in the past to understand digestibility and absorption of

calcium and have showed positive results. The absorption of calcium from eggshell powder with calcium from calcium carbonate in rats. The results of the study showed that calcium absorption from both the diet was not much different [10]. Some studies in the past have utilized eggshell as a source of calcium and developed bakery products using eggshell powder (ESP) as calcium supplement. Utilized chicken ESP as calcium supplement to prepare chocolate cakes. The cakes were prepared with different concentration of ESP (3, 6 & 9%) and were examined for physical, chemical and sensory properties. The supplementation of cakes at 6% ESP showed best results with higher amounts of calcium in them [8].

Breads were prepared with natural calcium sources such as milk powder (10%), ESP (2%), and oyster shell powder (2%). The bread prepared with egg and oyster shell showed lower general acceptability but higher water absorption, dough development, dough stability than the control bread sample [11]. The effect of ESP supplementation on chemical composition, physical and sensory properties and bioavailability of biscuits. The results showed changes in texture and sensory properties and an increase in calcium content and bioavailability on supplementation of biscuits with ESP [12].

The steps in the preparation of powder from chicken eggshell include cleaning, cooking, oven drying and pulverization. The eggshells are cooked after cleaning for 10 minutes to remove disease causing microorganisms and then oven dried at 200°C for 10 minutes. To make fine powder, the eggshells can then be grinded [13].

Objectives

- To conduct the physical, biochemical and microbiological analysis of the chicken eggshell powder.
- To compare chicken eggshell powder supplemented biscuits with the control biscuits
- To analyze the physical, biochemical and sensory of the prepared biscuits

3. METHODOLOGY

This section deals with the materials and methods as well as the instruments and analytical techniques that were employed in the present investigation for the physiochemical, textural and microbiological evaluation of samples of fresh eggshells and biscuits prepared from it.

3.1 Procurement of raw material

Eggs were procured from local market of Paharganj. Eggs were taken out and analyzed visually for quality. Cracked and dirty eggs were rejected and best suited were retained for the research. Ingredients required for

product formulation (wheat flour, butter, sugar, cream and milk) were provided by Institute of Home Economics college, situated in HauzKhas.

3.2. Pre-processing of eggshells

Procured eggs were cleaned and dried and subjected to candling and sink test to judge the quality. After this, eggs were broken down carefully to get the eggshells. Collected eggshells were washed with water (both from inside and outside) to get rid of dirt and other organic material. Washed eggshells were autoclaved for 121°C for 15 minutes. Eggshells were then dried in hot air oven and grinded to a particular size. After grinding, eggshell powder was passed through the series of micro sieves to get the small size particles.

3.3. Microbial analysis of eggshells

The major food outbreak in case of eggs is caused by *Salmonella* species. Although in the pre-processing of eggshells, appropriate heat treatment was provided which is sufficient to inactivate *Salmonella*. But to make sure that *Salmonella* has been inactivated microbial analysis of eggshell powder was done.

3.4 Proximate analysis of Chicken eggshell powder (CESP)

In the present study, the major raw material was wheat flour (utilized for product

formulation) and CESP. Proximate analysis of both the raw materials was done by using the standards of AOAC [14].

3.5 Incorporation of CESP in biscuits

Different levels of CESP were incorporated in the biscuits by keeping Recommended Dietary Allowance (RDA) in consideration. CESP was incorporated biscuits at three levels: 1.70g (600 mg of Ca), 2.27g (800mg of Ca) and 3.41g (1200mg of Ca). Apart from these samples a control sample was also prepared.

3.6. Analysis of physical properties of biscuits

For physical analysis of biscuits, the method was used with slight modifications[15]. Biscuits was analyzed for the following parameters.

- Thickness of the biscuits was measured with vernier caliper. Six readings was taken for each types of biscuit (control, and other two varieties of biscuits) and average of all these six reading was recorded for each set of sample. Thickness was expressed in millimeter.
- Diameter of the biscuits was again measured with Vernier caliper, and average of six reading was recorded for each set of sample. Diameter was expressed in millimeter.

- Weight of the biscuits was measured by using the digital weighing balance, and the average values for weight were recorded in grams.
- Spread ratio was calculated by dividing diameter by thickness.

3.7 Sensory analysis of biscuits

Biscuits was be subjected to the sensory analysis. Panelists were selected from the IHE college. The parameters for evaluation were taste, flavor, aroma, texture and overall acceptability. Sample was coded to reduce the biasness. The 9-point hedonic scale was used for evaluation.

4. RESULTS & DISCUSSION

The study was conducted in different phases namely, pre-processing of eggshells, microbial analysis of processed eggshells, proximate analysis of eggshell powder, incorporation of eggshell powder in biscuits, analysis of developed product and statistical analysis of the data. The results of the study are presented in following sections.

4.1 Pre-Processing of Eggshells

Eggs were cleaned and dried and then broken up carefully to get the eggshells. Eggshell powder was prepared by boiling cleaned eggshells with water for 30 minutes followed by oven during at 80°C for 2 hours and finally grinding into fine particles [8]. But to avoid any microbial growth on the eggshell, the

eggshells were cleaned and autoclaved (121°C for 15 seconds) followed by hot air drying. After the heat treatment, eggshell powder was prepared in a normal blending machine followed by passing through a series of micro sieves to make the particle size smaller.

4.2 Microbial Evaluation of Eggshell Powder

Both the eggshell powders (untreated and autoclaved) were then analyzed for microbiological quality. The results present in **Table 4.1** shows that, the eggshell powder without using any treatment showed microbial growth. The sample showed a total bacterial count as 90×10^3 (cfu/g) and no growth for yeast and mold. Whereas, an autoclaved sample of eggshell powder showed no growth of bacteria, yeast and molds. The results demonstrate that the autoclaving process removes the microbial contamination and the autoclaved raw material is safe for addition to biscuits.

Table 4.1 Microbial count of eggshell powder

TREATMENTS	TOTAL BACTERIAL COUNT (cfu/g)	YEAST & MOLD (cfu/g)
Untreated eggshells	90×10^3	Negative
Treated eggshells	Negative	Negative

4.3 Chemical Composition of Raw Material

Table 4.2 shows the chemical composition of two major raw materials used in the

formulation of calcium fortified biscuits. On comparing chicken eggshell powder with wheat flour, chicken eggshell powder showed the higher value of ash ($96.67 \pm 0.68\%$), whereas it was lower in Protein and fat ($3.17 \pm 0.07\%$ and $0.06 \pm 0.00\%$, respectively) than wheat flour ($10.55 \pm 0.33\%$ and $0.94 \pm 0.01\%$, respectively). Chicken eggshell powder contained lower moisture content (0.95 ± 0.00) than wheat flour ($12.67 \pm 1.20\%$). From table 4.2, it could be seen that, the eggshell powder showed higher value of Calcium (35.09 ± 2.63 g/100gm), whereas wheat flour showed lower value (0.018 ± 0.87 g/100gm) of the calcium.

Table 4.2 Chemical composition of Wheat flour and Eggshell powder

PARAMETER	WHEAT FLOUR	CHICKEN EGG SHELL POWDER
Ash (%)	0.94 ± 0.10	96.67 ± 0.68
Fat (%)	0.94 ± 0.01	0.06 ± 0.00
Calcium (g/100gm)	0.018 ± 0.87	35.09 ± 2.63
Protein (%)	10.55 ± 0.33	3.17 ± 0.07
Moisture (%)	12.67 ± 1.20	0.95 ± 0.00

*Results are mean \pm SD of three replicates

4.4 Product Formulation and Standardization

In this study, three RDAs were taken in consideration, which can provide 100% daily requirement of calcium for all age groups. The decided RDAs were 600, 800, 1200mg/day. According to the calcium present in the eggshells, quantities of

eggshell powder were calculated which could provide these three RDAs. The eggshell powder at 1.70, 2.27, and 3.41gm could provide 600, 800, and 1200mg of calcium per day respectively. Biscuits which contained 1.70g (600mg of calcium), 2.27g (800mg) and 3.41g (1200mg) of eggshell powder were coded as ESP1, ESP2 and ESP3 respectively. Apart from these three calcium fortified biscuits, a control (without added CESP) sample of biscuits was also prepared for comparison. The three levels of eggshell powder (1.70, 2.27, and 3.41gm) were incorporated by substituting it with wheat flour in biscuits.

The following basic recipe was utilized for the preparation of biscuits fortified with chicken eggshell powder:

Table 4.3 Basic recipe of biscuits

RAW MATERIAL	CONTROL	ESP1	ESP 2	ESP 3
Wheat flour	50 gm	48.3gm	47.7 gm	46.59 gm
Butter	25 gm	25 gm	25 gm	25 gm
Sugar	25 gm	25 gm	25 gm	25 gm
Baking powder	1/4t	1/4t	1/4t	1/4t
Chicken eggshell powder	0	1.70 gm	2.3 gm	3.41 gm

4.5 Chemical Composition of the Prepared Biscuits

The major ingredients used for biscuits were flour, sugar, fat, and milk, eggshell powder

was added to increase the calcium content of the biscuits. Flour, sugar and fat were mainly responsible for the nutritional and caloric values of the biscuits, whereas, milk improved the protein and mineral content of the biscuits.

The variations of nutrients of unfortified and fortified biscuits are illustrated in **Table 4.4**. There was a significant difference ($p < 0.05$) in the moisture, ash, fat protein and calcium content of the biscuits. The average protein content of the biscuits ranged from $9.28 \pm 0.01\%$ (ESP1) to $9.38 \pm 0.10\%$ (ESP3).

The variations in moisture content of fortified biscuits were ranged from 5.42 ± 0.01 to $6.65 \pm 0.03\%$. An increment of eggshell powder levels resulted in increment in moisture content. This increase in moisture can be attributed to the calcium crystals. In eggshells, calcium is majorly present as calcium carbonate crystals which are very less soluble in water. To incorporate these crystals in the dough more water is required. Ash content of the biscuit varied from 4.29 ± 0.03 to $9.70 \pm 0.01\%$. Due to the presence of high level of inorganic compounds (high mineral content) in eggshell powder, ash content of the biscuits increased with the increased proportions of eggshell powder. The variations in the fat content of biscuits were minor.

The ESP 1, ESP 2 & ESP 3 showed 596±1.41, 797.01±1.63 and 1198.2±4.16 mg/100gm of calcium respectively. This increase in calcium levels in biscuits was due

to the ample amount of calcium in the raw material (eggshell powder). The most pronounced effect on biscuits was shown in calcium.

Table 4.4 Chemical composition of produced biscuits

COMPONENTS	BISCUIT SAMPLE			
	Control	ESP1	ESP2	ESP3
Crude protein (%)	9.32±0.12 ^a	9.28±0.01 ^a	9.30±0.1 ^a	9.38±0.01 ^b
Ash (%)	1.26±0.02 ^c	4.29±0.03 ^d	7.34±0.01 ^e	9.70±0.01 ^f
Fat (%)	17.65±0.01 ^g	17.62±0.03 ^g	17.60±0.02 ^h	17.57±0.02 ^h
Calcium (mg/100gm)	16.01±0.01 ^{aa}	596.00±1.41 ^{bb}	797.01±1.63 ^{cc}	1198.2±4.16 ^{dd}
Moisture (%)	5.28±0.05 ^a	5.42±0.01 ^b	6.02±0.05 ^c	6.65±0.03 ^d

*Results are mean ± SD of three determinations

*Mean values with different superscripts with in a row are significantly different (p<0.05)

The data in **Figure 4.1** indicate the calcium content of control biscuits and biscuits supplemented with eggshell powder (ESP1, ESP2, ESP3). From the figure, it could be demonstrated that biscuits fortified with ESP partially met the RDA limits for all age groups.

4.6 Physical Properties of Prepared Biscuits

There was a significant difference (p<0.05) in the weight, moisture loss, thickness, diameter, spread ratio and water added to make the dough of biscuits. The result showed that the water requirement for dough formation increased from 15.0±0.02 to 16.4±0.02 ml per 100 g as the inclusion level of eggshell powder in the formulation increased from 1.70-3.41 gm. The increase in the water requirement was probably due to the calcium crystals.

The weight, thickness, and diameter of control and eggshell incorporated biscuits were not different. Diameter, thickness and spread ratio in control biscuits were 69.9±0.08mm, 5.93±2.58mm, and 11.80±0.08 respectively. Diameter and thickness increased but spread ratio decreased with increasing the level of eggshell powder.

Moisture loss of both the type of biscuits i.e control and supplemented with ESP, were also recorded. Control sample showed the minimum moisture loss of 18.1±1.00%, whereas in the case of supplemented biscuits moisture loss increased with the increased level of ESP.

The highest spread ratio was observed for control biscuits (11.80±0.08) and lowest spread ratio for ESP3 (11.65±0.05).

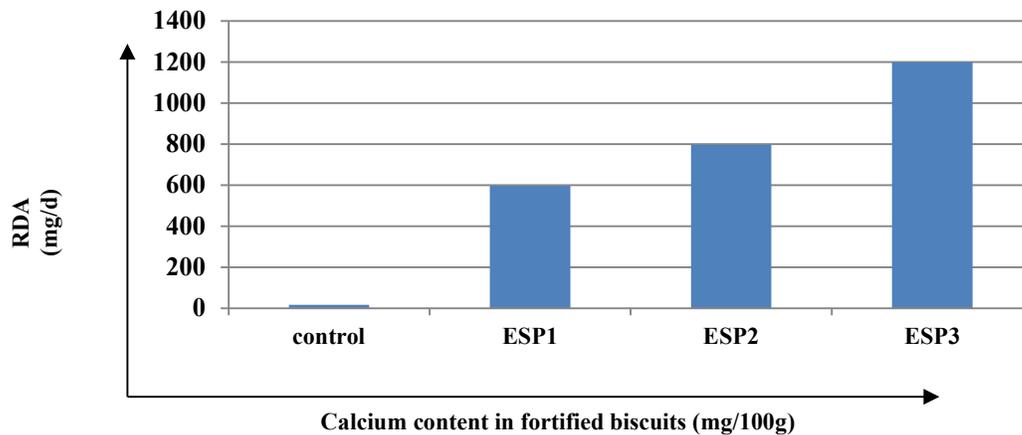


Figure 4.1: Relationship between calcium content in fortified biscuits and Recommended Dietary Allowances (RDA)

4.7 Sensory Evaluation of Prepared Biscuits

The sensory evaluation was done for the biscuits prepared from wheat flour and CESP (ESP1, ESP2 and ESP3) along with the control sample. 9-point hedonic scale was used to record the sensory attributes of the biscuits namely, texture, color & appearance, aroma, taste and overall acceptability. The sensory score obtained for the biscuits is given in **Table 4.6**.

The different variations of biscuits were coded as ESP0 (Control), ESP1 (contained 1.70g of CESP), ESP2 (contained 2.27g of CESP) and ESP3 (contained 3.41g of CESP). The sample were coded to reduce the biasness and the false assumptions about the products during sensory evaluation.

Evaluation of different variations of biscuits was done by a panel of 30 members consisting of faculty members and students of Food and Nutrition Department of the Institute of Home Economics. The mean and standard deviation of sensory scores for color & appearance, texture, aroma, taste and overall acceptability of biscuits are presented in **Table 4.6**.

There was a significant difference ($p < 0.05$) in the texture, color, aroma, taste and overall acceptability of the biscuits (Table 4.6). The mean score \pm standard deviation for texture, color & appearance, aroma, taste and overall acceptability of control biscuits were 7.6 ± 0.75 , 7.4 ± 0.94 , 7.3 ± 0.86 , 7.7 ± 0.83 , and 7.7 ± 0.70 respectively.



Figure 4.2: Sensory evaluation of prepared biscuits

Color is an important attribute because it can arouse individual's appetite. The color, aroma, texture and taste of ESP0 (control sample) was not significantly ($p < 0.05$) different from ESP1 and ESP2. This means that these two samples are as good as ESP0 (control) with respect to their texture, color, aroma and taste.

ESP3 was statistically different ($p < 0.05$) from the ESP0, ESP1 and ESP2 in terms of color, taste, aroma and texture. Although the ESP3 was statistically different from the other samples but its overall acceptability was same as the other. This means there was no statistical difference in the overall acceptability of the biscuits. It can be concluded that CESP did not affect the

overall acceptability of the prepared biscuit samples and the samples were equally acceptable by the panelists.

The inclusion of eggshell powder in the samples did not affect the mean sensory scores of all the sensory characteristics until ESP2. After words there was a rapid reduction in the mean sensory scores of all the attributes.

ESP3 did not scored much in terms of texture and proved to be unacceptable due to the grittiness. Although ESP3 had the highest level of calcium content in it, but it was not much acceptable by the panelist.

Table 4.6: Sensory Evaluation of biscuit supplemented with eggshell powder

Biscuit type	Texture (9)	Color (9)	Aroma (9)	Taste (9)	Overall Acceptability (9)
ESP0	7.6±0.75 ^a	7.4±0.94 ^c	7.3±0.86 ^c	7.7±0.83 ^g	7.7±0.70 ⁱ
ESP1	7.8±0.89 ^a	7.8±0.89 ^c	7.6±1.09 ^c	7.8±1.06 ^g	7.8±0.93 ⁱ
ESP2	7.5±1.07 ^a	7.3±1.03 ^c	7.7±1.06 ^c	7.5±1.04 ^g	7.5±1.04 ⁱ
ESP3	6.7±0.92 ^b	7.5±1.08 ^d	7.5±1.03 ^f	7.2±0.89 ^h	6.5±0.94 ⁱ

*Results are mean ± SD of three determinations

*Mean values with different superscripts within a column are significantly different ($p < 0.05$)

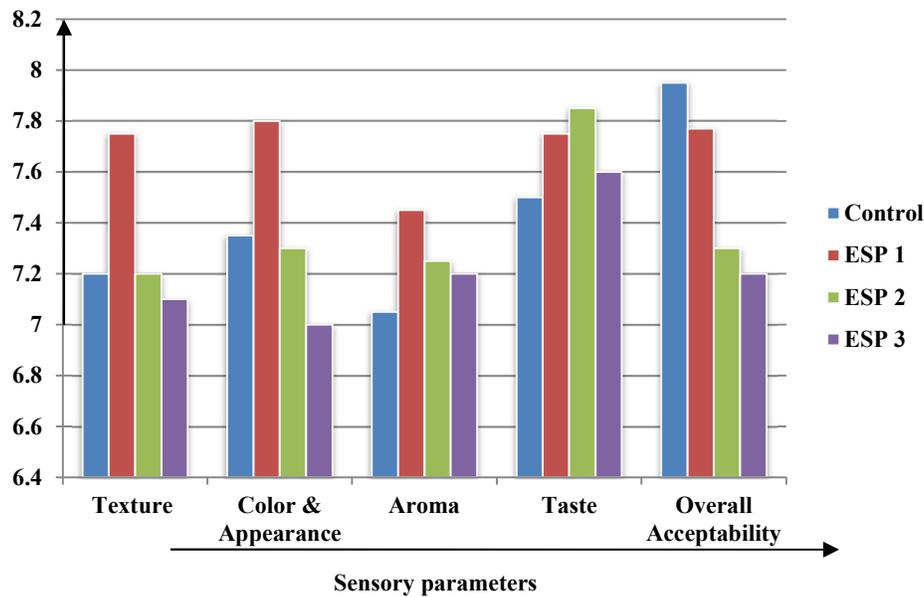


Figure 4.3: Graphical representation for sensory scores of the biscuits (n=30)

5. CONCLUSION

Broiler chicken eggshell has rich amount of elemental calcium nearly 35%. It can be concluded that CESP is an attractive source of calcium for human nutrition or can be utilized as a dietary calcium source. Eggshell powder incorporation with wheat flour in different levels viz. 1.70g, 2.27g and 3.41g was considered in the study. In conclusion, the fortification of biscuits with natural source of Ca i.e.CESP, was found to improve the nutritive quality of biscuits compared to the control biscuits. The proximate composition showed that CESP has a significant influence on the biscuits most especially the calcium content. The ESP1, ESP2 and ESP3 showed that Ca content as 596 ± 1.14 , 797.01 ± 1.63 and 1198.2 ± 4.16

mg/100g respectively. These values of calcium was much more higher than the control biscuits. ESP1 biscuits can be recommended to men, women and children (1 to 9 years) because the RDA of calcium for these age groups is 600mg/d. Whereas, ESP2 is suitable for postmenopausal women, boys and girls (10 to 17 years).

Apart from the calcium, other nutrients namely, protein and mineral content was also increased.

The physical parameters showed that ESP1 had the highest spread ratio and ESP3 had the highest calcium content. Though the calcium content was high in ESP3, ESP1 and ESP2 shows better overall acceptability. It is therefore recommended that incorporation of

CESP at 1.70g and 2.27g should be embarked upon by biscuit industries.

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