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Impact of Mollusca by-Products as a Natural Source of Calcium on the Quality of Rusk

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ABSTRACT

The body may not have enough calcium (Ca) if dairy products are avoided because of lactose sensitivity. Large quantities of this raw material are accessible as a by-product from the high Ca content of Mollusca bones and shells. This study was divided into two steps. Firstly, analysis of the chemical composition and minerals content of different Mollusca by-products (cuttlebone, oyster shell and donax shell). Secondly, cuttlebone powder was used as a source of calcium to improve the rusk. In addition, the influence of cuttlebone powders substitution (5, 7.5 and 10%) on the rheological properties of dough, minerals content and sensory properties of bakery products (rusk) was studied. The obtained results showed that the content of ash was 94.47, 98.34 and 97.93% for cuttlebone, oyster shell and donax shell, respectively. Cuttlebone powder had the highest calcium content (11405.17 mg/100g) followed by oyster and donax shells. The replacement of the rusk wheat with the cuttlebone powder led to a noticeable increase in Ca, Mg, and Na contents and improved the rheological properties of dough in the supplemented rusk. Moreover, sensory evaluation of rusk that has cuttlebone elicited comparable scores for those with the three substituted ratios. Hence, Cuttlebone powder can be suggested for use as a natural source of calcium in the creation of bakery products with high calcium content that are well-liked by consumers. Additionally, the practical reutilization of shell waste frequently involves issues like poor economic rewards and limited consumption.

Keywords: Calcium, cuttlebone, rusk, rheological characteristics.

INTRODUCTION

The aquaculture of shellfish has grown quickly, and more than 10 million tons of shell waste by-products are produced annually. Utilizing shell waste is a serious issue for the advancement of the circular economy and environmental conservation. Shell waste has typically been abandoned or transported to a landfill without further processing or reutilization due to its low economic worth, wasting resources and seriously harming the coastal habitat. The recycling of shell waste is useful for use in biomaterials, agriculture, building, environmental protection, chemical manufacture, and additions for food (Zhan, *et al.*, 2022).

The annual aquaculture production for the Arab Republic of Egypt increased from 919585 tons during the year of 2010 to 1561457 tons in the year 2018 (FAO Fish Stat). The amount of cuttlefish production was 348 thousand-ton (live weight) in the year of 2020 (FAO 2020) and generate a large number of shells, which pose a problem for the environment because they are a rich source of minerals, particularly calcium. If this garbage has been mistreated for a long time, the degradation of meat fragments still clinging to the shells or the microbial breakdown of salts into gases such NH3, H2S, and amines may be the cause of the foul stench. Scientific research on the composition and use of numerous marine by-products' constituent parts is generally lacking.

Morris *et al.*, (2021) showed that the uses of seashells were restricted to a number of well-established and long-lasting ones (such as soil conditioners, inexpensive adsorbents, calcium supplements, construction materials, etc.) as mentioned in Fig. (1)

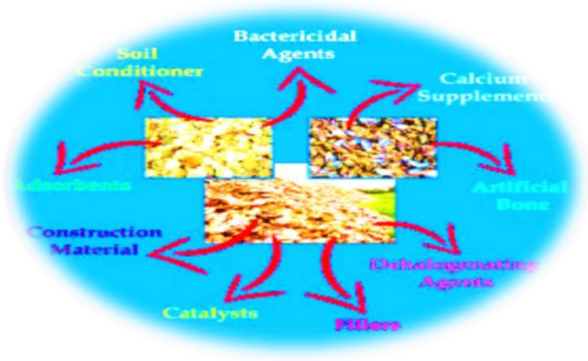

Fig. 1. Possible applications of shell waste as by-products.

The construction and maintenance of healthy bones are just two of the many vital physiological processes that calcium (Ca) is required for. A tiny quantity of calcium is also found in the muscle and intercellular fluid in addition to the body's storage of calcium in the bones and teeth. The most popular calcium supplements are calcium carbonate (which contains 40% calcium), calcium citrate (21% calcium), calcium gluconate (9% calcium), and calcium lactate (13% calcium), however the best way to get calcium is still through diet. (Alsuhaibani, 2018;Miller *et al.*, 2001; Kim and Jung, 2007). Milk and other dairy products, such as cheese, are the most popular and reliable sources of calcium. Alternative sources of calcium are required because dairy products consumption may be restricted in some communities due to lactose intolerance (Kettawan *et al.*, 2002). For these people, calcium-replaced products can serve as a good calcium supplement (Shahidi *et al.*, 2019).

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Minerals, enzymes, important protein and lipid fractions, and many other elements are present in marine by-products. The fish's bones, which made about 25–30% of its overall weight, might be turned into goods with extra value (Malde *et al*., 2010b and Tongchan *et al*., 2009). The waste from fish and shellfish could be used to make new food ingredients, medicines, and other high-value goods, among many other things. For instance, fishbone can be used as a source of calcium, an important mineral for human health, when it is transformed into an edible form through heat treatment in water or an acetic acid solution and then added to foods that are *replaced* with calcium (Shahidi and Zhong, 2007; Shahidi *et al*., 2019; Kim and Mendis, 2006). In addition, salmon bones can be used as a natural source of calcium and phosphorus in food, feed, or supplements (Malde *et al.*, 2010a). In this study, it was found that calcium from the bones of salmon, saithe, and cod was either as well absorbed as calcium carbonate or was absorbed even better. It is technically viable to substitute commercial CaCO3 with calcium carbonate derived from mussel and oyster shells (Hamester *et al*., 2012).

Calcium and fat may react to generate calcium soaps, which increase the amount of calcium and fat expelled in stools while reducing the amount of calcium that is absorbed. At neutral pH, fishbone peptides have been proven to prevent the development of insoluble calcium salts and reduce the loss of calcium in feces in rats with ovariectomies (Jung *et al*., 2006). In order to replace dairy products and provide an unique nutraceutical with excellent bioavailability for Ca and Ca-substituted food supplements, such as fruit juice or Ca-rich foods (Nemati *et al*., 2016).

Cuttlefish bone (CB) is a naturally occurring biomaterial that comes from the cuttlefish's chamber and can be powdered. All cephalopods have the brittle structure known as CB, which is a chambered, gas-filled shell used to regulate drifting. (Rexfort and Mutterlose, 2006). Cuttlebone (CB), otherwise called cuttlefish spine, is an inner shell of marine creatures known as cuttlefish (Sepia), having a place with the phylum Mollusca, class cephalopod, arrange Sepiidae (North *et al*., 2017 and Zhao *et al*., 2011). Cuttlefish bone is for the most part made of calcium carbonate. There has been a correlation between rising cuttlefish output and rising by-product waste, particularly cuttlebone. It is well known that cuttlebone contains calcium carbonate (CaCO3), an inorganic element that is useful as a calcium source (Henggu *et al*., 2019; Moon-Lae *et al*., 2001).

The major objectives of this research were to improve rusks with cuttlebone powder as a calcium source at home and compare the chemical composition and mineral content of some molluscan by-products (cuttlebone, oyster, and donax shells). Results may help future research examining the quantity of calcium availability, as an essential mineral, through an in vitro investigation.

MATERIALS AND METHODS

Materials:

Freshly cuttlefish (squid), oyster, and donax used for this research were obtained from the local market, in Alexandria City, Egypt. Butter, milk, salt, baking powder, sugar, and wheat flour (72% extraction) were purchased from the local market in Kafrelsheikh City, Egypt. El- Gomhoria Company for chemicals and drugs in Tanta, Egypt provided all of the chemicals used in the study.

Methods:

Preparation of Mollusca by-products powders:

Cuttlebone, oyster and donax shell powders were prepared according to (Hassan, 2015; Ali and Badawy, 2017) with a slight modification. Cuttlebone, oyster, and donax shells were manually separated from the flesh, afterwards; cleaned twice in warm water (37°C), boiled for one hour to kill any hazardous bacteria, and dried for two hours in an air oven at 100 C. The dried samples were ground using a BRAUN grinder (Moulinex Odacio 3) until they were reduced to a fine powder to pass through fifty mesh sieve. Following that, the fine powdered samples were collected and packed in polyethylene bags until needed (Fig. 2).

Fig. 2. Preparation of Mollusca by-products powder

Proximate chemical composition of Mollusca by-products powder:

A.O.A.C. (2012) procedures were used to determine moisture, ether extract (fat), ash, and crude fibre contents of cuttlebone, oyster, and donax shell powders.

Determination of minerals content of Mollusca by-products powder and rusks:

Minerals content of cuttlebone, oyster and donax shell powders and prepared rusk were evaluated according to Chapman and Pratt, (1978). Using an atomic absorption spectrophotometer, magnesium (Mg), iron (Fe), and zinc (Zn) were measured after wet ashing (Zeiss FMD3). Using a flame photometer, calcium (Ca) and sodium (Na) concentrations were measured. At a wavelength of 650 nm, phosphorus (P) was measured photometrically by spectrophotometer according to the methods described in the A.O.A.C. (2012).

Farinograph properties of dough prepared from the wheat-cuttlebone blends:

Cuttlebone powder and wheat flour (72% extraction) were thoroughly combined to create distinct combinations with replacement levels of 5, 7.5, and 10%. The dough prepared from wheat-cuttlebone blends underwent a farinograph test to measure water absorption (%), arrival time (min), dough development time (min), dough stability (min), and degree of softening (dough weakening, BU) as described in the (A.O.A.C., 2012) using farinograph apparatus (Brabender Duisburg, Germany).

Preparation of the rusk substituted with different levels of cuttlebone powder:

The dough was prepared using the method described by Strenhagen and Hosney (1994). Blends containing 5, 7.5, and 10% of cuttlebone powder were used as replacement of wheat flour (72% extraction). Then, for 20 minutes, all of the dried components were manually well-mixed. All components were combined well for 12 minutes with an electric mixer after the addition of butter and water. The dough prepared with cuttlebone and wheat flour combinations have been baked for 30 minutes at 275°C. Then let cool at room temperature before being examined. The same ingredients were used to produce the control but without the cuttlebone powders.

Determination of water absorption of rusks samples substituted with different levels of cuttlebone powder:

The water absorption of prepared rusks was calculated from the following formula according to Ünal and Altunok, (2019):

$$\text{Water absorption} = \frac{A - B}{B} \times 100$$

Where: A= weight of saturated test piece with water (g) and B = weight of dried test piece (g).

Sensory evaluation of rusks samples substituted with different levels of cuttlebone powder:

Rusks containing different cuttlebone levels and control were sensory tested for their crust and crumb color, appearance, odor, texture, taste, and overall acceptability by 15 trained members as described by Meilgaard *et al*., (2006).

Statistical analysis:

Using Sigma Stat, one-way analysis of variance (ANOVA) was used to analyse all findings for variance (v.3.5. Systat Software Inc.). P values 0.05 were used to determine whether differences were statistically significant (Steel and Torrie, 1986).

RESULTS AND DISCUSSION

Proximate chemical composition of Mollusca by-products powder:

Chemical analyses were performed on the calcium-rich cuttlebone, oyster, and donax shell powders to determine moisture, ether extract, ash, and crude fiber. The data in Table (1) revealed that, cuttlebone powder contained the highest value of moisture compared to oyster and donax shells where the values were 14.8, 0.74 and 0.89 %, respectively. While, oyster shells recorded the highest ash content (98.34%) followed by donax shell and cuttlebone powder were 97.93 and 94.47 % on a dry weight basis, respectively. From the same Table, it could be noticed that the ether extract content of cuttlebone powder (2.41%) was higher than oyster shell (0.94%) and donex shell (0.90 %). The moisture, ash and lipid contents of cuttlebone from Indonesia were 3.54, 89.61, and 0.32 %, respectively (Henggu *et al*., 2019). The differences may be related to the differences in bone types, places and nutrition. Finally, the donax shell powder showed the highest crude fiber content followed by oyster shell and then cuttlebone powders. Cho *et al*., (2001) found that the ash content of cuttlebone was about 7.5% on the whole cuttlefish and about 90% on a dry basis.

Table 1. Proximate chemical composition (%on a dry weight basis) of Mollusca by-products.

Components	Mollusca by-products powders (%)		
	Cuttlebone	Oyster shell	Donax shell
Moisture	14.8±1.20[a]	0.74±0.18[b]	0.89±0.13[b]
Ash	94.47±1.67[b]	98.34±1.96[a]	97.93±2.03[a]
Ether extract	2.41±0.98[a]	0.94±0.09[b]	0.90±0.12[b]
Crude fiber	0.74±0.28[b]	1.41±0.20[a]	1.66±0.38[a]

- **Values followed by different letters in rows are significantly different at $p \leq 0.05$.**
- **Each value is an average of three determinations.**

Minerals content of Mollusca by-products powder:

Minerals content of the cuttlebone, oyster, and donax shell powders are shown in Table (2). The findings showed that all Mollusca by-products included a sizable amount of minerals to satisfy the needs of human beings for minerals. The main inorganic elements found in the powders under study were Ca, Na, Mg, Zn, Fe, and P. It is clear from the results in Table (2) that calcium was the highest content among the other elements. These results are in agreement with Galal, (2019). Ca content was ordered from the highest to lowest as follows: 11405.17, 2775.86, and 2112.06 mg/100g for cuttlebone, oyster, and donax shells, respectively. These outcomes were in accordance with Hemmatti *et al*., (2018) and Galal (2019) whom announced that cuttlebone is a natural compound with a high level of Cao and $CaCO_3$. Also, Galal (2019) found that the Ca content of two different cuttlebones (from Korea and India) were 22341.4 and 22233.6 mg / 100 g, respectively. In addition, Negm (2018) reported that the mineral content of cuttlebone powder was (26.16, 14.24, 7.50 and 2.42 mg/g dry matter) for Ca, K, Mg, and P, respectively.

Table 2. Minerals content (mg /100 g) of Mollusca by-products powder

Minerals	Mollusca by-products powders (mg/100g)		
	Cuttlebone	Oyster shell	Donax shell
Ca	11405.17	2775.86	2112.06
Na	363.25	534.08	351.93
Mg	83.43	150.45	54.50
Zn	0.38	14.38	0.75
Fe	6.00	15.50	4.50
P	21.04	72.59	5.26

Meanwhile, the results in the same Table showed that oyster shells exhibited the highest sodium (Na) content of 534.08 mg/100g powder followed by cuttlebone and donax powders. Additionally, there are some variations in the concentration of different trace element between the three different Mollusca by-products (Table 2). Olgun *et al*., (2015) reported that the mineral content of the oyster shell was 320.9 calcium, 1.09 phosphorus, and 9.08 g/kg magnesium. Negm, (2018) indicated that cuttlebone contains a high Ca content, and low content of other elements such as K, Mg, and P with values of 26.16, 14.24, 7.50 and 2.42 mg/g , respectively.

Rheological properties of rusks dough substituted by different levels of cuttlebone powder:

Only cuttlebone powder (CB) was used in this study because it showed the highest calcium content of all the powders assessed. Wheat flour dough's rheological characteristics are crucial for the effective production of bakery goods because they govern how the dough behaves during mechanical manipulation, which has an impact on the final products' quality (Sarker *et al*., 2008).

The effects of substituting 5, 7.5, and 10% wheat flour with the same amount of cuttlebone powder on farinograph parameters were demonstrated by the data presented in Table (3). It was apparent that the amount of cuttlebone improved the rate of water absorption. Where, the water absorption of doughs replaced with 5, 7.5 and 10 % cuttlebone was 62, 63.5 and 65.5%, respectively. Compared to the control rusk (57.7%). Also, the arrival time increased as the amount of cuttlebone increased. However, it increased greatly beyond 10 % cuttlebone substitution. This could be due to the slow hydration of cuttlebone which could be due to the longer time to develop the best gluten network in the dough. In addition, the dough development time increased as the percentage of cuttlebone increased. Where, dough development showed a value of 1.5 min for control and this value increased for replaced doughs with 7.5 and 10% cuttlebone powder to 2 min. on the other hand, dough stability, which indicates the dough strength, increased with increasing the amount of cuttlebone from 5 to 10%, these blends could be mixed for the optimum time without damaging the gluten structure. However, the stability time decreased at 7.5 and 10% levels of cuttlebone - substitution. Similar results were found by Abdel-Kader, (2000) and Nassar *et al*., (2008). Moreover, Alsuhaibani, (2018) compared the rheological properties of wheat flour dough replaced with egg and oyster shells and he found increasing in development time, mixing time dough stability, and water absorption (%).The explanation for the longer dough development time and lower dough stability may be because the gluten content decreased since the cuttlebone does not contain gluten (Yaseen, 2000).

Table 3. Farinograph characteristics of doughs substituted with different levels of cuttlebone powder.

Farinograph parameters	Samples			
	Control	5% CB*	7.5 % CB	10% CB
Water absorption [%]	57.7	62.0	63.5	65.5
Arrival time [min]	0.5	1	1	1.5
Dough development time [min]	1.5	1	2	2
Dough stability time [min]	6	12 >	12 >	12 >

CB*: Cuttlebone powder

Effect of substitution by cuttlebone powder on minerals content (mg/100g) of rusk:

Minerals content (mg/100 g) of control and substituted rusk with 5, 7.5 and 10% cuttlebone (CB) powder are given in Table (4). Results showed that substitution of rusk with CB increased its content of Ca, Mg and Na. The highest values were obtained in the rusk substituted with 10 % CB. Where, the Ca, Mg, and Na values were increased from 22.68, 55.00, and 185.90 (mg/100 g) in control samples to 2731.25, 95.63, and 689.82 mg/100 g in rusk substituted with 10 % CB, respectively. This may have caused the calcium to phosphorus ratio in the substituted rusk to rise, favouring the likelihood that human calcium consumption will rise (Makai and Chudacek, 1991).

The recommended dietary allowance (RDAs) of calcium for children (1–12 years) is 800 mg/day (Lichtenstein *et al*., 2006). Rusk substituted with cuttlebone had significantly higher levels of Ca, especially 10%, which will provide children with 3.4-fold of their daily requirements. Hassan (2015); Ali and Badawy (2017) and Alsuhaibani (2018) used eggshell powders for fortifying biscuits, bread strips, and bread and the results recorded an increase in calcium content and other elements. Moreover, the obtained results were consistent with the results of Nematti *et al*., (2016) and Alsuhaibani, (2018) who reported that the addition of tuna bone and oyster shell powders significantly influenced the content of calcium in bakery products.

Table 4. Minerals content (mg /100g) of rusks replaced with cuttlebone powder.

Minerals (m/100 g)	Samples			
	Control	5% CB*	7.50 % CB	10 % CB
Ca	22.68	1063.75	2022.50	2731.25
Mg	55.00	71.13	91.13	95.63
Na	185.90	378.40	515.01	689.82

CB*: Cuttlebone powder

Water absorption ratio of substituted rusk with different levels of cuttlebone powder:

One of the most significant functional characteristics of crisps is their ability to absorb water, and customers generally find higher water-absorbent to be quite acceptable. Low break stress of bread crumbs is caused by high water absorption of bread (Zghal *et al*., 2001). The results of the impact of replacing cuttlebone powders (5, 7.5, and 10%) on the water absorption ratio of produced rusk are displayed in Fig (3). By replacing more cuttlebone powder, as compared to the control, the water absorption ratio was raised. This could be as a result of the cuttlebone powder being a hydrophilic filler with a higher water absorption capacity (Shuhadah and Supri, 2009).

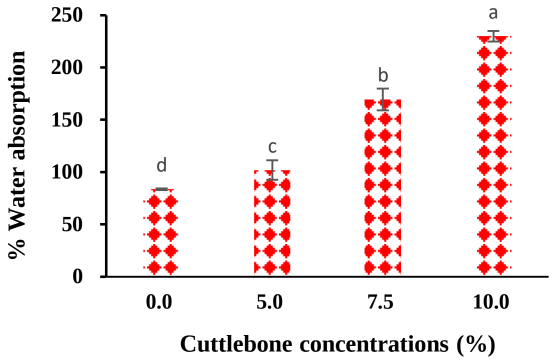

Figure 3. Water absorption ratio of rusk replaced with different levels of cuttlebone powder.

Significant differences were recorded between rusk replaced with different levels of cuttlebone powders, where rusks replaced with 5, 7.5 and 10% cuttlebone powder showed an increase in the absorption of water, 1.22, 2.03 and 2.75-fold, respectively compared to that of control. Fortification of bread strips with white and duck eggshell powders increased the water absorption (Ali and Badawy, 2017).

Sensory evaluation of rusks substituted with different levels of cuttlebone powder:

The produced rusk, controlled and replaced with different levels of cuttlebone powder, was estimated for sensory properties by fifteen trained judges (Fig. 4 and Table 5). The average scores for crust and crumb colors, taste, odor, texture, and overall acceptability of untreated rusk (control) were 8.9, 9.3, 8.8, 9.1, 9.2, and 9.2, respectively. The results in this Table (5) also revealed that no significant differences in the sensory properties were detected between the control sample and rusk which was substituted with 5, 7.5, and 10% cuttlebone powder.

Salem *et al*. (2012) investigated sensory characteristics of butter cake were affected by the addition of 10 and 20% eggshell powder as a source of calcium fortification. For color and overall acceptability, they observed no statistically significant differences between unfortified cake and cake fortified with 10% and 20% eggshell, but they did find significant differences in texture, odor, taste, and appearance. This successful outcome demonstrates that customers are amenable to cuttlebone. As a result, the main benefit of cuttlebone over commercial calcium is that it is produced at a low cost, comes from natural sources, and is thus environmentally benign.

Table 5. Sensory evaluation of substituted rusks with different ratios of cuttlebone powder

Properties	Samples			
	Control	5 % CB*	7.5 % CB	10 % CB
Crust color	8.9±0.7[a]	8.6±1.2[a]	8.8±1.0[a]	9.3±0.8[a]
Crumb color	9.3±0.7[a]	8.6±1.0[a]	9±1.1[a]	9.1±0.7[a]
Taste	8.8±0.8[a]	8.6±1.2[a]	8.8±1.3[a]	8.9±1.0[a]
Odor	9.1±1.0[a]	8.8±1.2[a]	8.7±1.2[a]	8.7±1.2[a]
Texture	9.2±0.8[a]	8.9±1.0[a]	9±1.1[a]	9.1±1.0[a]
Overall acceptability	9.2±0.6[a]	8.6±0.8[a]	9.4±0.7[a]	9.2±0.9[a]

CB*: Cuttlebone powder

- **Values followed by a different letter in a row are significantly different at $p \leq 0.05$.**
- **Each value is an average of twenty determinations.**

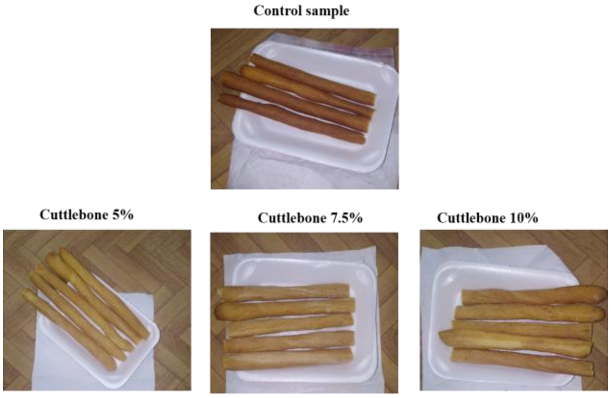

Fig. 4. Rusk samples substituted with different ratios of cuttlebone powder.

According to Brun *et al.* (2013), adding chicken eggshell powder to pizza, bread, or spaghetti resulted in the least amount of texture alteration and no flavour change when used as a calcium dietary supplement. Up to 10% levels of the same calcium source, the sensory test also revealed similarities in crispiness, flavour, and taste characteristics. However, while utilising a higher level, a greater fishy smell was noticed (Swiatkiewicz *et al*., 2015). Sensory evaluations of bakery items with tricalcium phosphate and tuna bone powder produced similar results for the two additions. Consequently, tuna bone powder could be utilised in the creation of bakery goods high in calcium that are well-liked by consumers (Nemati *et al*., 2016).

CONCLUSION

Mollusca bones and shells are industry added value by-products cause of their - high calcium content, high-quality food ingredients and easily supplements. In addition, cuttlebone powder can be employed as a reasonably priced source of dietary calcium in human nutrition. The restored rusk product's calcium content increased noticeably as a result of the addition of various cuttlebone powder concentrations. There was no discernible difference between the sensory qualities of rusk. Finally, it is advised that rusk product be replaced with cuttlebone powder at a 10% level in the human diet. The study's findings suggest that cuttlebone has the potential to replace other calcium sources in baked products due to its high calcium content. Additionally, the practical reutilization of shell waste frequently involves issues like poor economic rewards and limited consumption.

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تأثير مخلفات الرخويات كمصدر طبيعي للكالسيوم على جودة البقسماط

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الملخص

تجنب منتجات الألبان بسبب عدم تحمل اللاكتوز يمكن أن يؤدي إلى نقص الكالسيوم (Ca) في الجسم. تحتوي عظام وأصداف الرخويات على نسبة عالية من الكالسيوم ، وتتوفر كميات ضخمة من هذه المادة الخام كمنتج ثانوي . اجريت هذه الدراسة على مرحلتين. أولاً : تقدير التركيب الكيميائي والمحتوى المعدني لمختلف منتجات الرخويات الثانوية (عظام الحبار ، قشرة المحار ، قشرة دوناكس). ثانياً : تم استخدام مسحوق عظام الحبار كمصدر للكالسيوم لتحسين أحد منتجات المخابز (البقسماط). بالإضافة إلى ذلك ، تمت دراسة تأثير استبدال مسحوق عظام الحبار (5 ، 7.5 و 10٪) على الصفات الريولوجية للعجين ، ومحتوى المعادن ، و تمت دراسة الخصائص الحسية لمنتجات المخابز (البقسماط). أظهرت النتائج المتحصل عليها أن محتوى الرماد كان 94.47 و 98.34 و 97.93٪ لعظام الحبار وقشر المحار وقشر دوناكس على التوالي. احتوى مسحوق عظام الحبار على أعلى محتوى من الكالسيوم (11405.17 ملجم / 100 جم) يليه قشر المحار ودوناكس. ادى استبدال القمح بمسحوق عظام الحبار فى البقسماط إلى زيادة ملحوظة في محتويات الكالسيوم والمغنيسيوم والصوديوم وتحسين الصفات الريولوجية للعجين في البقسماط المدعم. علاوة على ذلك ، فإن التقييم الحسي لعينات البقسماط المعدة باستبدال مسحوق عظام الحبار أعطت درجات مماثلة لنسب الاستبدال الثلاثة . ومن ثم ، يمكن التوصية باستخدام مسحوق عظام الحبار كمصدر طبيعي للكالسيوم في إنتاج منتجات المخابز عالية الكالسيوم والتي تحظى بقبول المستهلك. أيضًا ، تتضمن إعادة الاستخدام العملي لمخلفات القشرة عمومًا مشاكل مثل الاستهلاك المحدود والفوائد الاقتصادية المنخفضة.

الكلمات المفتاحية : الكالسيوم – الرخويات – البقسماط – الخواص الريولوجية