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Utilizing peanut waste to enhance biscuits dietary fiber in a sustainable manner

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ABSTRACT

Food waste management and the enhancement of dietary fiber in baked products are pressing challenges in the food industry. Peanut shells and skins, often discarded as waste, are rich in fiber, phenolic compounds, and essential minerals, presenting an opportunity for sustainable food fortification. This study aimed to evaluate the potential of peanut shells and skins as fortifying agents in biscuits to enhance their dietary fiber content and antioxidant properties while maintaining acceptable sensory qualities. The study analyzed the physicochemical properties, mineral content, phenolic compounds, and sensory attributes of fortified biscuits made with varying concentrations of powdered peanut shells and skins. Chemical analysis showed peanut shells have higher moisture, ash, carbohydrate content, phenolic content, and dietary fibers while skins have total lipid and Crude Fiber. Sensory evaluation showed biscuits with 5% shell had high acceptability, but higher concentrations reduced acceptability. The study suggests that moderate use of peanut by-products, particularly 5% peanut shell, can improve biscuit nutritional content without compromising sensory quality. The study suggests that moderate use of peanut by-products, particularly 5% peanut shell, can improve biscuit nutritional content without compromising sensory quality. This study demonstrates the potential of peanut shells and skins as sustainable and nutritious additives for baked goods, specifically biscuits. By incorporating these byproducts, the study successfully enhanced the dietary fiber content and antioxidant properties of the biscuits while maintaining acceptable sensory qualities. This research contributes to addressing food waste management challenges and promoting healthier, more sustainable food options.

Key words: Peanut Shells, Peanut Skins, Dietary Fiber, Biscuit .

INTRODUCTION

Challenges like waste, economic inequality, environmental degradation, and climate change are all greatly exacerbated by the food system **(FAO, 2019).** It is extremely wasteful because food is wasted at every stage of the food supply chain **(Caldeira *et al.*, 2019).** As a requirement for the Sustainable Development Goals (SDGs), the United Nations has set a specific goal to reduce food losses through the production and supply chains and to cut per capita global food waste at the retail and consumer levels by 2030. **(UNEP, 2015)**.

Recycling food and agricultural waste is vital to reduce environmental pollution. The recent rise in global warming, climate change, and population growth threatens environmental health, leading experts to seek alternative solutions **(Vellidis *et al*., 2014).**

The plant known as peanut (Arachis hypogaea) belongs to the family Fabaceae. One of the most significant agricultural products produced in subtropical nations, peanuts are a valuable food that is consumed for health purposes worldwide. Although peanuts can be eaten, their shells are thrown away as garbage. Their shells are an essential component of the waste cycle **(Arya *et al*., 2016)**.

The Food and Agriculture Organization states that 30 thousand hectares produce 45 thousand tons of peanuts annually, with Asia leading global production at 65.3%, followed by Africa, the Americas, and Oceania. Peanuts are widely used in baked goods and snacks like peanut butter, biscuits, and candy. Peanut flour is also added to bread to boost its nutritional value **(Adeboye *et al.*, 2018).**

The main issue with peanut farming is managing byproducts like shells and hulls. China, the largest producer, is expected to generate 5 million metric tons of peanuts annually, increasing waste. Proper disposal or recycling of these by-products is necessary to address this challenge **(Zhao *et al.*, 2012)**.

Peanut shells and skins, a byproduct of peanut seed, are often discarded or used as animal feed due to their nutritional and functional benefits. Peanut shell extracts have been shown to have high levels of polyphenols, flavonoids, and amino acids, potentially preventing obesity and other disorders **(Adhikari et al., 2019).**

Peanut skin (PS), which accounts for 3% to 8% of the grain's weight, is a non-toxic substance rich in phenolic compounds with beneficial bioactive qualities **(Bodoira *et al.*, 2022).** PS, an industrial waste from blanched peanut processing, contains valuable phytochemicals that enhance the peanut supply chain. Notably, PS phenolic extracts, rich in antioxidants and antimicrobial agents, have a total phenol content of 90-150 g/kg (DW), primarily consisting of flavonoids like procyanidin and proanthocyanidin. **(Sorita *et al.*, 2020) and (Paul *et al.*, 2024).**

The low value placed on peanut skin leads to environmental impact, as businesses often overlook its potential benefits. To address this, researchers need data on its nutritional content, production, and health effects. With a rising demand for healthy foods, there is potential to use peanut skin as a valuable ingredient in food products. **(Huyard, 2020).**

Among other things, fatty acids, proteins, and polyphenolic chemicals can be found in peanut skin. Furthermore, it is known that peanut skins contain important minerals, such as antimicrobials and antioxidants that are utilized to preserve meat products and prevent the production of advanced glycation end products. Numerous constituents of phenolic extracts derived from peanut skin have been recognized as useful food product additives **(Centomo *et al.*, 2024)**. The antimicrobial and antioxidant properties of peanut skin are significant, with its total phenol content (TPC) ranging from 90 to 150 g/kg (DW). The predominant flavonoids, procyanidin and proanthocyanidin oligomers, contribute to its high antioxidant capacity, driven by the richness and diversity of its phenolic compounds. **(Dean, 2020)**.

Peanut shells have had several uses recently. They serve as food, fuel, feedstock, biofilter carriers, and fillers in fertilizers. They are also utilized in the composting of moist materials, the treatment of wastewater, plastic, and clothing **(Zaaba *et al.*, 2013)**. In peanut shells, hemicellulose, cellulose, and lignin are clearly visible. In addition, peanut shells have been shown to be an excellent source of protein in addition to other nutrients like fat, carbohydrates, sugars, and minerals. Numerous scientists have shown that peanut shells are a good source of polyphenols, flavonoids, carotene, luteolin, iso saponaretin, and other substances that are safe for ingestion by humans **(Prabhakar *et al.*, 2015)**.

According to reports, a peanut shell's antibacterial and antioxidant properties may fight off insect pest attacks. Thus, chemists and nutritionists have taken an interest in peanut shells because of their readily available supply of natural antioxidants. A significant industrial waste in nations that produce peanuts is peanut shells. Globally, an estimated 14 million tons of peanut shells are wasted **(F.A.O,STAT, 2020)**.

A fixed meal with fiber-rich foods is a key strategy for optimal health. Dietary fiber, including both soluble (e.g., pectin, gums) and insoluble (e.g., cellulose, lignin) fibers, can aid digestion and help prevent diseases like hypercholesterolemia and hyperlipidemia. Plant-based dietary fiber serves as a functional material that supports overall health. **(Viuda *et al.*,2010)**.

The water solubility of DF determines its classification into soluble dietary fiber (SDF) and insoluble dietary fiber (IDF). Whereas IDF cannot completely hydrolyze in the colon, SDF can, which promotes the growth of intestinal probiotics, prevents lipid transfer and cardiovascular disease, and scavenges free radicals. Several studies have shown the potential of using SDF made from material by-products as a workable replacement for fat **(Soleimani *et al.*, 2022)**.

A few physiological effects of dietary fiber include bettering gastrointestinal health; bettering insulin response and glucose tolerance; lowering the risk of cancer; and improving body weight and fat digestion. Bowel function is impacted by fiber in numerous ways depending on its type, source, and amount. Fiber that is resistant to fermentation in the colon, such as wheat bran, increases the volume of intestinal contents significantly, which aids in the passage of stools. Peanut skin and shell are one form of dietary fiber that can be utilized (**Ibrahim *et al.*, 2013).**

From a technological perspective, high-dietary-fiber peanut wastes have been used to formulate a variety of food products, including dairy, meat, biscuits, cookies, snacks, and drinks. When making baked goods, dietary fibers derived from various sources have been utilized in place of wheat flour **(Adriano *et al.*, 2014)**.

Biscuits are a widely consumed food due to their low cost, variety, availability, and long shelf life. These small, usually sweet baked items can be dry like crackers or soft like bread. With rising demand, biscuit consumption is expected to increase by 55–58%, boosting the demand for wheat, their primary ingredient. **(Gandhi *et al.*, 2001).** The growing food processing sector, especially in developing countries, is expected to increase by-products like seeds, skins, and peels, which contain beneficial substances such as dietary fiber **(McKee and Latner, 2000)**. This study aimed to assess the physiochemical properties of peanut shell and skin powder, use it to fortify biscuits at various concentrations, and evaluate the impact on the final product's characteristics**.**

Materials and Methods

Materials:

Raw material:

Raw peanuts were bought from the local market. The shell and skin of the peanuts were manually removed, and the samples were dried in an oven at 40 °C for 24 hours. After that, they were crushed into a powder and placed in plastic bags for further testing.

The following ingredients were bought from the local market in Cairo, Egypt: sugar, margarine, egg, baking powder, and wheat flour (72% extraction).

Methods:

preparations of peanuts shells (PS)

The peanut shells were extensively washed in water to remove dirt, sand and other impurities for 1-2 hours. These shells were then washed thoroughly in distilled water and dried under the sun light for 2 days.

The washed peanut shell was transferred to an oven maintained at 120 ^{o} C for one day to reduce the moisture content. The dried peanut shell was micronized using a kitchen grinder. The powder was sieved and a size fraction in the range of 200- 300 µm was used in all experiments. The powder was stored in airtight glass bottles to protect it from moisture **(Prabhakar *et al.*, 2015).**

Preparation of peanuts skins powder (Skin)

The roasted kernels (roasted at 165 °C for 15 minutes) were mechanically peeled. Peanut skins were mechanically separated and finely milled using a grinder, then sieved through mesh 60 (0.25 mm). The dried peanut skin (PS) powder was kept in sealed polyethylene bags and stored at -18 °C until used **(Mostafa *et al.*, 2022).**

Chemical analyses of peanuts shells and skins:

- According to **A.O.A.C, (2000),** the following parameters were measured: moisture, ash, protein, fat, and crude fiber. By using difference, the total carbohydrate content was determined as follows: Moisture + ash + protein + fat = 100%.
- According to **A.O.A.C, (2005)** PH measured by PH meter and calibrated with buffers has PH 4, 7, and 10.
- Minerals were determined by digesting the ash of the boiled and roasted groundnut samples in 3M hydrochloric acid.

calcium, magnsium, iron and potassium were determined using a flame photometer (Model: Corning 410) **(Amoniyan *et al.*, 2020).**

- Calculating the activity of antioxidants According to **Ansari *et al.*, (2013)**, the DPPH (2.2diphenyl1picryl hydrazyle) method was used to measure the antioxidants' activity.
- Phenolic compounds are analyses by HPLC. The phenolic compound fractionation of peanut shell and skin powder was measured at Cairo University's food safety and control lab, Agricultural Research Center, Giza, Egypt. The phenolic compounds were measured and separated using the HPLC method published by **Pascale *et al.*, (1999)**.
- Dietary fibre (DF) content was determined on samples of dried peanuts shell and peanuts skins according to AOAC Official Method 991.43 **(A.O.A.C, 2005).**

Physical properties:

Color instrumental Analysis

Six replications of the color characteristics of the prepared samples were measured using a tri-stimulus colorimeter (contact surface diameter: 8 mm) and a chroma meter (CR-400, Konica, Minolta, Tokyo, Japan). The white color standard was used for calibration prior to sample readings. The color system used by CIE Lab, where coordinates are specified as follows, was used to present color parameter data. L* stands for brightness (ranging from 0 (black) to 100 (white), a* for greenness/redness (going from -a* to +a*), and b* for blueness/yellowness (going from -b* to +b*) **(Babuskin *et al.*, 2014).**

Water-holding capacity

A dry sample was carefully weighed and then added to a graduated test tube with around 30 cc of water to determine the water-holding capacity (WHC). After that, the sample was left to hydrate at room temperature for eighteen hours. Subsequently, the supernatant was disposed of. After weighing the hydrated residue, the sample was dried for two hours at 105°C to produce the dry residue **(Sowbhagya *et al.*, 2007).** WHC (g/g) is equal to (dry weight / residual weight – residual hydrated weight).

Oil-holding capacity

The method **Abdul-Hamid and Luan, (2000)** established was used to evaluate the oil-binding capacity. Four grams of the sample were added to a 50 ml centrifuge tube that had 20 ml of maize oil. Five minutes at a time, the liquid swirled for 30 seconds. The tubes were centrifuged at 1600 g for 25 minutes after a total of 30 minutes. The liberated oil was then decanted, and the difference indicated how much oil had been absorbed. The amount of oil absorbed per gram of sample was the stated measure of the oil-binding capacity.

Swelling capacity

A measured dry sample was added to a graduated test tube, and then around 10 milliliters of water were added. The sample was then let 18 hours to hydrate, and the final volume the sample reached was then measured **(Sowbhagya *et al.*, 2007).**

SW (ml/g) = Volume filled by sample / Initial weight of sample.

Bulk density

The bulk density was calculated using the formula provided by **Narayana and Rao (1982),** which was weight (g) per unit volume (L) of the sample.

Biscuit formulations and preparation

The biscuits were prepared in the lab of Bread and Pastries Research Dept., Food Technology Institute. Agric. Research Center. Ingredients used to make biscuits were given in **Table (1).** Biscuits were made according to the method described by **Wade, (1988)** with some modification.

Table (1): The formula used for preparing sweet biscuits

Ingredients	Control
Wheat flour (g)	200
Butter (g)	67
Sugar (g)	72
Salt (g)	0.5
Baking powder (g)	1
Egg (g)	20
Vanilla essence (g)	13.5

*Water was dependent on the processing and ranged from 25.0% (100% wheat flour biscuits) to 30.7% (crust-fortified biscuits) of the total weight of ingredients *g means gram

Treatments:

Pretest experiment has been carried out to determine the best mix ratio of suggested raw materials that were chosen for this study as shown in the following **Table (2).**

In the formulations, a portion of the wheat flour was replaced by 5% and 10% of peanut shells on a dry weight basis **(Elsawy *et al.*,**

2024) and 1.3% and 1.8% of peanut skins **(De Camargo *et al.*, 2014)** **a**. A portion of the flour was replaced by a mixture of peanut shells and peanut skins at a rate of 5% and 1.3% of the flour weight.

Table 2: The formula used for preparing sweet biscuits

Ingredients	Ps (5%)	Ps (10%)	Skin (1.3%)	Skin (1.8%)	mixture
Wheat flour (g)	190	180	197.4	196.4	187.4
(Ps) powder (%)	10	20	0	0	1.3
Skin powder (%)	0	0	1.6	3.6	12.6
Butter (g)	67	67	67	67	67
Sugar (g)	72	72	72	72	72
Salt (g)	0.5	0.5	0.5	0.5	0.5
Baking powder (g)	1	1	1	1	1
Egg (g)	20	20	20	20	20
Vanilla essence (g)	13.5	13.5	13.5	13.5	13.5

*Water was dependent on the processing and ranged from 25.0% (100% wheat flour biscuits) to 30.7% (crust-fortified biscuits) of the total weight of ingredients *PS peanuts shells *Skins Peanuts skins.

Proximate analysis of biscuits:

biscuits' physical and dietary fiber characteristics:

- The physical characteristics (color and texture) of biscuit samples were determined according to the American Association of Cereal Chemists **(A.O.A.C, 2000).** All measurements were done in three replicates, each consisting of 5 biscuits.
- Dietary fibre (DF) content was determined on samples of fortified biscuits with peanuts shell, peanuts skins and their

mixture according to AOAC Official Method 991.43 **(A.O.A.C, 2005).**

Sensory assessment:

A sensory evaluation of biscuits involved 20 untrained panelists from the university community. The attributes covered appearance, color, taste, aroma, crispiness, aftertaste, and overall acceptability, utilizing a 7-point hedonic scale **(Nazi, and Maidin, 2024)**.

Statistical Analysis

The obtained data were exposed to analysis of variance. Duncan's multiple range test at 5% level of significance was used to compare between means. The analysis was carried out using the PROC ANOVA procedure of Statistical Analysis System **(SAS, 2006).**

Results and Discussions

Physicochemical properties

The table presents the chemical composition of peanut shells (PS) and peanut skins (skins) in terms of moisture, ash, crude fiber, total protein, total lipid, carbohydrates, and PH. The chemical composition of peanut shells and peanut skins reveals significant differences that influence their effectiveness as fortifying agents in food products. Peanut shells have a higher moisture content (6.08 g/100g) compared to peanut skins (3.43 g/100g). The lower moisture content in peanut skins indicates they may have a longer shelf life and are less susceptible to microbial spoilage, making them a more reliable ingredient for food fortification. Additionally, peanut shells contain more ash (3.49 g/100g) than peanut skins (1.86 g/100g), reflecting a higher mineral concentration. This higher mineral content suggests that peanut shells could be a more potent source of minerals, thereby potentially increasing the nutritional value of fortified foods.

Both peanut shells and skins are rich in crude fiber, with peanut skins slightly surpassing peanut shells (13.29 g/100g vs. 11.92

g/100g). This high fiber content indicates that both by-products could significantly boost the dietary fiber content in fortified foods, promoting better digestive health.

The protein content in peanut shells (6.34 g/100g) is slightly higher than in peanut skins (5.95 g/100g). While these protein levels are modest, they still add to the overall nutritional value of the by-products, though protein is not their primary benefit. Peanut skins have a significantly higher lipid content (18.6 g/100g) compared to peanut shells (8.34 g/100g). This increased lipid content may impact the texture and mouthfeel of fortified products, making them richer and more appealing. Peanut shells are also richer in carbohydrates (73.77 g/100g) compared to peanut skins (57.87 g/100g), which could boost the energy content of fortified foods. However, the higher carbohydrate content in peanut shells might also influence the texture and consistency of the final product. Lastly, peanut skins are more acidic, with a pH of 4.5 compared to 5.7 in peanut shells. This lower pH in peanut skins could affect the flavor profile and preservation qualities of fortified products, possibly adding a tangy note and improving shelf stability. g/100 g).

Table 3: chemical content of peanut skins and shells powder

Sample g/100g	PS	Skins
Moisture	6.08	3.43
Ash	3.49	1.86
Crude Fiber	11.92	13.29
Total protein	6.34	5.95
Total Lipid	8.34	18.6
Carbohydrates	73.77	57.87
PH	5.7	4.5

*PS peanuts Shell * Skins Peanuts Skins

These results are consistent with those of **Decamargo *et al.*, (2014),** who reported that peanut skins had a protein content of 4.66

g/100 g. However, **Munorz *et al.*, (2021)** reported that peanut skins had a protein content ranging from 8.88 to 12.7 g/100 g.

The results showed that peanut shells had a lower fat content (8.34 g/100g) than peanut skins (16.8 g/100g). Peanut skin powder showed an extremely high fat content. These findings are consistent with those of **Nepote *et al.*, (2002) a**, who showed that skin powder had a fat content of 16.60g/100g.However, according to **Munoz *et al.*, (2021)**, the fat content of peanut shells varied from 9.59 to 10.2g/100g.

The high fat content in PSK powder may be related to the peanut skin's absorption of peanut oil from the peanut kernel seed. **Mohebpour, (2021)** indicates that as peanuts are roasted, the oils within the seeds go to the surface of the seed. Additionally, the data indicate that skin has higher fiber levels than (Ps) (11.92 g/100 g) at 13.29 g/100 g Compared to (Ps) (3.49 g/100g). The amounts of carbohydrates in peanut shell and peanut skin powders were considerable (73.77 and g/100 g, respectively). These results corroborated the 69.8g/100g carbohydrate content of peanut skins discovered by **Nepote *et al. (2002)b***.

Skin has a lower level of ash (1.86 g/100g). According to reports from **Decamargo *et al.*, (2014)** and **Nepote *et al.*, (2002)**, the ash content of peanut skins is 2.89 and 2.83 g/100g. However, according to **Sulieman *et al.*, (2014)**, peanut skins have a significant ash concentration (9.42 g/100 g). According to the pH values listed in Table (3), Skin had a pH value of 4.5 whereas (Ps) had a pH value of 5.7. **Mostafa *et al.*, (2022)** found similar outcomes, reporting that grape powder (GS) had a lower pH value (3.95) than peanut skins (4.95) **(Shibli *et al*., 2019).**

Additionally clarify the nutritional and mineral profile of peanut shells, noting that they clearly show a significant quantity of fiber and protein in addition to other ingredients. They believed that peanut shells are an excellent source of fiber and protein, and that using them in goods with additional value has shown to be successful **(Varma *et al.*, 2020)**.

According to the pH values listed in Table (3), skin had a pH value of 4.5 whereas (Ps) had a pH value of 5.7. **Mostafa *et al.* (2022)** found similar outcomes, reporting that grape powder (GS) had a lower pH value (3.95) than peanut skins (4.95). ***Anake et al.,* (2016)**, approved that, peanut shells equally have a pH of roughly 6.8.

Minerals content

The results regarding the mineral content of the peanut shell and skin powder are in table 4. Peanut shells and skins are both valuable sources of essential minerals, though peanut shells generally have slightly higher concentrations. The calcium content in peanut shells is 873 mg/g, slightly higher than the 860 mg/g found in peanut skins. This suggests that both by-products can significantly contribute to the calcium content in food formulations, which is crucial for bone health and other physiological functions. The potassium content is also comparable, with peanut shells containing 16.01 mg/g and peanut skins at 15.36 mg/g. These similar levels indicate that either by-product can be used to enhance potassium levels in fortified foods, supporting proper cellular functions such as nerve signaling and muscle contraction. In terms of magnesium, peanut shells contain 2242 mg/g, marginally higher than the 2233 mg/g found in peanut skins. This high concentration of magnesium in both by-products is beneficial for energy production, DNA synthesis, and maintaining normal muscle and nerve function. Additionally, the iron content in peanut shells is 26.06 mg/g, slightly higher than the 25.4 mg/g in peanut skins. This makes both peanut shells and skins good sources of iron, essential for hemoglobin production and oxygen transport in the blood. Including these by-products in food formulations could help increase the iron content, potentially benefiting those with iron-deficiency anemia.

Table 4: The amount of minerals in peanut skin and shell powder (mg/g)

Samples	(ps)	(skin)
Ca	873	860
K	16.01	15.36
Mg	2242	2233
Fe	26.06	25.4

* Ca Calcium * K Potassium *Mg Magnesium * Fe Iron
*PS Peanuts Shell * Skins Peanuts Skins

. The iron content of peanut shell powder was higher than that of calcium, potassium, and magnesium. Similar patterns in the mineral composition of peanut skin were observed by **(Crenshaw, 2012)**, however they did not specify the type of peanut used. Understanding the concentration of minerals could help in the production of processed foods made using peanut skin, which could help alleviate animal and human mineral deficits. The processes involved in growth, development, and metabolism are negatively impacted by a mineral intake deficit. For example, the most common minerals in the body, calcium and phosphorus, might be deficient in these areas and lead to lameness, paralysis, rickets, and spontaneous fractures.

An alternative for use in less expensive diets for people and animals is the fortification of processed foods with peanut skin. However, to assess this idea, nutritional studies are required. Proanthocyanidins (PAC) precipitate proteins, which is another benefit of employing peanut skin: diets for both people and animals have more nutritional value. Hydrophobic interactions and hydrogen bonding lead to the formation of spontaneous complexes **(Viquez *et al.,* 2020)**.

About 20–30% of the weight of dried groundnut pods is composed of groundnut shells. Peanut shells may contain minerals, lignin, proteins, lipids, sugars, and carbohydrates with lignocellulosic compositions such as cellulose and hemicellulose **(Adhikari *et al.,* 2018)**.

Phenolic compounds analyses

Table (٥) presents the antioxidant activity as measured by DPPH (2,2-Diphenyl-1-picrylhydrazyl), the most widely used assay for assessing antioxidant activity. Its simplicity, short reaction times, and lower cost when compared to most other methods are its main advantages. The antioxidant activity percentages of peanut skin and peanut shell were remarkably high, at 85.09 and 95.59%, respectively.

These findings confirmed those of **Bishnu *et al.,* (2019)**, who concluded that peanut shells' capacity to scavenge DPPH radicals ranged from 61.9 to 87.6%. The presence of several antioxidant chemicals may account for the peanut shells' exceptional capacity to scavenge DPPH radicals. Phenolic chemicals, such as peanut shells, play a vital role in the DPPH radical scavenging abilities of legume crops. In addition to their seeds, peanut shells contain a variety of polyphenolic compounds that have a comparatively high potential for antioxidant activity as well as other health-promoting substances that could be efficiently utilized in the food industry.

Table (5) phenolic compounds in peanut shells and peanut skin powder mg/kg

Phenolic compounds	Ps	skins
p- Hydroxy benzoic acid	89.067	ND*
Catechin	159.49	ND
Chlorogenic acid	79.16	2.50
Vanillic acid	36.66	44.5
Caffeic acid	4.065	99.3
Syringic acid	13.12	4.13
p- Coumaric acid	39.71	ND
Rutin	2.54	35.6
Ferulic acid	2597.31	15.62
o- Coumaric acid	39.71	7.05
Hesperidin	4.81	3.5
Resveratrol	88.39	ND
Myricetin	78.05	16.2
Quercetin	247.70	120.5
Apigenin	0.66	ND
Catechol	4.5	4.50
Gallic acid	3.45	11.21
Kampherol	20.1	2.5
Rosemarinic	16.9	26.23
Total Antioxidants (DPPH) %	95.59	85.09

*ND means Non detected *DPPH: Diphenynl-1-picrylhydrazyl

Through HPLC analysis, around 20 components were identified in peanut shell powder. In Table ٥, the confirmed components were mentioned. The principal ingredients in peanut shell powder were Catechin (159.49 mg/kg), Chlorogenic acid (79.16 mg/kg), Vanillic acid (36.66 mg/kg), Ferulic acid (2597.31 mg/kg), o-Coumaric acid (39.71 mg/kg), and Resvertol (88.39 mg/kg). **Wee *et al.*, (2017)** similarly discovered similar outcomes, concluding that luteolin constituted the principal constituent of peanut shells according to the methanol extraction techniques.

In the same table (٥) peanut skin powder was high in phenol (2.50 mg/kg), vanillic acid (44.5 mg/kg), caffeine (99.3 mg/kg), syringic acid (4.13 mg/kg), and rosemarinic acid (26.23 mg/kg). These elements might have a significant impact on the antioxidant and radical-scavenging abilities of plants. Furthermore, the component (phenols or flavonoids) was connected to the kind of peanut variety and the techniques used for detection. This result was disagreed with **Wenbo *et al.*, (2020)** who confirmed that this study looked at the antioxidant capacity of peanut shell and skin extracts as well as how they affected the structural and physical characteristics of starch-chitosan film. The findings demonstrated that peanut skin extracts had a much better capacity to scavenge DPPH radicals than did peanut shell extracts. This might be because the peanut skin extracts included high concentrations of rutin and 4-O-caffeoulquinic acid.

Dietary fiber content

The dietary fiber content of peanut shells and skins is presented in Table (6), with a focus on the variations in total dietary fiber (TDF), soluble dietary fiber (SDF), and insoluble dietary fiber (IDF). Peanut shells exhibit a significantly higher total dietary fiber (TDF) content at 87.2% compared to 54.7% in peanut skins, indicating that peanut shells are a richer source of dietary fiber overall. This makes them particularly beneficial for enhancing the fiber content in food products. In terms of soluble dietary fiber (SDF), peanut shells contain 6.3%, slightly more than the 4.55% found in peanut skins. Soluble fiber is important for reducing cholesterol levels, improving gut health, and regulating blood sugar. Although both peanut shells and skins have relatively low soluble fiber content, peanut shells offer a marginally better source.

Table 6: Dietary fiber (DF) content (Total, soluble and in soluble) in peanut shells and peanut skins

Parameters	peanut shells	peanut skins
Tota dietary fiber (TDF)	87.2%	54.7 %
Soluble dietary fiber (SDF)	6.3%	4.55 %
In soluble dietary fiber (IDF)	80.8	51.3 %

The results of this research are consistent with the results of previous studies, which confirmed by **Camargo et al., (2014)** confirms that peanut by-products, including shells and skins, are rich in dietary fiber, particularly insoluble fiber, supporting the high fiber content observed in peanut shells. **Yu et al., (2010)** detail the chemical composition of peanut skins, highlighting the presence of both soluble and insoluble dietary fibers, which aligns with the significant fiber content found in peanut skins. **Wang *et al.*, (2016)** further confirm the high levels of dietary fiber, especially insoluble fiber, in peanut hulls (shells) and skins, consistent with the findings in this study. **Chen and Ma, (2021)** emphasize the functional properties of dietary fiber extracted from peanut shells and skins, noting the higher insoluble fiber content in peanut shells compared to skins, which aligns with the current study's results. Additionally, **Nepote *et al.*, (2002).** discuss the fiber composition of peanut skins, confirming their significant dietary fiber content, particularly insoluble fiber. **Adhikari *et al.*, (2012)** review the nutritional composition of peanut by-products, including shells and skins, highlighting their high total and insoluble dietary fiber content, consistent with the findings for peanut shells in this study. **Sandhu *et al.*, (2007)**, although focused on corn grains, provide insight into the high fiber content of various agricultural by-products, supporting the notion that peanut shells are particularly rich in dietary fiber. **Venkatachalam and Sathe (2006)** examine the chemical composition of various nut by-products, including peanut shells, confirming their high dietary fiber content, especially insoluble fiber, consistent with this study's results showing peanut shells as a superior source of fiber

Physical properties:

physicochemical characteristics of peanut skins and shells

Table (7) presents the obtained results. The values for L* (lightness), a* (redness), and b* (yellowness) in peanut shell powder are 59.12, 6.13, and 20.26, respectively. As indicated in Table 7, the peanut skin powder's Lightness (L), redness (+a), and yellowness (+b) were determined to be 50.5, 12.4, and 20.4, respectively. According to **Chukwumah *et al.*, (2009)**, the color of peanut skin can range from light brown to deep red. The study examined the possibility of using the color of peanut skin across 27 different cultivars as a biomarker for antioxidant capability and polyphenol concentration. For every cultivar, the values of b* (yellowness) and L* (lightness) were (25.67 to 13.58) and (54063 to 32.7), respectively. The range of a* values was 12.97 to 24.96. **Munoz *et al.*, (2021)** measured the CIE Lab values (L*, a*, and b*) for three different kinds of peanut skins: Spanish, Valencia, and Virginia. They discovered that the L* and b* values, which represent the skins' darkness, were, respectively, (44.1, 34.7, and 39.1) for the three varieties of peanut skins.

Table (7) physicochemical characteristics of peanut skins and shells powder

Parameters	PS	Skins
Water holding capacity (g/g)	3.02	4.05
Oil holding capacity (g/g)	2.91	1.8
Swelling capacity (mL/g)	1.98	1.6
Bulk of density (g/m)	0.768	0.544
Color parameters		
L*	59.12	50.5
a*	6.13	12.4
b*	20.26	40.4

lightness (L*), redness (a*), and yellowness (b*)

Table (7) presents the obtained results. The values for L* (lightness), a* (redness), and b* (yellowness) in peanut shell powder are 59.12, 6.13, and 20.26, respectively. As indicated in Table 7, the peanut skin powder's Lightness (L), redness (+a), and yellowness (+b) were determined to be 50.5, 12.4, and 20.4, respectively. According to **Chukwumah *et al.* (2009)**, the color of peanut skin can range from light brown to deep red. The study examined the possibility of using the color of peanut skin across 27 different cultivars as a biomarker for antioxidant capability and polyphenol concentration. For every cultivar, the values of b* (yellowness) and L* (lightness) were (25.67 to 13.58) and (54063 to 32.7), respectively. The range of a* values was 12.97 to 24.96. **Munoz *et al.*, (2021)** measured the CIE Lab values (L*, a*, and b*) for three different kinds of peanut skins: Spanish, Valencia, and Virginia. They discovered that the L* and b* values, which represent the skins' darkness, were, respectively, (44.1, 34.7, and 39.1) for the three varieties of peanut skins.

Table 7 also presents the physical parameters of peanut shells and skins. The bulk densities of the two powders were 0.768 and 0.544 g/ml. Capacity to hold water (3.02 and 4.05 g/g). Capacity to contain oil (2.91 and 1.8 g/g). whereas the swelling capacities for peanut shells and skins are 1.98 and 1.6 ml/g, respectively. The current study's findings regarding the low bulk density of peanut skin powder were in line with those collected by **Embaby and Rayan (2016)**, who examined acacia seed flour (ASF), finding that bulk density values ranged from 0.493 to 0.532 g/ml. The bulk density value that was obtained fell within the range that ***Appiah et al. (2011)*** had permitted for Artocarpus altilis flour (0.460-0.570 g/ml).

However, a higher value (3.7 ml/g) of swelling capacity in dehydrated tomato waste was reported by **El Nemr, (2008*)***. There were 3.70 milliliters per gram of water holding capacity (WHC). WHC readings have been found to be lower by **Anwar *et al.*, (2016)**. 2.49 ml/g was the oil holding capacity (OHC). These results are in line with the 2.35 ml/g value found by **Namir, (2014).** The peanut shell and skin had oil holding capacities (OHC) of 2.91 and 1.8 g/g, respectively. These values are consistent with the 2.35 ml/g found by **Anwar *et al.*, Sallam (2016)**.

Proximate analysis of biscuits:

Color Instrumental Analysis

Table (8) shows the color measurement of biscuits after adding peanut shell, peanut skin powder, and their combination at several percentages.

The findings demonstrated that when additional peanut shell powder (5% and 10%), peanut skin powder (1.3%), and a combination of peanut shells and peanut shell powder (5% and 1.3) were added, the lightness L* value of the biscuits fell but increased as more peanut skin (1.8%).

The difference in L* value between control biscuits (73.93%) and (1.3%) of peanut skin biscuits (68.14%) can be related to the peanut skin's natural color.

In addition, it was found that the a* value of biscuits incorporating peanut skin, shells, or a mixture of them was significantly higher than that of the control biscuits.

In this study, there was a slight decrease in the b* value (yellowness) as more peanut skin powder was added to the biscuit formulation. The results of this research were consistent with a previous study that found that adding more buckwheat flour to the recipe of the cookies boosted the biscuits' surface color for a value while decreasing it for a b* value (**Nazi and Maidin, 2024)**. The browning events that take place during baking, where brown pigments are assumed to be formed via Maillard browning and caramelization of sugar, may be connected to the variations in color of biscuits **(Suleman *et al.*, 2023)**

Control biscuits scored the highest for overall acceptability, followed by peanut skin (1.3%), peanut skin (1.8%), peanut shell (5%), peanut shell (10 %) and a mixture of peanut shell and peanut skin biscuits.

Control and peanut skin (1.3%) biscuits showed no significant difference, suggesting a preference for these formulations.

Substituting peanut skin (1.8%), peanut shell (5%), peanut shell (10 %) and a mixture of peanut shell and peanut skin were not recommended, as it may negatively impact sensory qualities despite providing higher nutritional value.

Table 8: Color analysis of biscuits with different proportions of peanut shells, peanut skins and its mixture

Samples	L*	a*	b*
Control	73.93	1.42	31.30
PS (5%)	63.88	4.14	27.04
PS (10%)	60.71	5.56	27.23
Skin (1.3%)	68.14	2.91	27.47
Skin (1.8%)	84.22	5.31	26.72
Mixture	62.60	4.23	23.57

lightness (L*), redness (a*), and yellowness (b*)

Study by **Nepote *et al.*, (2002)** highlights how peanut skins, rich in phenolic compounds, can affect the color properties of food products, particularly by increasing redness and potentially altering lightness. Similarly, research by **Sandhu *et al.*, (2007)** demonstrates that incorporating high-fiber by-products like peanut shells can result in darker and more intense color changes in food products due to the natural pigments in the shells. **Sudha *et al.*, (2007)** further confirms the trend of reduced lightness and yellowness when high-fiber ingredients such as peanut shells are used in baked goods, which aligns with the findings of the current study. Additionally, **De Camargo and Shahidi (2014) b** show that phenolic-rich peanut skins can modify the color of food products by enhancing redness and, in some cases, increasing lightness, consistent with the observations in this study.

These studies collectively provide a scientific foundation for the color changes observed in biscuits fortified with peanut shells and skins, confirming that these ingredients can significantly influence the visual characteristics of the final product.

Texture Profile of biscuits

Table (9) demonstrates the biscuits' hardness, adhesiveness, and fractur ability value as determined by the texture analyzer. For biscuits, textural qualities including hardness, adhesiveness, and fractur ability are essential and desirable.

Control biscuits exhibited a hardness of 28.91 ±1.47 and an adhesiveness of 0.8 ±0.3, reflecting a moderate firmness and a slightly sticky texture typical of standard biscuits.

Adding 5% peanut shell (PS) powder reduced the hardness to 21.6 ±0.2, making the biscuits softer, while their adhesiveness dropped to 0.1 ±0.1, indicating a non-sticky texture.

In contrast, 10% PS biscuits showed a significant increase in hardness to 57.9 ±3.3, suggesting that a higher concentration of peanut shell powder substantially hardens the biscuits. Despite the increased hardness, the adhesiveness remained low at 0.9 ±30.3, like the control. Biscuits with 1.3% peanut skin powder had a hardness of 27.57 ± 1.35, close to the control, and an adhesiveness of 0.5 ± 30.3, maintaining a similar firmness and slightly lower stickiness.

The 1.8% peanut skin biscuits recorded the lowest hardness value of 20.94 ±1.5, indicating a softer texture, with minimal adhesiveness at 0.1 ±30.3, consistent with other formulations.

The mixture of peanut shell and skin resulted in a hardness of 29.6 ±2.1, close to the control, with very low adhesiveness at 0.1 ±30.3, suggesting a balanced texture that retains both firmness and a non-sticky characteristic.

These findings demonstrate that peanut shell and skin powders can significantly impact the hardness of biscuits. Higher concentrations of peanut shell increase firmness, while lower concentrations of both ingredients tend to soften the biscuits. However, these changes do not significantly affect adhesiveness, as all formulations exhibited low and comparable stickiness. This suggests that while these ingredients can be used to adjust biscuit firmness, they will not influence the biscuit's stickiness, offering flexibility in achieving desired textural properties in biscuit formulations.

Table (9) Texture Profile of biscuits

Samples	Hardness	adhesiveness	Fractur ability
Control	28.91 ±1.47 [b]	0.8 ±0.3 [a]	28.91 ±1.47 [b]
PS (5%)	21.6 ±0.2 [c]	0.1 ± 0.1 [c]	21.6 ±0.2 [c]
PS (10%)	57.9 ± 3.3 [a]	0.9 ±30.3 [a]	57.9 ± 3.3 [a]
Skin (1.3%)	27.57 ±1.35 [b]	0.5 ±30.3 [b]	27.57 ±1.35 [b]
Skin (1.8%)	20.94 ±1.5 [c]	0.1 ±30.3 [c]	20.94 ±1.5 [c]
Mixture	29.6 ±2.1 [b]	0.1 ±30.3 [c]	29.6 ±2.1 [b]

* Data are presented as means ± SDM (n=5). Data in a row with different superscript letters are statistically different ($P \leq 0.05$)
* a, b, c: Means with different letter among treatments in the same row are significantly different

Sudha *et al.,* (2007) discuss how the incorporation of high-fiber ingredients, such as peanut shells, into baked products can significantly increase hardness, which aligns with the increased hardness observed in biscuits containing 10% peanut shell (PS) in this study. Similarly, **Arogundade and Nkama (2005)** demonstrate that adding by-products like soybean hulls can decrease adhesiveness and increase biscuit hardness, effects that are consistent with the higher hardness and lower adhesiveness seen in the 10% peanut shell biscuits in this research. **Sullivan *et al.,* (2016)** further confirm that high-fiber ingredients tend to increase the fracturability and hardness of baked goods while reducing their adhesiveness, supporting the findings of significantly higher hardness and fractur ability in the

10% peanut shell biscuits compared to the control. **Manley, (2011)** also provides a comprehensive explanation of how including high-fiber ingredients, such as peanut by-products, influences the textural properties of biscuits, typically leading to increased hardness and fractur ability while reducing adhesiveness. These references collectively provide a strong foundation for understanding the impact of peanut shells and skins on the textural properties of biscuits, confirming that the observed increases in hardness and fractur ability, particularly with higher concentrations of peanut shells, are consistent with previous research in the field.

Biscuit content of dietary fiber and antioxidants

The results in table (10) show that the control sample, which lacks peanut by-products, has the lowest dietary fiber content at 3.05%. Incorporating 5% peanut shell (PS) significantly boosts the dietary fiber content to 15.8%, demonstrating the substantial fiber contribution of peanut shells. The sample with 1.3% peanut skin shows a dietary fiber content of 10.9%, a marked increase compared to the control, highlighting the considerable fiber content in peanut skins. The mixture of peanut shell and skin achieves the highest dietary fiber content at 20.9%, indicating that combining these by-products maximizes the fiber content in the final product.

In terms of antioxidant activity, the control sample again shows the lowest value at 12.5%, as it does not contain phenolic-rich peanut by-products. The addition of 5% peanut shell increases antioxidant activity to 22.03%, underscoring the role of phenolic compounds in peanut shells in enhancing antioxidant properties. The sample with 1.3% peanut skin has an antioxidant activity of 18.5%, which, while higher than the control, is lower than that of the PS sample, indicating that peanut skins also contribute to antioxidant activity, albeit to a slightly lesser extent than peanut shells at this concentration. Notably, the combination of peanut shell and skin yields the highest antioxidant activity at 25.8%, suggesting a synergistic effect when both by-products are used together, further enhancing the antioxidant properties of the final product.

Table 10: Dietary fiber (DF) content (Total, soluble and in soluble) in peanut shells and peanut skins

Samples	Dietary fibers (%)	Antioxidant (%)
Control	3.05	12.5
PS (5%)	15.8	22.03
Skin (1.3%)	10.9	18.5
Mixture	20.9	25.8

Here are some recent studies that support the findings related to dietary fiber content and antioxidant activity in peanut shells and skins. **Camargo *et al.*, (2014)** confirm that peanut by-products, including shells and skins, are rich in dietary fiber and phenolic compounds, which contribute to increased antioxidant activity. **Yu and Goktepe (2010)** provide detailed insights into the antioxidant properties of peanut skins, demonstrating how their phenolic content significantly enhances antioxidant activity in food products. **Wang *et al.*, (2016)** explore the composition of peanut hulls and skins, confirming their high levels of dietary fiber and antioxidant compounds, aligning with the increased fiber content and antioxidant activity observed in formulations containing these by-products. **Chen**

and Ma (2021) focus on the functional properties of dietary fiber extracted from peanut shells and skins, highlighting their high fiber content and significant antioxidant activity, consistent with the findings of enhanced dietary fiber and antioxidant properties in the mixed formulations. These studies collectively validate the results observed in your research, confirming that peanut shells and skins significantly enhance both dietary fiber content and antioxidant activity when incorporated into food products.

Sensory evaluation

Here are the combined results of the biscuit properties (Color, Flavor, Texture, Taste, Aroma) and Overall Acceptability, along with the calculated average score for each formulation:

Table 11: Sensory evaluation of biscuits enriched with concentrations of peanuts shells, peanuts skins and its mixtrue

Biscuit properties	Color (10)	Flavor (10)	Texture (10)	Taste (10)	Aroma (10)	Overall acceptability (10)
Control	9.3 ±1.47^{a}	8.5 ±0.3^{b}	٩.7 ± ١.3^{a}	9.5 ±1.47^{b}	8.9 ±1.47^{b}	9.18 ±1.47^{a}
PS (5%)	8.80 ±1.35^{a}	9.3 ± 0.3^{a}	٨.٩±0.9^{a}	9.1 ±1.35^{b}	9.3 ±1.35^{b}	9.08 ±1.35^{a}
PS (10%)	7.0 ± ٠,٨^{d}	7.6 ±.٠,٩^{c}	٧.1 ±1.2^{a}	6.3 ± 3.3^{a}	7.3 ± 3.3^{a}	7.06 ± 3.3^{c}
Skin (1.3%)	7.5 ±0.2^{c}	8.7 ± 0.1^{b}	٧,٥ ±١.٥^{a}	8.7±0.2^{c}	8.5±0.2^{c}	8.1 ± 0.2^{b}
Skin (1.8%)	8.0 ±1.5^{b}	8.1 ±١.١^{b}	٨.2± 1.1 ^{a}	7.8 ±1.5^{c}	8.2 ±1.5	8.6 ±1.5^{b}
Mixture	6.5 ±2.1^{e}	6.9 ±٠,٧^{d}	٦,٠±0.85 a	6.7 ±2.1^{b}	6.3 ±2.1^{b}	6.48 ±2.1^{b}

* Data are presented as means ± SDM (n=15). Data in a row with different superscript letters are statistically different ($P \leq 0.05$)

* a, b, c: Means with different letter among treatments in the same row are significantly different

The sensory evaluation of biscuits highlighted clear preferences and the effects of incorporating peanut shell and skin on various sensory properties. The control biscuits achieved the highest ratings across most categories, including color (9.3), texture (9.7), taste (9.5), aroma (8.9), and overall acceptability (9.18), indicating a strong preference for the traditional biscuit without the addition of peanut by-products.

When 5% peanut shell (PS) was incorporated, the biscuits experienced only a slight reduction in color score (8.8) but maintained high scores in flavor (9.3), texture (8.9), taste (9.1), aroma (9.3), and overall acceptability (9.08). This suggests that a modest amount of peanut shell can enhance certain attributes, particularly flavor and aroma, without significantly compromising the overall quality.

In contrast, higher concentrations of peanut shell (10%) and the combination of peanut shell and skin resulted in the lowest scores across all evaluated properties. The biscuits with 10% peanut shell and the mixture showed lower ratings in color (7.0 and 6.5), flavor (7.6 and 6.9), texture (7.1 and 6.0), taste (6.3 and 6.7), aroma (7.3 and 6.3), and overall acceptability (7.06 and 6.48). These findings suggest that higher concentrations of peanut by-products negatively impact the sensory qualities of the biscuits, making them less appealing in terms of color, texture, flavor, and aroma.

In summary, the control biscuits were the most preferred overall. However, the 5% peanut shell formulation shows potential for enhancing flavor and aroma while still being acceptable to consumers. Conversely, higher concentrations of peanut shell and mixtures with peanut skin are less favored due to their adverse effects on multiple sensory attributes.

Research by **Sandhu *et al.*, (2007)** on the fortification of baked goods with various by-products highlighted that excessive fiber could lead to a harder texture and reduced consumer appeal.

fortification of biscuits and other baked products with by-products like fruit peels, vegetable powders, and grain brans has shown similar trends. For example, research by **Sudha *et al.*, (2007)** on wheat bran in biscuits found that moderate levels of these ingredients could improve fiber content without negatively impacting taste and texture. The current study's observation that low levels of peanut skin (1.3%) were well-received by consumers mirrors these findings, reinforcing the notion that moderation is key in successful product fortification.

Flavor and aroma are critical determinants of consumer acceptance in fortified foods. **Liu *et al.*, (2022)** demonstrated that peanut skin contains phenolic compounds that can enhance the flavor and aroma of baked goods when used in appropriate amounts. However, **Patel *et al.*, (2019)** noted that excessive use of peanut shell powder can introduce undesirable bitter notes and overpowering aromas, negatively impacting overall flavor.

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الاستفادة من مخلفات الفول السودانى لتعزيز الالياف الغذائية للبسكويت بطريقة مستدامة

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المستخلص

إدارة نفايات الطعام وتعزيز الألياف الغذائية في المخبوزات تمثل تحديات هامة في صناعة الأغذية. تعتبر القشور الخارجية والداخلية للفول السوداني، التي تُهدر عادة كنفايات، مصدرًا غنيًا بالألياف والمركبات الفينولية والمعادن الضرورية، مما يفتح آفاقًا لاستخدامها في تعزيز المنتجات الغذائية بشكل مستدام. تهدف هذه الدراسة إلى تقييم فعالية قشور الفول السوداني الخارجية والداخلية كمكونات تقوية للبسكويت لزيادة محتواه من الألياف الغذائية وتعزيز خصائصه المضادة للأكسدة، مع الحفاظ على جودة الطعم والمظهر المقبولة. تم فحص الخصائص الفيزيائية والكيميائية، والمحتوى المعدني، والمركبات الفينولية، وكذلك الخصائص الحسية للبسكويت المُقوّى بتركيزات متفاوتة من مسحوق القشور الخارجية والداخلية للفول السوداني. أظهر التحليل الكيميائي أن قشور الفول السوداني الخارجية تحتوي على نسبة أعلى من الرطوبة والرماد ومحتوى الكربوهيدرات ومحتوى المركبات الفينولية والألياف الغذائية بينما تحتوي القشور الداخلية على إجمالي الدهون والألياف الخام. كشفت التقييمات الحسية أن البسكويت الذي يحتوي على ٥٪ من القشور كان الأكثر قبولاً، بينما أدى استخدام كميات أعلى إلى انخفاض القبولية. توصلت الدراسة إلى أن الاستخدام المعتدل للمنتجات الثانوية للفول السوداني، خاصة بإضافة ٥٪ من قشور الفول السوداني، يمكن أن يعزز القيمة الغذائية للبسكويت دون التأثير سلبًا على جودته الحسية. توضح هذه الدراسة إمكانية استخدام قشور الفول السوداني كإضافات مستدامة ومغذية للمخبوزات، وخاصة البسكويت. ومن خلال دمج هذه المنتجات الثانوية، نجحت الدراسة في تعزيز محتوى الألياف الغذائية والخصائص المضادة للأكسدة للبسكويت مع الحفاظ على

الصفات الحسية المقبولة. يساهم هذا البحث في معالجة تحديات إدارة النفايات الغذائية وتعزيز خيارات غذائية أكثر صحة واستدامة.

الكلمات المفتاحية: قشور الفول السوداني الخارجية والداخلية، والألياف الغذائية، البسكويت.