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RESEARCH*ARTICLE*
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Physiochemical And Microstructure Properties Of Pancake Supplemented With Some Novel Components And Different Levels Of Beetroot Powder (Beta Vulgaris).

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ABSTRACT
The global demand for healthier functional foods, particularly cereal-based products, is rising. Consumers seek options low in sugar and carbohydrates but rich in protein, minerals, and dietary fiber. This study aimed to develop nutrient-dense pancakes with enhanced fiber and antioxidant content by incorporating novel functional ingredients. Beetroot powder (BT) was added at varying levels (0, 5, 10, 15, and 20%) as a partial flour replacement. Samples underwent physical, chemical, sensory, and microstructural evaluations using SEM.
The results showed that physically, increasing BT levels decreased diameter and whiteness, while thickness and volume increased. Chemical analysis showed significant (P<0.05) increases in protein (11.0% to 16.25%), moisture (45.7% to 49.0%), ash (1.3% to 1.7%), fat (10.3% to 13.4%), and dietary fiber (2.6% to 4.7%). Carbohydrate content decreased by nearly 50% at 20% BT substitution. Sensory evaluation indicated that all formulations were acceptable (scored >5), with 20% BT being the most preferred. SEM analysis revealed that BT addition reduced starch gelatinization, strengthened the gluten-starch matrix, and increased micro-holes, enhancing structural integrity.
In conclusion, the results confirm possibility of developing healthier pancake using novel ingredients and BT with acceptable physical and sensorial attributes in order to replace conventional pancake that would be acceptable by consumers.

Keywords: functional food; beetroot powder; microstructure; physiochemical properties; sensory evaluation, pancake.

INTRODUCTION

The growing consumer interest in health-promoting foods, particularly those rich in antioxidants and low in carbohydrates, has driven an increased demand for innovative functional foods.(Galali et al., 2022). Various functional food products have been developed, ranging from beverages to dressings, with particular emphasis on bakery products. This focus is attributed to the widespread global consumption of bakery products, which are favored for their convenience, extended shelf life, and broad availability.(Krishnan et al., 2011).

Bakery products are commonly consumed worldwide as staple foods and part of daily diet (Paul et al., 2015). Common bakery products such as biscuits, muffins, cakes, bread, pastries, and pies are widely consumed across different cultures (Peng et al., 2016). Pancakes are known by various names and are incorporated into diverse culinary traditions worldwide (Gocmen et al., 2009).

Incorporating fruit and vegetable powders into food formulations has gained increasing attention due to their significant health benefits. Beetroot powder, in particular, has been utilized in numerous food products to enhance nutritional value and confer health-promoting effects. Its functional and nutritional composition includes carbohydrates (10 g), proteins (1.68 g), fats (0.18 g), dietary fiber (2 g), and minerals (0.483 g) per 100 g of wet weight(Chen et al., 2021). Moreover, beetroot is a rich source of bioactive compounds with potential health benefits, including the prevention of cardiovascular diseases and diabetes. Beetroot and its derivatives have been incorporated into a variety of food products, including dairy products (Mukherjee et al., 2024), sausages (Swastike et al., 2020), legume bakery products (Mitrevski et al., 2023) and legumes (Purificación García-Segovia, 2021).

However, despite its extensive application of beetroot and derivatives, there is still more information needed in the literature regarding its utilization in common bakery products such as low-carbohydrate pancakes, as well as its impact on their physical, chemical, and microstructural properties. This is due to the fact that addition novel functional ingredients might compromise quality and sensory attributes.
Therefore, the study aims to address this gap by investigating the effects of beetroot powder incorporation on low-carbohydrate pancakes' physicochemical, structural, and sensory attributes, thereby contributing to the development of healthier functional bakery products.

Material And Methodology

Material

All the materials used in this study such as Wheat flour, coconut oil, skimmed powdered milk, iodized salt; Vanilla, baking powder, Eggs, and Stevia were purchased freshly in the local markets in Erbil city.

Methodology

1- Beetroot powder preparation:

The locally sourced beetroot variety was thoroughly washed and peeled using a peeler to remove the outer skin. It was then sliced into uniform pieces with a thickness of 1 mm. The sliced beetroot was arranged on specialized trays and dehydrated at 52±2°C for 24 hours until a constant weight was achieved. Subsequently, the dehydrated beetroot was finely ground using a laboratory grinder (Gourmet Maxx 4201, Nutrition Mixer Deluxe, Germany). The resulting beetroot powder was stored in a specialized airtight container and kept in a dark environment to preserve its quality for future use (Mitrevski et al., 2023).

2- The pancake preparation

The pancake samples were prepared by mixing 24 g of skimmed powdered milk, 30 ml of coconut oil, 250 ml of water, 1 g of salt, 3 g of vanilla, 3 g of baking powder, 61.5 g±2 of eggs, 12 g of stevia, and 200 g of flour. For pancake samples, the flour was replaced with 5%, 10%, 15%, and 20% beetroot powder.

Table 1. ingredients percentage of pancake based on wheat flour with beetroot powder.

Component	Control	%5 BT	%10 BT	%15 BT	%20 BT
Wheat flour	200g	190g	180g	170g	160g
Beetroot powder	0g	10g	20g	30g	40g
milk	24g	24g	24g	24g	24g
Coconut Oil	30ml	30ml	30ml	30ml	30ml
Water	250ml	250ml	250ml	250ml	250ml
Salt	1g	1g	1g	1g	1g
Vanilla	3g	3g	3g	3g	3g
Baking powder	3g	3g	3g	3g	3g
Egg	61.5 g±2	61.5 g±2	61.5 g±2	61.5 g±2	61.5 g±2
Stevia	12g	12g	12g	12g	12g

BT, Beetroot powder, Control (100% wheat flour +%0 Beetroot), *%5* (95% wheat flour+5% Beetroot), %10 (90% wheat flour+10% Beetroot), %15 (85% wheat flour+15% Beetroot), %20 (80% wheat flour+20% Beetroot)

3- Physical analysis

A- Color assessment

The color of the pancake samples with and without novel ingredients was determined using a colorimeter (Hunter Lab Colour Flex, Model No. 45/0, USA). The color determination included a* (+: red; -: green), L* (100=white; 0=black), and b* (+: yellow; -: blue) using illuminate D65/10 as reference using the following equation:

$$\text{Whiteness} = 100 - [(100 - L*)^2 + a^{*2} + b^{*2}]^{0.5}$$

B- Volume

The volume of the pancake was determined using a standard seed displacement method. The process involved filling a known volume with seed and then emptying it. The samples were placed in, the seed was added, and the remaining volume was measured in a cylinder and considered sample volume (Galali, 2014).

C- Thickness

After cooling down the samples to ambient temperature, thickness of the pancake were measured using lab ruler, for accuracy, the cake turned around and another measurement were taken (Galali et al., 2022).

D- Texture analyzer

The texture of the pancake samples were measure using texture analyzer (Brookfield CT3 Texture Analyzer). The pancake texture were measured for hardness (Galali et al., 2022).

E- Diameter

Prior to cooling down the samples, Pancake diameter was measured using the a ruler (Al-Dmoor H. , Galali, 2014)

4- Chemical analysis of Pancakes

The chemical composition of the pancakes was determined by following the standard procedure as laid down in the literature of AOAC.

A-Crude fat determination

The fat content was determined by using Soxhlet extraction method (AOAC, 2012). In this method moisture free 5g sample was taken in a ready- made thimble and oil was extracted in pre-weighed round bottom flask (cleaned, dried and weighed) using petroleum ether is SOCS plus for 2.5 to 3 hours. The flask was then dried in a hot air oven to evaporate petroleum ether and allowed to cool, after cooling the final weight of the flask was taken and used for the estimation of crude fat content of sample.

The following equation was used for estimation of crude fat content (%) in the sample:

Fat content: (w1-w2/w) x100

Where,

W = Weight of sample taken (g)

W1= Weight of empty round bottom flask (g)

W2= Wight of the flask with fat (g)

B- Crude Protein determination

The protein content was determined using standard method of AACC46-10.01. The samples were first digested with H2So4. It was then distilled with ammonia and then titrated with NaoH. The crude protein was calculated based on the dry matter using the factor 6.25/ gN/100 g sample (Committee, 2000).

C-Determination of ash

The standard method of (AACC, 2009)was used to determine Ash content. An amount of 3 gm of the sample was placed in a crucible and then placed in muffle furnace at 550°C. The content of the Ash was calculated based on the % dry

The ash contents were expressed as ash in dry basis.(Committee, 2000).

D-Moisture content determination

The gravimetric method was used to quantify moisture content. An amount of 5 gm of the sample in a Petri dish was placed in the electric oven at 70°C for 2 hours and then cooled down and weighed. The process was continued until the weight stayed stable. The equation below was used to calculate moisture content.(AOAC, 2012).

Moisture content: (w1-w2/w) x100

Were,

W = Weight in g of sample taken.

W1 = Weight in g of the dish with the material before drying, W2 = Weight in g of the dish with the material after drying.

E-Carbohydrate content

The total carbohydrate content was calculated using the difference method. The amount of carbohydrate was taken out from, protein, fat, ash and moisture using the following equation

$$Total\ Carbohydrate\ (\%) = [100 - (\%\ moisture + \%\ ash + \%protein + \%fat)]$$

F-Energy value

The sample's energy value was calculated using the following mathematical equation:

$$Energy\left(\frac{kcal}{100g}\right) = [(\%carbohydrate * 4) + (\%protein * 4) + (\%fat * 9)]$$

5- Sensory Evaluation

The sensory evaluation of the pancake with and without the novel ingredients was done by 25 semi-trained students and staff members of the food technology department of Salahaddin University-Erbil under normal daylight. The pancakes were assessed for appearance, color, texture, flavor, and overall acceptability on a nine-hedonic scale (1, extremely disliked, to 9, extremely liked).

6- Microstructure determination (Scanning Electron Microscopy)

The microstructure of the pancake samples was studied using scanning electron microscopy (FEI Quanta 450, Oregon, United States). After drying the samples, they were placed on the holder and coated with gold and imaged at a magnification of 500.

Results

Table (2) proximate analysis of chemical composition of the pancake samples

Samples	%Protein	%Moisture	%Ash	%Fat	%Carbohydrate	%Fiber	Energy value (kcal/100g)
Control	11.02±1.2[e]	45.78±0.6[bc]	1.3±0.2[cde]	10.30±0.9[b]	31.56±0.8[a]	2.60±0.1[c]	262.2±6[a]

5% Beetroot	14.14±0.6^{cd}	46.25±0.5^{ab}	1.4±0.09^{dc}	12.35±1.0^{a}	25.83±1.9^{cd}	2.90±0.1^{d}	271.0±7^{b}
10% Beetroot	15.16±1.0^{abc}	42.17±1.8^{e}	1.5±0.04^{abc}	12.60±0.8^{a}	28.53±2.7^{ab}	3.60±0.1^{c}	288.1±5^{b}
15% Beetroot	15.72±1.0^{ab}	44.18±1.5^{cd}	1.6±0.02^{ab}	12.62±0.7^{a}	25.83±2.8^{bc}	4.20±0.1^{b}	279.7±5.6^{b}
20% Beetroot	16.25±0.9^{a}	49.07±2.4^{a}	1.7±0.03^{a}	13.40±1.0^{a}	19.53±1.3^{e}	4.70±0.1a	263.7±7.3^{b}

Control (100% wheat flour +%0 Beetroot), *%5* (95% wheat flour+5% Beetroot), %10 (90% wheat flour+10% Beetroot), %15 (85% wheat flour+15% Beetroot), %20 (80% wheat flour+20% Beetroot)

The results of the study showed that the protein content increased significantly (p>0.05) from 11.02g (control) to 16.25g (20% beetroot) (Table 2). Similarly, the addition of BT increased the moisture content from 45.78% to 49.07%. Moreover, ash content, fat content, and crude fiber increased from 1.3 (control) to 1.7 (20% BT). 10.3 (control) to 13.4 (20% BT) and 2.6 g/100 g (control) to 4.7 g/100 g (20% BT), respectively. On the other hand, carbohydrate content reduced from 31.56 (control) to 19.53 (20% BT). The addition of BT significantly increased the energy value of the products from 262.2 to 288.1 kcal. Generally, all the food nutrients increased with BT except carbohydrates, which decreased.

Table (3) Physical Properties of Pancake samples

Samples	Diameter (mm)	Thickness (mm)	Texture mg	Volume (ml)	Whiteness	Color		
						a	L	b
Control	122.5±2^{a}	5.7±0.2^{e}	332.0±2.6^{a}	47.0±6^{e}	49.7±5.9^{a}	14.61±3.4	68.29±5.7	36.02±2.4
5% Beetroot	115.0±3^{b}	7.2±0.2^{c}	332.6±2.5^{a}	75.3±3^{ab}	30.9±2.1^{b}	24.34±1.6	41.16±2.7	26.61±1.2
10% Beetroot	108.0±2^{c}	7.7±0.0^{c}	325.6±2.8^{a}	79.0±5^{a}	33.5±1.8^{b}	23.07±3.0	42.29±2.9	23.27±1.1
15% Beetroot	103.5±1^{cd}	8.5±0.2^{b}	336.0±4.0^{a}	64.6±6^{cd}	30.4±1.6^{b}	27.02±1.2	40.32±2.2	23.31±0.5
20% Beetroot	95.9±2^{e}	9.6±0.09^{a}	332.3±1.5^{a}	69.6±3^{bc}	25.3±1.6^{c}	23.68±3.5	32.06±1.1	19.72±1.2

Control (100% wheat flour +%0 Beetroot), *%5* (95% wheat flour+5% Beetroot), %10 (90% wheat flour+10% Beetroot), %15 (85% wheat flour+15% Beetroot), %20 (80% wheat flour+20% Beetroot)

The results of the physical analysis showed that the diameters of the samples were significantly (P<0.05) decreased with the increasing BT dose (Table 3). The control sample recorded the highest at 122.5 mm to the lowest 95.9 mm with the addition of 20% BT. In contrast, thickness (control (5.7 mm) and 20%BT (9.6) and volume (control (47 ml) and 20%BT (69.6) respectively, were significantly different. Furthermore, the whiteness of the samples was decreased with the addition of the beetroot. The whiteness of the control was recorded to be 49.7, and the lowest whiteness recorded was 25.3 for the 20% BT sample. Similarly, this is more obviously visualized in the pancake pictures (figure 2). It is clearly seen that the darkness of the colour is increasing in parallel with increasing.

Regarding the sensory attributes of samples with and without the BT, the benchmark and passing scale was five. From the results of figure 1, it can be seen that the control, only appearance, and overall acceptability recorded seven; the rest recorded six out of nine. Regarding samples with 5%, 10%, and 15%, the majority of the parameters got six out of nine. However, surprisingly, the sensory characteristics of the pancake with 20% BT scored seven out of nine. This could mean that all the samples were accepted by the panelists because they recorded and passed the benchmark (5).

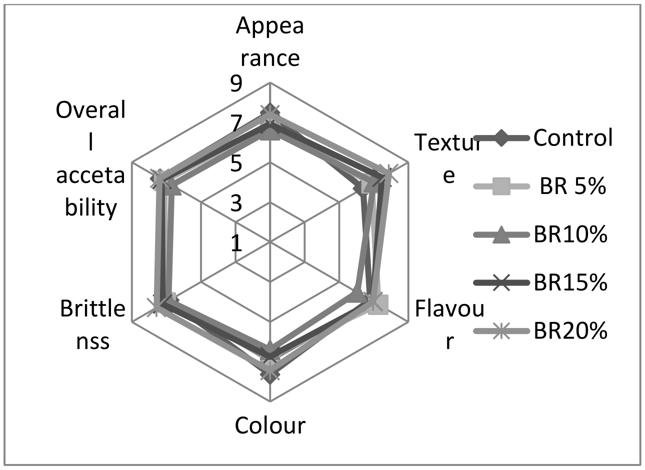

Figure (1) Sensory attributes of the pancake samples with and without beetroot
Control (100% wheat flour +%0 Beetroot), *%5* (95% wheat flour+5% Beetroot), %10 (90% wheat flour+10% Beetroot), %15 (85% wheat flour+15% Beetroot), %20 (80% wheat flour+20% Beetroot)

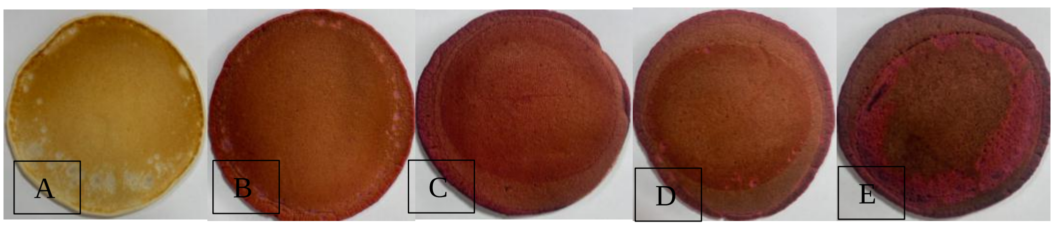

Figure (2) Appearance of pancake samples
A) Control (100% wheat flour +%0 Beetroot), (B) *%5* (95% wheat flour+5% Beetroot), (C)%10 (90% wheat flour+10% Beetroot), (D)%15 (85% wheat flour+15% Beetroot), (E)%20 (80% wheat flour+20% Beetroot)

The SEM analysis of the samples helped visualize the impact of novel ingredients on the microstructure of pancakes, particularly the protein and starch matrix. The control sample (A) seems to be comprehensively gelatinized, and the starch outline cannot be determined and is covered with protein. However, in samples with the BT added, the starches are less gelatinized. The hole size is 600 µm to a maximum of 940 µm. On the other hand, the hole of other samples seems to be larger and mostly more than 1 mm.

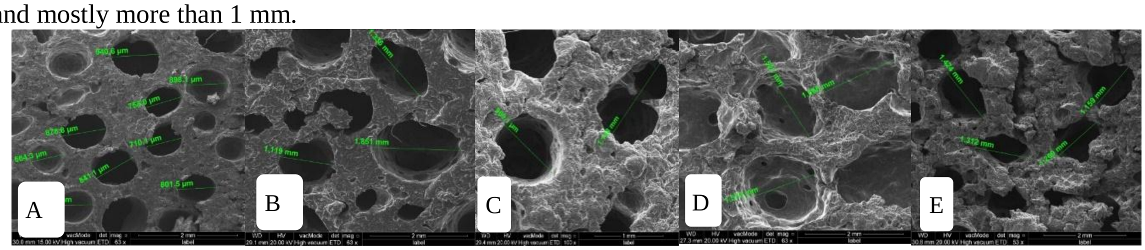

Figure (3) The microstructure of SEM of Pancake with and without beetroot powder
(A) Control (100% wheat flour +%0 Beetroot), (B) *%5* (95% wheat flour+5% Beetroot), (C)%10 (90% wheat flour+10% Beetroot), (D)%15 (85% wheat flour+15% Beetroot), (E)%20 (80% wheat flour+20% Beetroot)

DISCUSSION

The results of the physical properties analysis showed that the samples with BT is smaller in diameter but thicker in thickness, similar in texture and larger in volume. Previous result showed that addition of BT to cookies (Sahni & Shere, 2016) reduced diameter and increased thickness. The results of earlier study showed that addition of BT 15-20% improved physical properties (Lucky et al., 2020). This might be due to the fact that addition of BT make is stronger because of having soluble dietary fibre. This fibre has a greater affinity toward water and retains more water. This was also confirmed as moisture content of the samples with BT was proportionally increased with increase in BT content. Increase In the moisture content improves the texture and shelf life of the products (Galali et al., 2022).

The results of the chemical analysis showed that majority of the components like protein, fat mineral and dietary fibre increased. That could mean that the samples are improved nutritionally. This could be attributed to the addition of the BT.

This results is in congruent with previous who stated that supplementation of BT into bakery products improved nutritional value (Lucky et al., 2020; Mitrevski et al., 2023). earlier study confirmed increasing BT percentage to a sample proportionally increases important nutrients like Ash and dietary fibre (Manivannan & Rajasimman, 2011). Increasing fibre consumption might reduce the risks of metabolic diseases (Malekpour et al., 2023; Weickert & Pfeiffer, 2018). On the other hand carbohydrate content decreased due to the replacement of flour with BT. This is also a positive indication on the development of products since many researchers connect sugar and carbohydrate with many metabolic diseases.

Sensory evaluation by the panellist showed the acceptance level of sensory attributes. It was not expected that adding 20% of BT would gain highest consumer acceptance. Previous results showed that adding 15 and 20% of BT showed better sensory attributes (Lucky et al., 2020). This is a positive indication that the addition of the BT not just did not compromise the quality, but it rather improved the sensory attributes and increased acceptability by the consumers.

The microstructure of the pancake showed that the starches are less gelatinized in the BT samples comparing to the control (0% BT) and the outline of the starch matrix are clearly seen. This is also confirmed by previously conducted research. Previous study also showed that addition of dietary fibre or sources of dietary to bakery products absorb more water and reduces starch gelatinization (Galali et al., 2022). This can be due to great affinity of dietary fibre to moisture comparing to flour protein and polysaccharides. SEM analysis revealed that BT addition reduced starch gelatinization, strengthened the gluten-starch matrix, and increased micro-holes, enhancing structural integrity. This result was also seen in thickness and diameter that the thickness was increased and the diameter was reduced.

Conclusion

The interest of functional foods is growing worldwide due to the concern of community about health. In this study, the addition of beetroot powder significantly enhanced both the physical and sensory attributes of the pancake samples. Furthermore, the chemical composition and nutritional profile exhibited proportional improvements with increasing levels of beetroot powder. The findings indicate that it is feasible to develop pancakes with up to 20% beetroot powder substitution while maintaining acceptable physical and sensory characteristics, along with enhanced nutritional value.

Conflict of interest: None

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References

[1]. Al-Dmoor H. , Galali, Y. (2014). Novelty Formulas of Free Gluten Flat Bread for Celiac Disease Patients. *World Journal of Medical Sciences*, *11*(3), 306–311.

[2]. AOAC. (2012). *Official Method of Analysis Association of Analytical Chemists. 19th Edition, Washington DC, 121-130.* https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1819676

[3]. Chen, L., Zhu, Y., Hu, Z., Wu, S., & Jin, C. (2021). Beetroot as a functional food with huge health benefits: Antioxidant, antitumor, physical function, and chronic metabolomics activity. *Food Science & Nutrition*, *9*(11), 6406–6420. https://doi.org/10.1002/FSN3.2577

[4]. Committee, A. A. of C. C. A. M. (2000). *Approved methods of the American association of cereal chemists* (Vol. 1). American Association of Cereal Chemists.

[5]. Galali, Y. (2014). *Quality and shelf life of Pita and Tandoori breads supplemented with three novel functional ingredients*. University of Plymouth.

[6]. Galali, Y., Rees, G., & Kuri, V. (2022). The Impact of Waxy Wheat Flour, Inulin and Guar Gum on Post- Prandial Glycaemic and Satiety Indices, Sensory Attributes and Shelf Life of Tandoori and Pita Breads. *Applied Sciences (Switzerland)*, *12*(7). https://doi.org/10.3390/APP12073355

[7]. Gocmen, D., Inkaya, A. N., & Aydin, E. (2009). Flat Breads. *Bulgarian Journal of Agricultural Science*, *15*(4), 298–306.

[8]. Krishnan, R., Dharmaraj, U., Sai Manohar, R., & Malleshi, N. G. (2011). Quality characteristics of biscuits prepared from finger millet seed coat based composite flour. *Food Chemistry*, *129*(2), 499–506. https://doi.org/10.1016/J.FOODCHEM.2011.04.107

[9]. Lucky, A. R., Al-Mamun, A., Hosen, A., Toma, M. A., & Mazumder, M. A. R. (2020). Nutritional and sensory quality assessment of plain cake enriched with beetroot powder. *Food Research*, *4*(6), 2049–2053. https://doi.org/10.26656/FR.2017.4(6).268

[10]. Malekpour, M. R., Abbasi-Kangevari, M., Ghamari, S. H., Khanali, J., Heidari-Foroozan, M., Moghaddam, S. S., Azangou-Khyavy, M., Rezazadeh-Khadem, S., Rezaei, N., Shobeiri, P., Esfahani, Z., Rezaei, N., Aali, A., Abd-Elsalam, S., Abdoun, M., Absalan, A., Abu-Gharbieh, E., Abu-Rmeileh, N. M., Abu-Zaid, A., … Farzadfar, F. (2023). The burden of metabolic risk factors in North Africa and the Middle East, 1990–2019: findings from the Global Burden of Disease Study. *EClinicalMedicine*, *60*. https://doi.org/10.1016/j.eclinm.2023.102022

[11]. Manivannan, P., & Rajasimman, M. (2011). Optimization of process parameters for the osmotic dehydration of

beetroot in sugar solution. *Journal of Food Process Engineering*, *34*(3), 804–825. https://doi.org/10.1111/J.1745-4530.2009.00436.X

[12]. Mitrevski, J., Pantelić, N., Dodevska, M. S., Kojić, J. S., Vulić, J. J., Zlatanović, S., Gorjanović, S., Laličić-Petronijević, J., Marjanović, S., & Antić, V. V. (2023). Effect of Beetroot Powder Incorporation on Functional Properties and Shelf Life of Biscuits. *Foods*, *12*(2), 322. https://doi.org/10.3390/FOODS12020322/S1

[13]. Mukherjee, P., Tewari, S., & Chakravarti, A. R. (2024). Development of novel non-dairy synbiotic chocolates for promoting desirable gut microbiome. *International Journal of Advanced Biochemistry Research*, *8*(6), 619–626. https://doi.org/10.33545/26174693.2024.V8.I6H.1389

[14]. Paul, D., Biswas, R., & Bhattacharyya, N. S. (2015). Investigating photonic crystal fiber within e to L communication band with different material composites. *Optik*, *126*(23), 4640–4645. https://doi.org/10.1016/j.ijleo.2015.08.075

[15]. Peng, P., Namkung, J., Barnes, M., & Sun, C. (2016). A meta-analysis of mathematics and working memory: Moderating effects of working memory domain, type of mathematics skill, and sample characteristics. *Journal of Educational Psychology*, *108*(4), 455.

[16]. Purificación García-Segovia, M. I. andJavier M.-M. (2021). Beetroot Microencapsulation with Pea Protein Using Spray Drying: Physicochemical, Structural and Functional Properties. *Applied Sciences (Switzerland)*, 11, 6658.

[17]. Sahni, P., & Shere, D. M. (2016). Physico-chemical and sensory characteristics of beet root pomace powder incorporated fibre rich cookies. *International Journal of Food and Fermentation Technology*, *6*(2), 309. https://doi.org/10.5958/2277-9396.2016.00055.6

[18]. Swastike, W., Suryanto, E., Rusman, R., Hanim, C., Jamhari, J., Erwanto, Y., & Jumari, J. (2020). The Substitution Effects of Tapioca Starch and Beetroot Powder as Filler On The Physical and Sensory Characteristics Of Chicken Sausage. *Jurnal Ilmu Dan Teknologi Hasil Ternak* , *15*(2), 97–107. https://doi.org/10.21776/UB.JITEK.2020.015.02.5

[19]. Technical, A. (2009). Moisture--Air-Oven Methods. *AACC International Approved Methods*. https://doi.org/10.1094/AACCINTMETHOD-44-15.02

[20]. Weickert, M. O., & Pfeiffer, A. F. H. (2018). Impact of Dietary Fiber Consumption on Insulin Resistance and the Prevention of Type 2 Diabetes. *The Journal of Nutrition*, *148*(1), 7–12. https://doi.org/10.1093/JN/NXX008

الخصائص الفيزيائية والكيميائية والبنية الدقيقة للفطائر المضاف إليها بعض المكونات الجديدة ومستويات مختلفة من مسحوق الشمندر (Beta vulgaris).

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الخلاصة

يتزايد الاهتمام العالمي بالأغذية الوظيفية الصحية، لا سيما المنتجات القائمة على الحبوب التي تتميز بانخفاض محتواها من السكر وارتفاع قيمتها الغذائية من حيث البروتين والمعادن والألياف الغذائية. تهدف هذه الدراسة إلى تطوير فطائر غنية بالعناصر الغذائية من خلال استبدال الدقيق جزئيًا بمستويات متفاوتة من مسحوق الشمندر (***BT***) بنسبة 0، 5، 10، 15، و20%. خضعت العينات لتقييمات متعددة شملت التحليل الفيزيائي والكيميائي، والتقييم الحسي، وتحليل البنية المجهرية باستخدام المجهر الإلكتروني الماسح. أظهرت النتائج أن إضافة ***BT*** أدت إلى انخفاض القطر ومستوى البياض، في حين زاد كل من السمك والحجم. من الناحية الكيميائية، لوحظت زيادة معنوية (***P<0.05***) في محتوى البروتين (من 11% إلى 16.25%)، الرطوبة (من 45.7% إلى 49.0%)، الرماد (من 1.3% إلى 1.7%)، الدهون (من 10.3% إلى 13.4%)، والألياف الغذائية (من 2.6% إلى 4.7%). في المقابل، انخفضت نسبة الكربوهيدرات بنحو 50% عند استبدال 20% من الدقيق بـ ***BT***. أظهرت نتائج التقييم الحسي تقبل جميع العينات، مع تحقيق عينة 20 ***BT***% لأعلى درجات القبول. كما كشفت صور البنية المجهرية أن إضافة ***BT*** قللت من جلتنة النشا، لكنها عززت تكوين مصفوفة الجلوتين والنشا، وزادت من عدد الثقوب المجهرية.. وفي الختام، تؤكد النتائج إمكانية تطوير فطائر أكثر صحة باستخدام مكونات جديدة و***BT*** بخصائص فيزيائية وحسية مقبولة لتحل محل الفطائر التقليدية.

الكلمات المفتاحية: اغذية وظيفية؛ مسحوق البنجر؛ التركيب الدقيق؛ الخصائص الفيزيائية والكيميائية؛ التقييم الحسي فطيرة.