USE OF PINEAPPLE CORE AND DURUM SEMOLINA IN PASTA MAKING: EFFECTS OF DIFFERENT RATIOS OF PINEAPPLE CORE POWDER ON THE PRODUCT QUALITY

Le Nguyen Phuc[1], Nguyen Hong Anh[1],
Tran Thi Thu Tra[1], Ton Nu Minh Nguyet[1], Le Van Viet Man[1]

ABSTRACT

Pineapple core is a by-product of canned sliced pineapple in syrup. In this study, this by-product was proved to be a source of dietary fiber and phenolic compounds with high antioxidant activity. Pineapple core powder (PCP) was then added to pasta recipe at 0 (control), 5, 10, 15 and 20% of the blend weight for pasta making. The effects of different ratios of PCP on the pasta quality were investigated. Increase in PCP ratio improved total dietary fiber, and phenolic content as well as antioxidant activity of the product but reduced its starch content. In addition, high level of PCP in the pasta formulation resulted in high hardness and cooking loss but low elongation rate, tensile strength, and overall acceptability. When the PCP ratio varied from 5 to 15%, the obtained pasta was high fiber food with acceptable sensory quality. PCP is a potential ingredient in the formulation of pasta with high fiber and antioxidant content.

Keywords: *Antioxidant, dietary fiber, pasta, pineapple core.*

Received: 2 May 2022; revised: 12 June 2022; accepted: 20 July 2022

1. INTRODUCTION

Dietary fiber and antioxidants are noticeably crucial supplements for human diet since they can make positive impacts on health such as improving digestive system, reducing blood cholesterol, preventing obesity, type-2 diabete, and colonic cancer [1]. Pasta is a well-known food worldwide and the consumption of pasta has been increasing in the world market. However, traditional pasta is poor in dietary fiber and antioxidant [2]. From the last recent years, different by-products originated from food processing have been added to pasta recipe for the improvement in dietary fiber and antioxidant content such as cellulase-treated wheat bran [3], apple pomace [4], grape pomaces [5]. Nevertheless, high ratio of food by-products in the pasta formulation decreases textural and cooking properties as well as sensory quality of the product [3-5]. It should be noted that the use of by-products in food industry to make pasta with high dietary fiber and antioxidant content is a sustainable development for a better exploitation of agricultural products.

Pineapple is tropical fruit which has been widely cultivated in Vietnam. This fruit is industrially processed into different food products, among which canned pineapple slices in syrup is a popular canned food due to high convenience, long shelf-life, high microbiological quality. In the production of canned pineapple slices in syrup,

[1] Department of Food Technology, Ho Chi Minh city University of Technology (HCMUT)
Vietnam National University - Ho Chi Minh city (VNU-HCM)
Corresponding author: lvvman@hcmut.edu.vn

pineapple core is a by-product which is conventionally used for animal feeding. It is reported that pineapple core is treated and utilized as a dietary fiber source for supplementation in bakery products such as doughnut and steamed bread [6]. However, the use of pineapple core in pasta making has not been considered in the world.

In this research, pineapple core powder (PCP) was added to durum semolina for pasta making. The aim of this study was to investigate the impacts of different ratios of PCP on the pasta quality including proximate composition, antioxidant activity, cooking quality, texture profile and overall acceptability.

2. MATERIALS AND METHODS

2.1. Materials

Pineapple (*Ananas comosus* L.) core was provided by Viet Duc Food Technology Co., Ltd. Durum semolina was purchased from Vietnam Wheat Milling Co., Ltd. Refined salt with added iodine was supplied by Southern Salt Group, Vietnam.

2.2. Analytical chemicals

Enzyme preparations including α-amylase Termamyl®SC, glucoamylase Dextrozyme®GA and protease Neutrase®2.5L used for dietary fiber determination were provided by Novozymes (Denmark). Chemicals with analytical grade were originated from Sigma-Aldrich (USA) and Xilong Scientific Company (China).

2.3. Preparation of pineapple core powder (PCP)

Fresh pineapple core was milled and pressed for juice extraction. The resulting pomace of pineapple core was sterilized at 115°C for 10 min to inactivate microorganisms and enzymes, then dried at 50°C for 4 h until the moisture content reached 13%. The dried product was sieved through a 70 mesh (210 μm) sieve and the product powder was stored in the freezer at 4°C for further experimentation.

2.4. Pasta making procedure

In this recipe, the blend of durum semolina and PCP with total weight of 150 g and 0,75 g salt were dry-mixed at room temperature in a mixer at 72 rpm for 3 min to form a uniform mixture. The dry mix was then added with 68 g water at 42°C and kneaded in 20 min using a stand mixer to produce a uniform dough. The obtained dough was extruded by an extruder to make pasta. The pasta was subsequently dried at 50°C for 8 h until it reached 9-11% moisture content. The ratio of PCP was 0% (control), 5%, 10%, 15% and 20% of the blend weight.

2.4. Analytical methods

Moisture content was measured by drying to constant weight using an infrared moisture analyzer. Total protein was determined by Kjeldhal-Nessler method (AOAC 984.13). Lipid was quantified followed Soxhlet method (AOAC 960.39). Ash was determined according to AOAC 9930.30 method. Starch was measured following AOAC 996.11 method. Total, insoluble and soluble dietary fiber (TDF, IDF and SDF) was estimated according to AOAC 985.29, 991.42 and 991.43 method, respectively. Total phenolics were determined by colorimetric method with Folin-Ciocalteu reagent. Antioxidant activity including DPPH (2.2-diphenyl-1-picrylhydrazyl) radical scavenging activity and ferric reducing power (FRAP) were analyzed according to the procedure described by Nguyen *et al.* (2020) [3]. The particle size distribution of PCP and durum semolina samples was determined by a laser diffraction particle size distribution analyzer (Horiba, Japan); the mean particle size (d4,3) and specific surface area were calculated using LA-920 software (Horiba, Japan); the span value was calculated by the formula reported by Kippax (2005) [7]. Water and oil holding capacity of wheat semolina and

PCP as well as optimal cooking time, cooking loss, and swelling index of pasta samples were measured following the procedure reported by Nguyen *et al.* (2020) [3]. Instrumental color data including L*, a*, b* indexes were quantified by a CM-3700A colorimeter (Konica Minolta, Japan); the color difference (ΔE) between the control pasta and the pasta added with PCP was calculated by the formula described by Martin (2015) [8]. Textural properties of cooking pasta samples were analyzed by a TA-TX structural analyzer (Stable Micro Systems Co., UK) coupled with the Exponent Connect Lite 7.0 software. Overall acceptability of pasta samples was evaluated using a nine-point hedonic test [3]. Sixty untrained panelists were randomly selected from the students at Ho Chi Minh city University of Technology (HCMUT) without training and gender consideration. About 1 L of water was used to cook every 100 g of raw pasta according to their optimal cooking time. Then, 30 g of each cooked samples were labeled with different codes and served at the same time with randomized order to each panelist. Water was also provided for mouth cleansing between samples. The panelists were asked to consume the cooked pasta and rate their overall acceptability ranging from 1 (extremely dislike) to 9 (extremely like).

2.5. Statistical analysis

All experiments were repeated three times to calculate the average value. The results are presented as mean ± standard deviation. The experimental results were processed by Analysis of Variance (ANOVA) using the Statgraphics Centurion XVI software (USA). Significant differences were ultimately determined by multiple range test ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1. Proximate composition, antioxidant activity, and physical properties of pineapple core powder and durum semolina

Table 1 shows the proximate composition, antioxidant activity, and physical properties of PCP and durum wheat semolina. The moisture content of durum semolina was slightly higher than that of PCP. Additionally, the protein and starch content of durum semolina were significantly higher than that of PCP. In contrast, the lipid and ash content in PCP was 1.9 and 3.6 times, respectively, higher than that of durum semolina. The dietary fiber content is an important indicator to evaluate the potential use of PCP as a source of dietary fiber. In this study, the TDF content of PCP was approximately 19 times higher than that of durum semolina. PCP was therefore proved to be a good dietary fiber source for pasta supplementation.

Phenolic compounds are representative antioxidants of PCP [9]. The total phenolic content in PCP was about 2.4 times higher than that in durum semolina. As a result, the DPPH radical scavenging activity and ferric reducing power of PCP were significantly greater than those of durum semolina. Thus, PCP was also a potential antioxidant source for supplementation to different food products.

In terms of physical properties, the particle size mean of PCP was smaller than that of semolina while the specific surface area of PCP was greater. The higher SPAN index of PCP revealed a better uniformity in particle size as compared to that of durum semolina. The water holding capacity of PCP was 7.9 times higher than that of semolina due to its higher fiber content and specific surface area. It should be noted that the hydroxyl group of fiber could interact with water [10], resulting in high water holding capacity for fiber material. Similarly, the oil holding capacity of PCP was 4.3 times higher than that of durum semolina due to porous structure of pineapple core fibers [11].

The instrumental color data showed that durum semolina had slightly higher brightness (L* = 91.2) than PCP (L* = 85.7).

Table 1. Proximate composition, antioxidant activity, and physical properties of pineapple core powder and durum semolina

Raw materials	Pineapple core powder	Durum wheat semolina
Moisture (%, ww)	9.3 ± 0.1 [a]	10.2 ± 0.1[b]
Crude protein (%, dw)	5.1 ± 0.1 [a]	13.8 ± 0.1 [b]
Lipid (%, dw)	3.1 ± 0.1[b]	1.6 ± 0.1 [a]
Ash (%, dw)	1.8 ± 0.1[b]	0.5 ± 0.1 [a]
Starch (%, dw)	3.5 ± 0.1 [a]	80.2 ± 1 [b]
TDF (%, dw)	65.7 ± 0.4 [b]	3.3 ± 0.5 [a]
IDF (%, dw)	2.4 ± 0 [b]	1.4 ± 0.3 [a]
SDF (%, dw)	63.3 ± 0.4 [b]	1.9 ± 0 [a]
Total phenolics (mgGAE/ kg dw)	2554 ± 99 [b]	1051 ± 76 [a]
Ferric reducing power (µmolTE/ kg dw)	5381± 55 [b]	753± 21 [a]
DPPH radical scavenging activity (µmol TE/ kg dw)	4634 ± 98 [b]	1316 ± 74 [a]
Water holding capacity (g water/g dw)	6.3 ± 0.1 [b]	0.8 ± 0.1 [a]
Oil holding capacity (g oil/g dw)	3 ± 0.1 [b]	0,7 ± 0.1 [a]
Mean particle size (µm)	117.7 ± 3.1[a]	182.7 ± 5.5[b]
Specific surface area (m^2 /kg)	738.5 ± 16.7 [b]	277.4 ± 14.3 [a]
SPAN	2.8 ± 0.1 [a]	3 ± 0.1 [b]
L*	91.2 ± 0[b]	85.7 ± 0.1 [a]

Values that do not share a lowercase letter (a-d) within a row are significantly different ($p < 0.05$).

3.2. Proximate composition of pasta

Table 2 presents the proximate composition of pasta with different PCP ratios. The moisture content of all pasta samples was statistically similar ($p>0.05$), and this moisture content met the required standard for pasta storage at room temperature. When the PCP ratio of the pasta formulation increased from 0 to 20%, the protein content of the product reduced by 13% while its lipid content increased by 22%. That is due to the difference in protein and lipid content of PCP and durum semolina. Nevertheless, the increased PCP ratio did not result in significant change in ash content of the pasta since the difference in ash content between PCP and durum semolina was little.

Increase in PCP ratio in the pasta recipe from 0 to 20% increased the SDF, IDF and TDF content of the product by 1.3; 7.8 and 4.8 times, respectively, but decreased its starch content by 19%. Similar increase in dietary fiber content was also reported when grape pomace was supplemented to the pasta formulation [5]. It should be noted that when the PCP ratio was 5% or higher, the resulting pasta was considered as high fiber food since its TDF content was higher than 6 g/100 g [12].

Table 2. Proximate composition of pasta with different ratios of pineapple core powder

Ratio of pineapple core powder (%)	0	5	10	15	20
Moisture (%, ww)	9.0 ± 0.1 ^{a}	9.0 ± 0.1 ^{a}	9.0 ± 0.2 ^{a}	9.0 ± 0.1 ^{a}	9.0 ± 0.1 ^{a}
Crude protein (%, dw)	12.9 ± 0.2 ^{d}	12.6 ± 0.1 ^{d}	12.2 ± 0.1 ^{c}	11.7 ± 0.1 ^{b}	11.2 ± 0.2 ^{a}
Lipid (%, dw)	1.8 ± 0.2 ^{a}	1.9 ± 0.2 ^{a}	2.0 ± 0.1 ^{ab}	2.1 ± 0.1 ^{b}	2.2 ± 0.1 ^{b}
Ash (%, dw)	0.8 ± 0.1 ^{a}	0.8 ± 0 ^{a}	0.8 ± 0.1 ^{a}	0.9 ± 0.1 ^{a}	0.9 ± 0.1 ^{a}
Starch (%, dw)	80.2 ± 0.7 ^{e}	76.4 ± 0.4 ^{d}	72.5 ± 0.6 ^{c}	68.7 ± 0.3 ^{b}	64.9 ± 0.5 ^{a}
TDF (%, dw)	3.3 ± 0.1 ^{a}	6.3 ± 0.2 ^{b}	10.1 ± 0.3 ^{c}	12.8 ± 0.3 ^{d}	15.8 ± 0 ^{e}
IDF (%, dw)	1.8 ± 0.1 ^{a}	4.8 ± 0.1 ^{b}	8.5 ± 0.3 ^{c}	11.1 ± 0.3 ^{d}	14.0 ± 0^{e}
SDF (%, dw)	1.4 ± 0 ^{a}	1.5 ± 0 ^{b}	1.6 ± 0.1 ^{b}	1.7 ± 0 ^{c}	1.8 ± 0 ^{d}

Values that do not share a lowercase letter (a-d) within a row are significantly different ($p < 0.05$)

3.3. Antioxidant activity of pasta

Figure 1 demonstrates the effects of PCP supplementation on the phenolic content and antioxidant activity of pasta. When the PCP ratio was enhanced from 0 to 20%, the total phenolic content of the pasta increased by 1.2 times while its DPPH radical scavenging activity and ferric reducing power were improved by 1.7 and 2.9 times, respectively. Similar results were also recorded in the study of Yadav and Gupta (2015) when apple pomace was added to pasta formulation [4]. Thus, PCP was a good source for both fiber and antioxidant supplementation to pasta products.

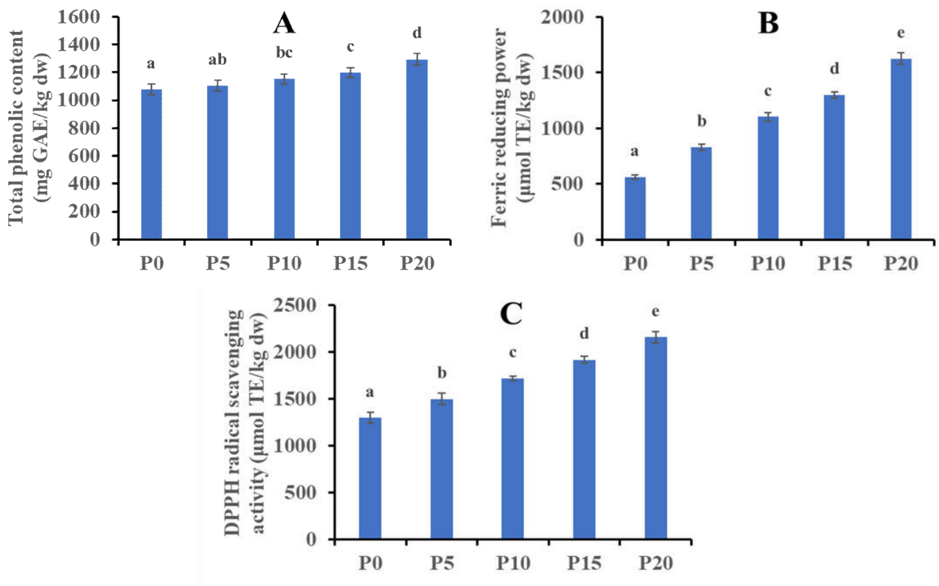

Figure 1. Total phenolic content (A), ferric reducing power (B), and DPPH radical scavenging activity of pasta with different pineapple core powder ratios

Values that do not share a lowercase letter (a-d) within each sub-figure are significantly different (p < 0.05)

3.4. Cooking quality of pasta

Table 3 illustrates the effects of PCP addition on the cooking quality of pasta. Increase in PCP ratio from 0 to 20% decreased the optimal cooking time by 26%. On the other hand, when the level of PCP increased from 0 to 20%, the cooking loss was enhanced by 64%. It can be explained that the use of PCP decreased gluten content in the pasta dough as well as resulted in the distribution of fiber molecules in gluten-starch network of the dough [5]. These modifications could cause a physical disturbance of the gluten-starch network, allowing water rapidly to diffuse into pasta as well as dissolved compounds of pasta to release more into the cooking water. When durum bran and germ (pollard) were added to pasta formulation, the reduction in optimal cooking time and increase in cooking loss were also reported [13].

Besides, the supplementation of PCP to pasta recipe also decreased the swelling index of the product. At 20% PCP level, the swelling index decreased by 39% compared to that of the control probably due to a reduction in starch content of pasta. During pasta cooking, water adsorption was observed for starch granules which are mainly responsible for pasta swelling [14].

Table 3. Cooking quality of pasta with different pineapple core powder ratios

Ratio of pineapple core powder (%)	0	5	10	15	20
Optimal cooking time (min)	13.4 ± 0.1 ^{e}	12.3 ± 0.2 ^{d}	11.8 ± 0.2 ^{c}	10.8 ± 0.2 ^{b}	9.9 ± 0.1^{a}
Cooking loss (%)	4.5 ± 0.1 ^{a}	4.8 ± 0.1 ^{ab}	5.4 ± 0.1 ^{b}	6.5 ± 0.4 ^{c}	7.4 ± 0.7 ^{d}
Swelling index	1.8 ± 0.1 ^{d}	1.8 ± 0.1 ^{d}	1.5 ± 0.1 ^{c}	1.3 ± 0.1 ^{b}	1.1 ± 0.1 ^{a}

Values that do not share a lowercase letter (a-d) within a row are significantly different (p<0.05).

3.5. Instrumental color, textural properties, and overall acceptability of pasta

The effects of PCP use in pasta recipe on the instrumental color, texture profile, and overall acceptability of pasta are visualized in table 4. The increased PCP level in the recipe slightly decreased the L* value but enhanced both a* and b* values. In practice, the pasta samples with PCP were slightly darker, and their yellow color became more obvious. Nevertheless, the color difference between the PCP added pasta and the control was little since the ΔE value varied from 0 to 5.9.

The use of PCP enhanced the hardness of pasta. At 20% PCP level, the hardness of pasta was 64% higher than that of the control. The increased fiber content might reduce the water absorption and swelling capacity of the starch granules, leading to the increased hardness of pasta [14]. In contrast, the cohesiveness decreased by 12% for the pasta sample with 20% PCP level as compared to that of the control. For high fiber pasta, the network between protein and starch molecules was disrupted by fiber compounds, leading to an increase in cooking loss and a reduction of cohesiveness [3]. The gumminess and chewiness of pasta sample supplemented with 20% PCP level were 44% and 41%, respectively, higher than those of the control. The same tendency was recently observed in the study of Sohaimy *et al.* (2020) when durum semolina and chickpea powder were used in pasta making [15]. Furthermore, the addition of PCP to pasta recipe decreased tensile strength and elongation rate since the presence of fibers might disrupt gluten network of the product [3].

Table 4 also reveals that the overall acceptability of pasta gradually decreased with the increased proportion of PCP. However, the pasta samples with PCP level of 5, 10 and 15% were considered acceptable since their overall acceptance score was above 5 points. The recommended ratio of PCP used in making fiber with high dietary fiber and antioxidant content was therefore from 5 to 15% of the blend weight.

Table 4. Color values, texture profile and overall acceptability of pasta

Ratio of pineapple core powder (%)	0	5	10	15	20
L*	90.4 ± 0.1 ^{e}	89.5 ± 0 ^{d}	88.5 ± 0.1 ^{c}	87.3 ± 0 ^{b}	86.2 ± 0.1 ^{a}
a*	0.9 ± 0 ^{b}	0.8 ± 0 ^{a}	0.9 ± 0 ^{b}	1.1 ± 0 ^{c}	1.3 ± 0^{d}
b*	8.8 ± 0.2 ^{a}	10.0 ± 0.2 ^{b}	11.3 ± 0.2 ^{c}	12.3 ± 0.4 ^{d}	12.9 ± 0.4 ^{e}
ΔE	0 ± 0 ^{a}	1.5 ± 0.2 ^{b}	3.1 ± 0.2 ^{c}	4.7 ± 0.3 ^{d}	5.9 ± 0.3 ^{e}
Hardness (g)	2321 ± 59 ^{a}	2956 ± 60 ^{b}	3274 ± 78 ^{c}	3545 ± 92 ^{d}	3814 ± 82 ^{e}
Gumminess (g)	1510 ± 26 ^{a}	1806 ± 57 ^{b}	1932 ± 49 ^{c}	2050 ± 62 ^{d}	2171 ± 98 ^{e}

Chewiness (g)	1465 ± 28 [a]	1745 ± 53 [b]	1854 ± 63 [c]	1959 ± 82 [d]	2063 ± 79 [e]
Cohesiveness	0.65 ± 0.01 [d]	0.61 ± 0.01 [c]	0.59 ± 0.01 [b]	0.58 ± 0.01 [ab]	0.57 ± 0.02 [a]
Tensile strength (kPa)	32 ± 0.9 [e]	29.1 ± 0.6 [d]	26.6 ± 0.5 [c]	23.9 ± 1.1 [b]	21 ± 0.9 [a]
Elongation rate (%)	97.1 ± 4.8 [e]	48.7 ± 2 [d]	36.9 ± 1.7 [c]	31.1 ± 1.5 [b]	16.4 ± 0.7 [a]
The overall acceptability	6.8 ± 1 [d]	6 ± 1.1 [c]	5.4 ± 0.9 [b]	5.3 ± 0.9 [b]	4.4 ± 0.9 [a]

Values that do not share a lowercase letter (a-d) within a row are significantly different (Turkey's comparison test, $p < 0.05$)

4. CONCLUSION

PCP was proved to be a good source of fiber and phenolic compounds with considerably higher antioxidant activity than durum semolina. When the PCP ratio in pasta recipe increased, the dietary fiber and total phenolic content as well as the antioxidant activity of the pasta were significantly improved while the starch content decreased. In addition, increase in PCP ratio in the pasta formulation enhanced hardness of the product but reduced its elongation rate and tensile strength. Pasta with increased PCP ratio had enhanced cooking loss but its optimal cooking time, swelling index and overall acceptability decreased. When the PCP ratio varied from 5 to 15%, the obtained pasta was a high fiber product and accepted by consumers. Therefore, businesses can consider the addition PCP to pasta formulation in the range of 5 to 15% depending on target consumers. Use of PCP for pasta fortification with dietary fiber and antioxidant was potential for development of healthy food products.

ACKNOWLEDGMENTS

This research is funded by Vietnam National University - Ho Chi Minh city (VNU-HCM) under grant number NCM2020-20-01. We acknowledge the support of time and facilities from Ho Chi Minh city University of Technology (HCMUT), VNU-HCM, for this study.

REFERENCES

1. Alabaster, O., Tang, Z., & Shivapurkar, N. (1996). Dietary fiber and the chemopreventive modelation of colon carcinogenesis. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 350(1), 185-197.

2. Brennan, C. S. (2013). Fibre-enriched and wholewheat pasta. In: "Fibre-rich and wholegrain foods: improving quality", Editors Delcour J.A. and Poutanen K, Woodhead Publishing, 273-290.

3. Nguyen, S. N., Ngo, T. C. T., Tran, T. T. T., & Ton, N. M. N. (2020). Pasta from cellulase-treated wheat bran and durum semolina: Effects of vital gluten addition and/or transglutaminase treatment. Food Bioscience, 38, 100782.

4. Yadav, S., & Gupta, R. K. (2015). Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity. *Journal of Pharmacognosy and Phytochemistry,* 4(1).

5. Tolve, R., Pasini, G., Vignale, F., Favati, F., & Simonato, B. (2020). Effect of grape pomace

addition on the technological, sensory, and nutritional properties of durum wheat pasta. Foods, 9(3), 354.

6. Roda, A., & Lambri, M. (2019). Food uses of pineapple waste and by-products: a review. *International Journal of food science & technology,* 54(4), 1009-1017.

7. Kippax, P. (2005). Appraisal of the laser diffraction particle-sizing. Pharmaceutical Technology, 3, 88-89.

8. Martin, A. (2015). 4.4 Lab Colour Space and Delta E Measurements. Graphic design and print production fundamentals, 95.

9. Hadidi, M., Amoli, P. I., Jelyani, A. Z., Hasiri, Z., Rouhafza, A., Ibarz, A., … & Tabrizi, S. T. (2020). Polysaccharides from pineapple core as a canning by-product: Extraction optimization, chemical structure, antioxidant and functional properties. *International Journal of Biological Macromolecules,* 163, 2357-2364.

10. Huang, X., Dou, J. Y., Li, D., & Wang, L. J. (2018). Effects of superfine grinding on properties of sugar beet pulp powders. LWT, 87, 203-209.

11. Chen, J., Gao, D., Yang, L., & Gao, Y. (2013). Effect of microfluidization process on the functional properties of insoluble dietary fiber. Food Research International, 54(2), 1821-1827.

12. Bröring, S., & Khedkar, S. (2018). Regulatory compliance and company strategies: the case of the nutrition and health claims regulation (EC) No. 1924/2006. In Regulating and Managing Food Safety in the EU (pp. 105-128). Springer, Cham.

13. Aravind, N., Sissons, M., Egan, N., & Fellows, C. (2012). Effect of insoluble dietary fibre addition on technological, sensory, and structural properties of durum wheat spaghetti. Food chemistry, 130(2), 299-309.

14. Rakhesh, N., Fellows, C. M., & Sissons, M. (2015). Evaluation of the technological and sensory properties of durum wheat spaghetti enriched with different dietary fibres. *Journal of the Science of Food and Agriculture,* 95(1), 2-11.

15. El-Sohaimy, S. A., Brennan, M., Darwish, A. M., & Brennan, C. (2020). Physicochemical, texture and sensorial evaluation of pasta enriched with chickpea flour and protein isolate. Annals of Agricultural Sciences, 65(1), 28-34.