Evaluating the Quality Characteristics of Pringles Prepared by Partial Replacing of Potato Flour with Potato Flakes

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ABSTRACT:

Pringles is the most popular snack all over the world. This research was carried out to prepare Pringles by partial replacing of potato powder (PP) with Potato flakes (PF) with replacing levels; 25, 50 and 75% to produce three Pringles samples which namely, PP/PF1, PP/PF2 and PP/PF3 in addition to control sample which is formulated with PP only. The results revealed that the bulk density of Pringles formulas was decreased as the replacing level of PP with PF is increased since the bulk density values were 1.73, 1.68, 1.68 and 1.51 g/cm3 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively. Also, the swelling values of Pringles formulas were, 1.35, 1.31, 1.28 and 1.22 cm3/ g for Control, PP/PF1, PP/PF2 and PP/PF3, respectively. In contrary, the highest value (3.1g/g) was noticed for Control formula while the lowest value was recorded for PP/PF3 formula (2.11g/g). The result showed that Potato powder contained higher fiber content 10.50 % as compared to potato flakes, 7.50%. The crude protein content of pringles formulas was increased with increasing the replacing level of PP with PF, since it increased from 5.30 % for control sample to 7.61, 7.70 and 8.00 % for PP/PF1, PP/PF2 and PP/PF3. The fiber content was decreased with increasing the PF content in pringles formulas. The lowest fiber content was recorded for PP/PF3 (6.49%) whereas the highest fiber content was recorded for control (9.50%). The results revealed the superior pringles sample for all sensory properties was PP/PF2 which is formulated with replacing 50 % of PP in the pringles formula with PF.

Keywords: pringles; processed potato; snack food; Potato powder; potato flakes; junk food; potato dough based snack product; Rice flour; wheat flour.

INTRODUCTION

Snacks have become an important because it light, easy to eat, great taste, quick energy and quick meal eaten between meals or instead of a main meal. A snack should be balanced nutritionally and healthy (Adedapo *et al*., 2014). Snack products are processed mainly by two methods; the first is the traditional by producing snacks from thinly sliced fresh potatoes with deep frying; the second is typical restructured potato crisps which processed from a potato dough, which are molded into desired shape by extruding or pressing before frying, such as Pringles product (Pedreschi *et al*., 2018).

Pringles is a snacks which have pale yellow color and oval saddle curved shape without bubbles, its packaged in a cylindrical cardboard canister which have a foil - lined interior with a plastic lid (Shivkumar,2012). Pringles are mainly processed from potatoes flour, vegetable oils (contains one or more of the following: corn oil, cottonseed oil, soybean oil, and/or sunflower oil), rice flour, wheat starch, maltodextrin, salt and dextrose.

Potato (*Solanum tuberosum* L.) is the most important vegetable crop in terms of quantities produced and consumed worldwide. It is popularly known as the "Vegetable King" since it provides a major source of nutrition and income to many populations and communities. potato is a versatile, carbohydrate-rich food. It contains about 80 % water and 20 % dry matter content when freshly harvested. About 60 to 80 % of the dry matter is starch. On a dry weight basis, potato protein content is similar to cereals (5 -7%) but very high when compared with other root and tuber crops. It is low in fat content (0.1%), Potato is a moderate source of iron, and its high vitamin C content promotes iron absorption. It is a good source of vitamins like Vitamin B1, B3, and B6, and minerals such as potassium, phosphorus, and magnesium. Potatoes also contain antioxidants, which play a part in preventing diseases related to aging, and dietary fiber, which benefits health (Singh *et al*., 2020).

Potato flakes are a key base ingredient in a lot processed products and snacks (Al-Rekabi *et al*., 2021). It commonly used in food industry to enhance water retention and maintain the freshness of the final products for example potato dough-based products like Pringles.

The aim of this research was preparing pringles by using potato flakes as partial replacer of potato powder and evaluating the

effect of this replacing on its quality characteristics.

MATERILS AND METHODS

Materials:

Starch, rice flour, salt, wheat flour and sugar were purchased from the local market of Tanta city, El-Gharbia, Governorate, Egypt.

Potato powder (PP) was purchased from BIRK AMIDON Company, Germany.

Potato flakes (PF) was purchased from PPZ Bronislaw Company, Poland.

All chemicals were obtained from El-Gomhoria Company for chemicals and Biodiagnostica, Tanta city, El-Gharbia Governorate, Egypt.

Methods:

Preparation of pringles:

Pringles were prepared by using the formulas showed in Table 1. as follows: The ingredients were weighed separately and then mixed well followed by adding water to obtain a cohesive dough which is spread under pressure to obtain a flat sheet with a thickness of 2 mm by using Electric pasta machine, Horcatec, Italy (Figure 1) which is cut into oval shape to facilitate the packaging, followed by frying in vegetable oil at 160, 170, 180°c for 5,10,15 s; 170°c/ 10 s is the best condition for color and crispness of Pringles then cooled and packaged, the manufacture process of pringles is shown in Figure 2.

Physiochemical properties of potato powder, potato flakes and Pringles formulas.

pH value was determined by mixed 10g sample in 100 g distilled water according to the method of AOAC (2012).

Bulk Density was determined by put the sample in graduated cylinder (10 ml) then agitated for five min then record the weight of cylinder

Bulk density = weight of sample (g) / unit volume (ml) (Murphy *et al*., 2003).

Swelling Capacity: 10 ml distilled water plus 0.2 g dry sample were put in graduated cylinder for 18h.

Swelling Capacity = volume Occupied (ml) / original sample weight (g) (Raghavendra *et al*., 2004).

Water Absorption Capacity: 1 g sample plus 10 ml distilled water which stirred for 30 min then centrifuge at 2200 xg / 30 min, and estimated the disposed water after centrifuge. (Wani and Kumar, 2014).

Proximate composite of potato powder, potato flakes and pringles formulas:

Crude protein (Total Nitrogen x 6.25), crude lipid, moisture content, fiber and ash content were determined according to the Official Method of Analysis **(Latimer, 2023).** Total carbohydrates were determined by difference.

Caloric value = [(Total carbohydrate + total proteins) × 4] + [total lipid × 9] (Akhobakoh *et al*., 2022).

Sensory evaluation of pringles:

The pringles samples were sensory evaluated for color, odor, taste, crispness by ten panelists form the staff of Home Economics faculty and used score from 1 to 9 where the score 9 = excellent, the score 1 =bad (Kramer and Twigg, 1973).

Statistical analysis:

Statistical analysis for data obtained was subject to analysis of variance according to Varghese *et al*., (2023). Significant differences among individual means analyzed by Duncan's multiple range test (Duncan. 1955)

RESULTS AND DISCUSSION

Physicochemical properties of potato powder, potato flakes and Pringles recipes mixtures.

Physicochemical properties of potato powder and potato flakes are shown in Table 2. The results showed that PP and PF were had the same pH value (7.00). Regarding, bulk density the results exhibited that potato powder had higher bulk density as compared to potato flour which were 1.5 and 1 g/cm^3 for PP and PF, respectively. The same trend was observed for swelling capacity, since the swelling capacity of PP (1.2 cm3/g) was higher than that of PF (1 cm^3/g). Similarly, the water absorption capacity of PP was twofold that of PF with values 1.99 and 1 g/g, respectively.

In the context, the physicochemical properties of Pringles formulas mixtures are shown in Table 3. The data showed that there are not significant differences between pH values of all pringles formulas since it records the following pH values, 6.99, 6.95, 6.99 and 6.90 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively, these results are in agreement with the that reported by Adedapo *et al*. (2014) and Ali *et al.* (2019).

The bulk density of pringles formulas was decreased as the replacing level of PP with PF is increased since the bulk density values were 1.73, 1.68, 1.68 and 1.51 g/cm^3 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively, the highest bulk density value was observed for control formula which is formulated without potato flour, while the lowest bulk density value was recorded for PP/PF3 formula which formulated with replacing 75% of PP with PF. The bulk density is very important for packaging Pringles (Ali et al., 2019 and Gabr et al., 2013), since it determines the space which is occupied in the Pringles packag (Adedapo *et al*., 2014).

The swelling capacity value is decreased as the level of replacing PP with PF is increased. The swelling values of pringles formulas were, 1.35, 1.31, 1.28 and 1.22 cm$^{3/}$ g for Control, PP/PF1, PP/PF2 and PP/PF3, respectively. The results revealed that the highest swelling capacity was recorded for Control whereas the lowest value was recorded for PP/PF3 formula which is processed with replacing 75% of PP with PF. These results may be due to the high water absorption capacity of potato powder (Adedapo *et al*., 2014 and Ali *et al.,* 2019).

The Water absorption capacity is important for Pringles because it is indicator to the water binding during formation of pringles dough. The water binding depended on Pringles ingredients specially potato powder and potato flakes. The recorded values of water absorption capacity were 3.1, 2.8, 2.35 and 2.11g/g for Control, PP/PF1, PP/PF2 and PP/PF3, respectively. The highest value (3.1g/g) was noticed for Control formula while the lowest value was recorded for PP/PF3 formula (2.11g/g).

Chemical composition of Potato powder and Potato flakes.

The main components pringles are Potato powder (PP) and Potato Flakes (PF). The proximate chemical composition of PP and PF are shown in Table 4. The result showed that Potato powder contained higher fiber content 10.50 % as compared to potato flakes, 7.50%; Potato flakes also had higher contents of protein, fat, ash and Total carbohydrate (9.60, 0.9, 5.00 and 67.00 % respectively as compared to 9.10, 0.31, 4.45, 65.64 %, respectively for potato powder also the caloric value of potato flakes (314.50 Kcal /100g) was higher than that of potato powder, which recorded 314.50 and 301.75 Kcal /100gm respectively. The results are in the line with that reported by Avule and singh (2009) and Singh *et al*. (2020).

Proximate chemical composition of Pringles.

Proximate chemical composition of Pringles formulas was shown in Table 5. The results showed that there is no significant difference in moisture content for all pringles samples, since it ranged from 3.55 to 3.40 %. On the other hand, the results revealed that crude protein content of pringles formulas was increased with increasing the replacing level of PP with PF, since it increased from 5.30 % for control sample to .61, 7.70 and 8.00 % for PP/PF1, PP/PF2 and PP/PF3, which are significantly higher when compared to control. The same trend was observed with crude lipid content which is increased with increasing the incorporation of potato flakes as partial replacer of potato power, since the highest crude lipid content was noticed for PP/PF3 (17.34 %) which formulated with the highest replacing level of PP with PF (75%) whereas the lowest lipid content was recorded for Control sample which formulated without PF (15.00%).

Similarly, the ash content was increased with increasing the replacing level of PP with PF, since the highest ash content was recorded for PP/PF3 pringles sample (4.57%) while the lowest ash content was noticed for Control sample (2.24%).

On contrary, the fiber content was decreased with increasing the PF content in pringles formulas. The lowest fiber content was recorded for PP/PF3 which formulated by replacing 75 % of PP with PF (6.49%) whereas the highest fiber content was recorded for control (9.50%), which is significantly different from the pringles sample which prepared by replacing PP with PF. The same trend was noticed with total carbohydrates content which is decreased with increased PF content in pringles samples. The lowest carbohydrates content was observed for PP/PF3 sample (61.77) as compared to 64.41% for control sample which is significantly higher than of other pringles samples. The caloric value of pringles samples is increased with increasing the level of pp replacing with PF which may be due to the increasing of protein and lipid content with increasing the replacing level of PP with PF, since PP/PF3 pringles sample exhibited the highest caloric value 429.34 Kcal/100g, whereas the control sample which formulated without PF revealed the lowest caloric value (413.84 Kcal/100g). These results are in the same trend with the findings of Adedapo *et al*. (2014) and Ali *et al.* (2019).

Sensory evaluation of pringles:

The scores of sensory evaluation of pringles samples for color, odor, taste, crispness and overall acceptability were present in Table 6. The results exhibited that all sensory properties were enhanced with replacing potato powder with potato flakes. The results showed that the color of pringles is enhanced with replacing PP with PF, since the color scores of pringles sample which formulated with replacing PP with PF were higher than that of Control sample, where it recorded the following scores; 7.,8.7,9.0 and 8.8 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively.

Regarding, odor the data in Table 6 confirmed the conclusion which is previously mentioned, since it was enhanced with replacing PP with PF since Pringles samples were had the following scores; 8.0,8.7,8.9 and 8.9 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively.

The same trend was clear also with taste scores which were 8.1,8.6,8.9 and 8.7 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively.

Also, the crispness was increased with replacing of PP with PF in formulation of pringles since the crispness scores were 7.3, 8.5,8.9 and 8.6 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively.

The same trend was reflected on the overall acceptability since it obvious that it increased with replacing PP with PF with the following scores, 7.5, 8.0,9.0 and 8.5 for Control, PP/PF1, PP/PF2 and PP/PF3, respectively.

Form these results it obvious the superior pringles sample for all sensory properties was PP/PF2 which is formulated with replacing 50 % of PP in the pringles formula with PF. These results are in agreement with that obtained by Adedapo *et al.* (2014); Ali *et al.* (2019) and Gabr *et al.* (2013).

CONCLUSION

Finally, the results showed that Pringles can be formulated with PP/ PF at the ratio of 50/50 with keeping of high physicochemical, chemical and sensorial properties.

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Table 1: Pringles formulas.

Components %	Pringles formulas*			
	Control	PP / PF1	PP/ PF2	PP/PF3
Potato powder (PP)	78 %	58.50 %	39 %	19.5 %
Potato flakes (PF)	0%	19.50 %	39 %	58.5 %
Starch	16 %	16 %	16 %	16 %
Rice flour	2 %	2 %	2 %	2 %
Wheat flour	2 %	2 %	2 %	2 %
Salt	1 %	1 %	1 %	1 %
Sugar	1 %	1 %	1 %	1 %

*PP= potato powder, PF= potato flakes; Control = PP only; PP / PF1 =75 PP/25 PF, PP/PF2= 50PP/50PF PP/PF3=250PP/75PF.

Table 2: Physicochemical properties of potato powder, potato flakes.

parameters	PP	PF
pH	7.00	7.00
Bulk density (g/cm^3)	1.50	1.00
Swelling capacity (cm3/g)	1.20	0.98
Water absorption capacity (g/g)	1.99	1.00

Table 3: Physicochemical properties Recipes powder.

Formulas*	Parameters			
	pH	Bulk density (g/cm^3)	Swelling capacity (cm^3/g)	Water absorption capacity (g/g)
Control	6.99 ^{a} ±0.13	1.73 ^{a} ±0.11	1.35^a±0.11	3.10^a±0.09
PP / PF1	6.95 ^{a}±0.05	1.68 ^{b} ±0.07	1.31^b±0.07	2.80^a±0.05
PP / PF2	6.99 ^{a} ±0.19	1.68 ^{b} ±0.13	1.28^c±0.05	2.35^a±0.09
PP / PF3	6.90 ^{a} ±0.07	1.51^c±0.09	1.22^d±0.02	2.11^a±0.10

*Control = PP only; PP / PF1 =75 PP/25 PF, PP/PF2= 50PP/50PF PP/PF3=250PP/75PF. In Colum, means having the same superscript (small litter) are not significantly different at 5% level.

Table 4: Chemical composition and caloric value of Potato powder and Potato flakes.

Component %	Potato powder	Potato flakes
Protein	9.10	9.60
Fat	0.31	0.9
Moisture content	10.00	10.00
Fiber	10.50	7.50
Ash	4.45	5.00
Total carbohydrates	65.64	67.00
Total calories	301.75	314.5

Table 5: Proximate chemical composition and caloric value of Pringles.

Component %	Control	PP / PF1	PP/ PF2	PP/PF3
Moisture content	$3.55^{a} \pm 0.10$	$3.50^{a} \pm 0.20$	$3.49^{a} \pm 0.05$	$3.40^{a} \pm 0.10$
Crude protein	$5.30^{b} \pm 0.10$	$7.61^{a} \pm 0.13$	$7.70^{a} \pm 0.03$	$8.00^{a} \pm 0.01$
Crude lipid	$15.00^{b} \pm 0.11$	$16.1^{ab} \pm 0.50$	$16.23^{ab} \pm 0.16$	$17.34^{a} \pm 0.06$
Ash	$2.24^{b} \pm 0.10$	$3.60^{ab} \pm 0.28$	$3.73^{ab} \pm 0.20$	$4.75^{a} \pm 0.22$
Fiber	$9.50^{a} \pm 0.05$	$7.67^{b} \pm 0.41$	$7.08^{b} \pm 0.01$	$6.49^{b} \pm 0.50$
Total carbohydrates	$64.41^{a} \pm 0.30$	61.51 b ±0.15	$61.77^{b} \pm 0.20$	$61.77^{b} \pm 0.10$
Caloric value (Kcal/100g)	$413.84^{d} \pm 0.10$	$421.47^{c} \pm 0.16$	$423.95^{b} \pm 0.20$	$429.34^{a} \pm 0.50$

*Control = PP only; PP / PF1 =75 PP/25 PF, PP/PF2= 50PP/50PF PP/PF3=250PP/75PF. In row, means having the same superscript (small litter) are not significantly different at 5% level.

Table 6: Sensory evaluation of Pringles

Formulas*	Parameters				
	Color	Odor	Taste	Crispness	overall acceptability
Control	$7.50^{a} \pm 0.1.30$	$8.00^{a} \pm 0.99$	$8.10^{a} \pm 1.73$	$7.30^{a} \pm 0.95$	$7.50^{a} \pm 1.16$
PP / PF1	$8.70^{a} \pm 1.21$	$8.70^{a} \pm 1.43$	$8.60^{a} \pm 1.85$	$8.50^{a} \pm 1.08$	$8.00^{a} \pm 1.37$
PP / PF2	$9.00^{a} \pm 1.00$	$8.90^{a} \pm 1.59$	$8.90^{a} \pm 1.43$	$8.90^{a} \pm 1.77$	$9.00^{a} \pm 1.52$
PP / PF3	$8.80^{a} \pm 1.50$	$8.80^{a} \pm 1.68$	$8.70^{a} \pm 1.22$	$8.60^{a} \pm 1.93$	$8.50^{a} \pm 1.84$

*Control = PP only; PP / PF1 =75 PP/25 PF, PP/PF2= 50PP/50PF PP/PF3=250PP/75PF. In Colum, means having the same superscript are not significantly different at 5% level.

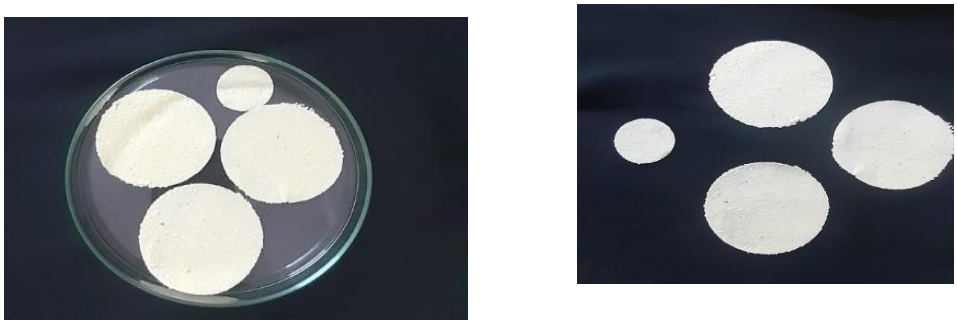


Figure 1: The pringles dough.

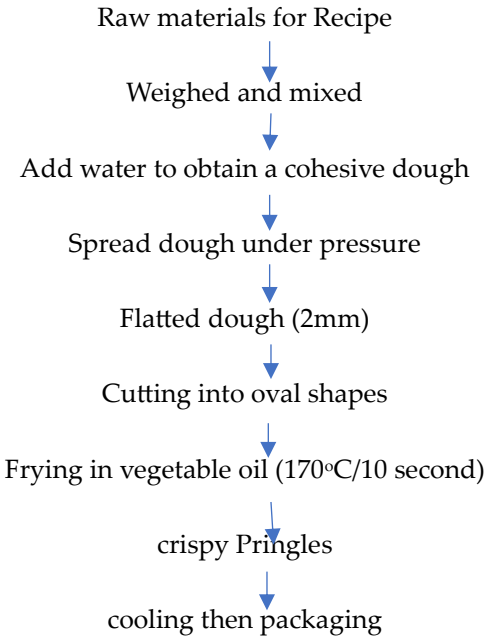
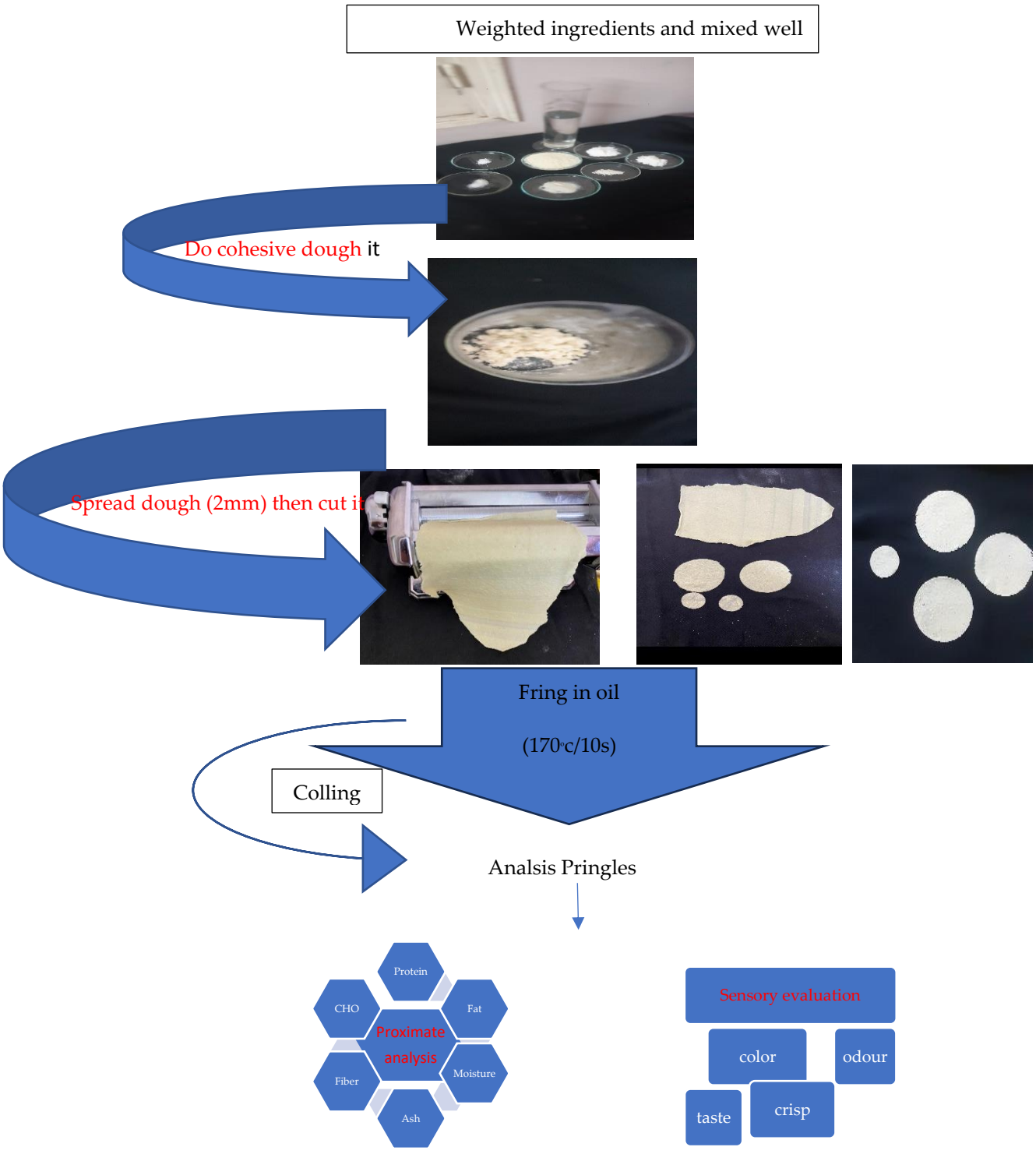


Figure 2: Flow chart for processing pringles

Graphic abstract



تقييم خصائص جودة رقائق البطاطس المحضرة بالاستبدال الجزئي لدقيق البطاطس برقائق البطاطس

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الملخص العربي:

البرينجلز هي الوجبة الخفيفة الأكثر شعبية في جميع أنحاء العالم. تم إجراء هذا البحث لتحضير بطاطس برينجلز عن طريق الاستبدال الجزئي لمسحوق البطاطس (PP) برقائق البطاطس (PF) بمستويات استبدال 25 و 50 و 75% لإنتاج ثلاث عينات برينجلز هي PP/PF1 وPP/PF2 وPP/PF3 بالإضافة إلى عينة المقارنة التي تمت تصنيعها باستخدام مسحوق البطاطس PP فقط. وقد أظهرت النتائج أن الكثافة الظاهرية لعينات البرينجلز انخفضت مع زيادة مستوى استبدال PP بـ PF حيث كانت قيم الكثافة الظاهرية 1.73 و1.68 و1.68 و1.51 جم/سم3 لعينات Control وPP/PF1 وPP/PF2 وPP/PF3 على التوالي. كما كانت قيم الانتفاخ لها1.35، 1.31، 1.28 و 1.22 سم3/جم. وعلى العكس من ذلك، سجلت أعلى قيمة امتصاص ماء (3.1 جم/جم) بعينة المقارنة بينما سجلت عينة PP/PF3 أقل قيمة امتصاص ماء. كما أظهرت النتيجة أن مسحوق البطاطس يحتوي على نسبة ألياف أعلى 10.50% مقارنة برقائق البطاطس 7.50%. وقد زاد محتوى البروتين الخام في عينات البرينجلز مع زيادة مستوى استبدال PP بـ PF، حيث زاد من 5.30% لعينة المقارنة إلى 0.61 و7.70 و8.00% لـPP/PF1 وPP/PF2 وPP/PF3 علي التوالي وقد انخفض محتوى الألياف مع زيادة محتوى PF في عينات البرينجلز.فقد تم تسجيل أقل محتوى ألياف لـ PP/PF3 والذي تم تصنيعه عن طريق استبدال 75% من PP بـ PF (6.49%) بينما تم تسجيل أعلى محتوى ألياف لعينة المقارنة (9.50%) . وقد أظهرت النتائج أن عينة البرينجلز الأعلي في جميع الخصائص الحسية هي PP/PF2 والتي تمت تصنيعها باستبدال 50% من PP بـ PF.

الكلمات الاسترشادية: برنجلز, بطاطس مصنعة, أغذية خفيفة, أغذية خفيفة مصنعة من عجينة البطاطس,دقيق البطاطس , فليكس البطاطس, دقيق الأرز , دقيق القمح.