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Utilization of Some Pigmented Corn Hybrids in Preparing High Nutritional Value Instant Fried Noodles

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ABSTRACT

Pigmented corn contains several bioactive phytonutrients that possess antioxidant, antitumor and anti-inflammatory properties. In this study, potential beneficial components of five pigmented corn hybrids: white (132), red (R370 and Rsc-1), and yellow (178 and 180) were investigated. In addition, wheat flour was substituted by corn flour hybrids at different levels. 0, 10, 20 and 30% (w/w), respectively to prepare instant fried noodles. Color, cooking properties and sensory characteristics of instant fried noodle were evaluated. The highest values of protein and total phenols were observed in R370 hybrid, meanwhile, yellow178 had the highest oil, P, Fe and Zn content among other hybrids. Besides, Rsc-1 had high content of anthocyanin and K. Yellow corn hybrids had a high content of carotenoids. However, high antioxidant activity was observed in red corn hybrids. With respect to the sensory characteristics points of view, preparation of noodles by substituted wheat flour with yellow 180 flour at different levels enhanced noodles color in relative to other noodle samples. There were no significant differences among all noodle samples in odor score. Regarding to overall acceptability and total quality scores, there were no significant differences among control and 10 and 20% substitution levels samples of yellow 178 and 180. In general substitution with 10% of white and red hybrids was accepted. The cooking noodle weight was increased with increasing the addition of different corn hybrids until 30%. A slight decrease was observed in protein content in substituted noodles with corn flour. Meanwhile, ash and fiber content was increased in noodles with increasing corn flour levels. Therefore, the production of noodles using corn flour-wheat composite flour is recommended.

Keywords: corn hybrids, pigmented corn, chemical composition, instant fried noodles, cooking quality.

1. Introduction

Maize (*Zea mays* L.) is an important cereal crop (Family Poaceae) which ranks the third after wheat and rice. In Egypt, it is used as human food, livestock and poultry feed as well as a row material for industrial products such as oil and starch. It is an essential cereal crop which grown in the summer or at late-summer seasons in Egypt. (Ahmadi *et al.,* 2010 and Hassaan, 2018).

It would be beneficial to introduce new manufactured corn products to the Egyptian food market (El-Shayeb *et al.,* 2018).

Different maize, (*Zea mays* L.) varieties including pigmented maize have been used for thousands of years as a healthy food source, Maize ingestion could contribute to the reduction in the rate of non-communicable diseases and, in turn, to its function as an adjuvant in their management. These diseases are mainly associated with oxidative stress, which is characterized by a redox cell imbalance produced due to pro-oxidant molecules accumulation, inducing irreversible damages. (Magaña-Cerino *et al.,* 2020).

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Corn (*Zea mays* L.) has a wide range of kernel colors such as white, yellow, orange, purple and black. In addition to its attractive colors, the pigmented corn is rich in phytochemicals and many secondary metabolites such as phenolic compounds, carotenoids and flavonoids (Žilić *et al.,* 2012). These constituents are regarded as an important source of antioxidants in cereals (Montilla *et al.,* 2011).

Field corn with yellow or orange kernel color of endosperm has been recognized as the major source of carotenoids (provitamin A) (Yang and Zhai, 2010), and normal purple corn is a rich source of anthocyanin for use as colorants and functional food ingredients (Jing and Giusti, 2007).

Wheat based products are a major food source worldwide, with wheat area for cultivation than any other crop. Wheat represents over 30% of global cereal production and noodles are one of the popular end products that are a staple food. (Widjaya, 2010).

Noodles are one of the favorite foods for many countries and many researchers have concentrated on the quality improvement of noodles through fortification due to obtaining stable noodles with high nutritional values, health benefits, desirable eating qualities, and the cost-effectiveness of noodle products (Parvin *et al.,* 2020).

The consumption of noodles had estimated to have a 7% spread growth around the world annually, (David-Abraham, 2014).This is due to its relatively low cost, desirable sensory quality, ease of cooking and short cooking time (Karim and Sultan, 2015). Instant noodles are mainly made with the use of dehydration and pregelatinization of only wheat flour, or wheat flour and/or other flours (Bronder *et al.,* 2017). Use of composite flours in noodles manufacture would help to reduce the cost of production and allow for utilization of locally available raw materials (Aluyor and Okwundu, 2017).

Instant noodles are classified into two types on the basis of methods used for the removal of moisture, i.e., instant dried noodles and instant fried noodles.but, in current market era, the oil fried instant noodles dominating the noodle market mostly due to their lower cooking time (Gulia *et al.,* 2014).

The properties of instant noodles like taste, nutrition, convenience, safety, longer shelf life, and reasonable price have made them popular worldwide. Instant noodles are also used as space and emergency food. (WINA, 2011).

The pigmented corn is a rich source of phytochemicals and many secondary metabolites. Therefore, the objectives of this study were to evaluate the chemical and physical properties of some pigmented corn hybrids and investigate the quality of instant fried noodles substituted with different levels of some pigmented hybrids corn flour.

2. Materials and Methods

2.1. Materials

Five pigmented corn hybrids (white132, yellow180, yellow 178, red Rsc-1, and red 370) were obtained from Crop Research Institute, Agricultural Research Center, Giza, Egypt.Wheat flour (72% extraction) was obtained from South Cairo Company of milling. 2, 2-diphenyl-1-picrylhydrazyl (DPPH), Gallic, amylose standards were purchased from Sigma/Aldrich Chemical Company, USA. Folin-Ciocalteu reagent was obtained from LOBA Chemie, India. All other chemicals were of the analytical reagent grade.

I. Corn flour preparation

Corn grains were carefully inspected from broken grains and extraneous matters and milled using laboratory mill (IKA- Laboratechnic, Janke and Kunkel Type: MFC, Germany) to get a whole meal flour for chemical analysis. A 60 mesh siever was used to get fine flour (the most particle sizes range are around 250 microns) for noodles preparation and then packed in polyethylene bags and kept in a freezer until further analyses.

II. 1000-grain weight and component parts of corn grains

The weight of 1000-grain and component parts (endospern, germ and pericarp) percentages of corn grains were determined according to Hussein (1981).

2.2. Chemical composition

Moisture, protein, fat, crude fibers, ash, phosphorus, potassium, Mn, Fe and Zn contents of corn samples were measured and the total carbohydrate value was calculated by difference according to AOAC (2016). Amylose content (as g/100g dry weight) was determined using the method outlined by Juliano (1971).Total phenols were calorimetrically determined as described by Singleton and Rossi (1965) with some modifications, and gallic acid was used as a standard.

Carotenoids content was determined using the method described in AOAC (2016). Antioxidant activity was determined using. 2, 2-diphenyl-1-picrylhydrazyl (DPPH) according to Brand-Williams *et al.,* (1995).Total anthocyanins content was measured using a spectrophotometric pH differential protocol was described by Giusti and Wrolstad (2001) and Wolfe *et al.,* (2003) with slight modifications.

2.3. Dough Rheological Properties

The dough rheological properties of different wheat with corn flour dough blends (0%, 10%, 20 and 30%) were examined with the Brabender Farinograph and Brabender Extensograph according to the constant flour weight procedure AACC (2002).

2.4. Instant fried noodle preparation

Noodle samples were prepared according to (Gulia *et al.,* 2014) with a slight modification. The ingredients, Wheat flour72%substituted with corn hybrids flour (White corn Flour (132) - Red corn Flour (370 -sc-1), and (Yellow corn Flour 180 - 178) at 0, 10, 20 and 30%, levels (Table 1) and sodium chloride (1 g) mixed with water (previously determined by farinograph) and molded for about 10 min to make stiff dough. Subsequently, the dough was cut into1mm–thickness noodles using the noodle maker appliance (Demaco, Defrancis machine corporation Germany).The raw noodles were steamed at 100ºCfor 3 min then fried using sun flower oil at 140 ºC for a one min. The instant noodles were packaged in a polyethylene bags.

Table 1: Flour blends used in preparing noodles dough (g)

Wheat flour (72%)	White corn flour (132)	Red corn flour (Rsc-1)	Red corn flour (370)	Yellow corn flour (180)	Yellow corn flour (178)
100 (control)	---	----	----	----	---
90	10	----	----	----	---
80	20	---	---	----	---
70	30	----	----	----	---
90	---	10	----	----	---
80	---	20	----	----	---
70	---	30	---	---	---
90	---	---	10	---	---
80	---	---	20	---	---
70	---	---	30	---	---
90	---	---	---	10	---
80	---	---	---	20	---
70	---	---	---	30	---
90	---	---	---	---	10
80	---	---	---	---	20
70	---	---	---	---	30

2.5. Color measurement

The color of the flours and noodles was measured according to the method outlined by McGurie (1992) using a hand-held Chromameter (model CR-400, Konica Minolta, Japan). The results were expressed in terms of: *L* (lightness), *a* (redness-greenness), and *b* (yellowness -blueness).

2.6. Sensory evaluation

The instant fried noodles were rehydrated in boiling water for 5 min and were served hot for the sensory evaluation. Products were evaluated by a panel of 10 well -trained judges in (ARC) for different sensory attributes (color, texture, odor, taste and overall acceptability using a` 9-- point hedonic scale, according to Bashir *et al.,* (2012).

2.7. Evaluation of cooking quality of noodles

I. Cooking losses

Cooking tests of noodles including determination of weight gain, volume change and cooking loss were performed in triplicates by the following methods: noodles (10 g) were cooked in 200 ml of boiling water for3-5 min; noodles were then drained and immediately weighed. The cooking water was retained and boiled to evaporate most of the water, and then, dried in an oven at 105 ºC until constant weight. The weight gain (%), volume change (%) cooking loss (%) of instant fried noodles were calculated according to the method described by Lai (2002).

The respective formulae used in the calculations are as follow:

Weight change (%) = (weight of cooked noodle (g) −weight of fresh noodle (g) /weight of fresh noodle (g) × 100

Cooking loss (%) = remaining solid content after drying (g) ×100 weight of fresh noodle (g)

Volume change (%) = (volume of cooked noodle (ml) −volume of fresh noodle (ml) / volume of fresh noodle (ml)) × 100

Statistical Analysis

The obtained data were exposed to analysis of variance ANOVA. Duncan's multiple range test at 5% level was used to compare among means (Steel *et al.,* 1997).

3. Results and Discussion

3.1. 1000-grains weight and component parts of corn hybrid grains

Thousand grain weight and component parts (endosperm, germ and pericarp) of pigmented corn hybrid grains are shown in Table (2), Results revealed that, the highest thousand grain weight was recorded for White corn hybrid followed by Yellow 178 (358.50 and 353.10, respectively) while, the lowest1000- grains was recorded for yellow 180 (330.50). These results are in the same trend with those reported by Jan *et al.,* (2018) who found that a significant variation in 1000- grains for corn hybrids. Also, El-Mekser *et al.,* (2020) stated that 1000-grains weight, ranged from 321.7 to 400 g for white corn hybrids and for yellow corn hybrids ranged from 266.0 to 375.0g.

Sener *et al.,* (2004) and Varga *et al.,* (2004) reported that differences in the thousand grain weight among hybrids could be due to their genetic potential.

The main parts of corn kernel are the endosperm, pericarp and germ. Each part presents distinct chemical composition and quality in-dependent from the genetic material as well as from the environment conditions (Pinto *et al.,* 2009).

Results cleared that endosperm is the largest component, ranged from 79.66 to 81.95% of the maize grain weight for R370 and white 132 corn grains, respectively, while germ ranged from 10.29 to 13.60% for white132 and yellow 178, respectively and pericarp from 7.24 to 7.96 % for Rsc-1 and yellow 180, respectively. Results are in accordance with results previously published by Zilic *et al.,* (2011). Corn kernel is constituted by three principal parts, where the endosperm represents 80.0-85.0%, germ10.0-12.0% and pericarp 5.0-6.0% (Berger and Singh, 2010).

Table 2: 1000-grains weight and component parts of corn hybrid grains

Corn hybrid	Endosperm%	Germ%	Pericarp%	1000-grain weight (g)
R (370)	$79.66^{c}\pm 0.11$	$12.78^{b}\pm0.04$	$7.56^{ab}\pm 0.06$	$333.80^{d}\pm 0.06$
Yellow (180)	$79.38^{c}\pm 0.06$	$12.66^{b}\pm 0.06$	$7.96^{a}\pm 0007$	$330.50^{e}\pm 0.21$
R (sc-1)	$80.29^{b}\pm 0.02$	$12.47^{b}\pm 0.14$	$7.24^{b}\pm 0.17$	$345.00^{c}\pm 0.14$
Yellow (178)	$78.53^{d}\pm 0.07$	$13.60^{a}\pm0.13$	$7.87^{a}\pm 0.21$	$353.10^{b}\pm 0.08$
White (132)	$81.95^{a}\pm 0.35$	$10.29^{c}\pm0.13$	$7.76^{a}\pm0.22$	$358.50^{a}\pm0.07$

Values are mean of three replicates ±SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

3.2. Chemical composition of pigmented corn hybrids flour.

Table (3) shows the chemical composition of pigmented corn hybrids included in our study. Results showed that protein content were found in the range of 8.68 to9.67% for white 132 and R370 corn hybrid, respectively. This results are agreement with findings of Sánchez *et al.,* (2019) who found that protein content of different corn hybrids ranged from 7.39- 11.72. Scrob *et al.,* (2014) reported that hybrids had a significant effect on the protein content.

Motto *et al.,* (2011) reported that the oil stored in the embryo. Oil, in fact, is the most valuable co-product from industrial processing of maize grain through wet milling or dry milling and it represents a source of high-quality oil for humans. Yellow178 significantly had the highest oil content (4.19%) in relative to other hybrids flour. While the lowest oil content was observed in white132 corn hybrid (3.27%), Similarly, El-Mekser *et al.,* (2020) reported that the oil variation in maize flour ranged from 3.25–4.22%.

The same Table, showed that there was no significant differences that among corn hybrids flour in ash content. Ash content of five corn hybrids ranged from 1.16% (yellow 178) to 1.26% (white 132 corn). Similar results (1.08 – 1.65%) for ash content in different maize hybrids were reported by El-Mekser, *et al.,* (2020).

The same trend there were found no significant differences in fiber content among the five corn hybrids. The mean values recorded for crude fiber content were found in the range of2.49% (Rsc-1) to 2.75% (yellow 180). Regarding to carbohydrate content there were non-significant differences among hybrids except white corn 132 which had significantly high value of carbohydrates in relative to other hybrids (84.21%).

Bacchetti *et al.,* (2013) found that there were no significant differences as far as concerns carbohydrate and fiber content between corn hybrids.

From the same Table, amylose content was affected by hybrids. It ranged from 21.03 to 27.52%, the highest amylose content was observed in white corn 132 (27.52%). Normal starch consists of two types of polysaccharidean: amylose and amylopectin. Amylose occupies approximately 15-30% of starch (Pandey *et al.,* 2000).

Table 3: Chemical composition of pigmented corn hybrids flour (% dry wet).

Corn hybrid	Moisture	Protein	Oil	Fiber	Ash	Carbohydrate	amylose
R (370)	9.33b ± 0.14	9.67 a ± 0.25	3.81 ^{b} ± 0.03	2.58 ^{a} ± 0.14	1.21^{a} ± 0.12	82.73 ^{b} ± 0.21	21.42 ^{c} ± 0.11
Yellow (180)	9.93a ± 0.07	9.59 a ± 0.27	3.59^{c} ± 0.02	2.75^{a} ± 0.12	1.2 ^{a} ± 0.04	82.87 ^{b} ± 0.22	22.94 ^{b} ± 0.15
R (sc-1)	9.43 b ± 0.18	9.63 a ± 0.20	3.76^{b} ± 0.07	2.49^{a} ± 0.16	1.17^{a} ± 0.07	82.95^{b} ± 0.43	21.03 c ± 0.19
Yellow (178)	9.34 ^{b} ± 0.23	8.94 ^{ab} ± 0.14	4.19 ^{a} ± 0.08	2.5 ^{a} ± 0.04	1.16 ^{a} ± 0.04	83.21^{b} ± 0.25	23.22 ^{b} ± 0.39
White (132)	9.27 ^{b} ± 0.06	8.68 ^{b} ± 0.23	3.27^{d} ± 0.04	2.58 ^{a} ± 0.02	1.26 ^{a} ± 0.07	84.21^{a} ± 0.04	27.52 ^{a} ± 0.03

Values are mean of three replicates ±SD, number in the same column followed by the same letter are not significantly different at 0.05 level

Total phenols, anthocyanin, carotenoid content and antioxidant activity of the pigmented corn hybrids are shown in Table (4).Total phenols content ranged from 70.15 mg.,100 g^{-1} to 270.43., mg100 g^{-1} of dry weight of corn samples. The highest value was observed in R370.

These results are in a good agreement with previous studies that reported that pigmented corn have a high total phenol content greater than that of the other corns at some maturity stage (Zilić *et al*., 2012). In general, red corn in this study is an important source of phenols content.

Red and blue maize are especially high in phenolic compounds as compared to light colored maize genotypes (Hu and Xu 2011).

Anthocyanins content was detected just only in red corn hybrids R370 (45.8 mg100g^{-1}) and Rsc-1(48.65mg., 100g^{-1}) .Some of the yellow accessions did not contain anthocyanins (Syedd-León *et al*., 2020).

The carotenoid content of the five corn hybrids is shown in Table (4) The highest total carotenoids has been observed in yellow 180. Previous studies shown that corn composition is modulated by genetic factors, by stages of maturation, and processing (Rios *et al.,* 2011and Pelissari *et al.,* 2008). The levels of phytonutrients such carotenoids and polyphenol ssignificantly differ in different corn genotype (Pelissari *et al.,* 2008). Changes in carotenoid profile in the corn kernel have been reported with direct influence of genotype x environment interaction (Rios *et al*., 2014), existing relationship between the yellow or orange color of the endosperm and the presence of carotenoids (Chandler *et al.,* 2013).

As shown in Table (4), the antioxidant capacity of hydrophilic corn extracts evaluated by DPPH assay ranged from 14.35 to 31.57%. The highest values were observed in R370 .Such results are expected, because the highly content of phenolics and anthocyanin as compounds responsible for antioxidant activity (Nikolić *et al.,* 2019)

Table 4: Total phenols, anthocyanin, total carotenoids and antioxidant activity of pigmented corn hybrids flour.

Corn hybrid	Phenols (mg. $100g^{-1}$)	Anthocyanin (mg. $100g^{-1}$)	Antioxidant activity %	Total carotenoid (mg. kg^{-1})
R (370)	270.43 ^{a} ±1.58	45.8 ^{b} ±0.28	31.57 ^{a} ±0.07	6.99 ^{c} ±0.19
Yellow (180)	119.71 ^{c} ±2.39	Nd	26.60 ^{c} ±0.29	12.3 ^{a} ±0.29
R (sc-1)	253.17 ^{b} ±3.06	48.65 ^{a} ±.72	28.35 ^{b} ±0.14	6.31 ^{d} ±0.09
Yellow (178)	113..5 ^{d} ±2.12	Nd	22.90 ^{d} ±0.08	11.27 ^{b} ±0.21
White (132)	70.15 ^{e}±1.55	Nd	14.35 ^{e} ±0.28	2.16 ^{e}±0.17

Values are mean of three replicates ±SD, number in the same column followed by the same letter are not significantly different at0.05 level.–Nd= Not detected

3.3. Color measurement of pigmented corn hybrids flour

L, a and *b* values of corn hybrids flour are shown in Table (5).Color characteristics of corn hybrid flours showed differences among them. R370 flour showed the lowest value of *L* followed by Rsc-1 (68.62 and 70.62, respectively).It could be attributed to the presence of pigments of these hybrids. White corn flour had the highest significant *L* value (88.28). The results in this study were supported by previous findings and confirmed that corn genotypes with darker kernel color were associated with high total phenolic content than corn genotypes with lighter kernel color. (Khampas *et al.,* 2013).

Rsc^{-1} and R370 flour showed the highest values (5.39 and 5.12, respectively) indicating the domination of red over the green color in this flour. This could be related to the high anthocyanin content of R370 and Rsc^{-1}. (Yang *et al.,* 2008). For White corn flour a value (0.54) was near to zero indicating no domination of red over green color. Values of *b* parameter were much higher than *a* for all studied flours. Yellow 180 and 178 flour showed the highest *b* values (35.26 and 31.92, respectively) that is indicative of its yellow color due to the presence of high amount of carotenoids (Sandhu *et al.,* 2007). The lowest *b* value corresponded to White corn flour (12.85). (Kljak *et al.,* 2012). Stated that there was a high positive correlation between *b* value and total carotenoid content. Also, Chandler *et al.,* (2013) reported an existing relationship between the yellow or orange color of the endosperm and the presence of carotenoids.

Table 5: Color of measurement pigmented corn hybrids flour

Corn hybrid	*L*	*a*	*b*
R (370)	68.62 ^{e} ±0.14	5.12 ^{b} ±0.11	19.13 ^{c} ±0.03
Yellow (180)	79.89 ^{c} ±0.12	4.38 ^{c} ±0.01	35.26 ^{a}±0.08
R (sc-1)	70.62 ^{d} ±0.14	5.39 ^{a}±0.09	18.36 ^{d} ±0.03
Yellow (178)	82.12 ^{d} ±0.04b	4.32 ^{c} ±0.03	31.92 ^{b} ±0.07
White (132)	88.28 ^{a}±0.05	0.54 ^{d}±0.03	12.85 ^{e} ±0.04

Values are mean of three replicates ±SD, numbers in the same column followed by the same letter are not significantly different at0.05 level.

Minerals content of corn hybrids flour are presented in Table (6) Results showed that Rsc-1 had the highest content of k followed by R370 while the lowest content was observed in yellow 178 however, this hybrid (yellow 178) had the highest content of P.

Hybrid corn flour samples do not differed in a statistically significant manner (P<0.01) in terms of Fe content except white corn flour (2.2mg.$100g^{-1}$).

Yellow hybrid corn (178 and 180) had high content of Mn in relative to other hybrids. The content of Zn in the studied corn hybrid can be considered to be high, it ranged from1.56to 2.20mg.100g^{-1}.The literature there is data showed that Zn content ranged from 0.45 to 2.21 mg/100 g in white, yellow and sweet corn flour (Siyuan *et al.,* 2018). The high content of zinc found in yellow and white corn flour can be considered an important fact. Based on Recommended Dietary Allowance (RDA) for zinc for men which is 14 mg/day (Anonymous, 2018), it has been prove that 100 g of white corn flour could satisfy as much as 73.1% of an adult man's needs, 100 g of yellow corn flour 21.5%.

Table 6: Minerals content of pigmented corn hybrids flour (mg., w100g^{-1}).

Corn hybrid	K	P	Fe	Mn	Zn
R (370)	310.05 ^{b} ±1.62	180.38 ^{d} ±1.66	2.78 ^{a} ±0.05	0.41 ^{b} ±0.02	2.06 ^{b} ±0.02
Yellow (180)	284.42 ^{d} ±0.82	173.55 ^{c} ±1.897	2.55 ^{ab}±0.13	0.51 ^{a} ±0.01	1.99 ^{b} ±0.04
R (sc-1)	317.5 ^{a} ±2.12	220.53 ^{b} ±.2.16	2.58 ^{ab}±0.12	0.31 ^{c} ±0.01	2.00 ^{b} ±0.01
Yellow (178)	264.22^{e} ±21.73	230.41 ^{a} ±0.86	2.90 ^{a}±0.14	0.48 ^{a} ±0.02	2.20 ^{a} ±0.03
White (132)	299.45 ^{c} ±0.78	187.89 ^{c} ±1.26	2.2 ^{b}±0.18	0.24 ^{d} ±0.01	1.56 ^{c} ±0.02

Values are mean of three replicates ±SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

3.4. Dough Rheological Properties

Farinograph of wheat flour substituted with different levels of corn hybrids flour. The rheological index of wheat dough is an important basis for predicting the quality of final wheat-based products. Farinographic properties reflect the dynamic changes in the consistency of the dough during stirring (Mis *et al.,* 2012).

From Table (7**),** it was obvious that these partially addition of different corn hybrids (white 132, red 370 and sc-1), and yellow corn (180 and 178) at different levels (10, 20, and 30%), respectively, were added separately to wheat flour 72% extraction. The results displayed that different effects on the farinograph properties for noodles dough since the dough development time increased with increasing the water absorption rate.

The water absorption of the wheat flour (control) was 30.0%.Increasing substitution with different corn hybrids (10% to 30%), led to increase the water absorption, ranged by 31.0 to 33.5% in white corn, 31.5 to 34.5% in red corn hybrid, 32.0 to 36.0% in red 370 hybrid, from 30.0 to 33.5% in yellow 176 corn hybrid and from 32.0 to 34.5% in yellow corn hybrid, respectively.

The dough development time, for wheat flour (control) was 3.0 min, In addition the value of different corn hybrids increased with increasing substitution level.

This can be explained by different characterization of wheat flour and different corn hybrids since the polar group in protein can combine with water through hydrogen-bond interaction and physical entrapment which can enhance the water absorption rate. At the same time, protein and some polysaccharides can help to fill the protein–gluten network which can influence the dough development time, dough stability time, and degree of softening (Zaidul *et al.,* 2010).

The stability of the flour dough is another parameter that indicates the processing resistance. The processing capacity of the dough with short stability is reduced at that rate and fermentation times are short. The low degree of softening in the Farinograph indicates that gluten proteins are intact (Aydoğan *et al.,* 2015). Dough stability time is an important index for wheat flour to represent the gluten properties. The less time required for dough formation can be related to the decreased gluten content. Results showed that the addition of different corn varieties resulted in decreased gluten in blends and weakened the expansion of gluten network. If gluten protein is removed from the wheat flour, the flour is likely to lose its stability. Higher concentrations of different corn hybrids can weaken the amount of gluten which was the reason for disintegration of the dough. Almost all the farinograph properties were evidently changed at 30% different corn hybrids supplementation. Higher concentration of different corn varieties can cause the dough to fail to support the starch granule to bond in the protein network and make the dough unstable. The similar results were also reported by Zhang *et al.,* (2012), where blending corn flour with wheat flour would change dough mixing parameters.

Table 7: Farinograph of wheat flour substituted with different levels of pigmented corn hybrids flour.

Samples	Water Absorption (%)	Arrival Time (min)	Dough Development (min)	Stability Time (min)	Degree of Softening (B.U)
Control (wheat flour (72%)	30.0	2.0	3.0	9	100
90%wheat flour (72%) + 10% white (132) corn flour	31.0	2.0	3.0	6	110
80%wheat flour (72%) +20% white (132) corn flour	32.5	3.0	3.5	5	120
70%wheat flour (72%) +30 % white (132) corn flour	33.5	5.0	4.5	4.5	130
90%wheat flour (72%) + 10% Red sc-1corn flour	31.5	2.0	3.0	5.5	110
80%wheat flour (72%) + 20% Red sc-1 corn flour	33.0	2.0	3.5	5	120
70%wheat flour (72%) + 30% Red sc-1 corn flour	34.5	3.0	5.0	4.5	130
90%wheat flour (72%) + 10% Red 370 corn flour	32.0	1.5	3.5	6	100
80%wheat flour (72%) + 20% Red 370 corn flour	34.0	2.0	4.0	5.5	110
70%wheat flour (72%) + 30% Red 370 corn flour	36.0	2.5	5.0	4	120
90%wheat flour (72%) + 10% yellow 180 corn flour	30.0	1.0	3.5	6	100
80%wheat flour (72%) + 20% yellow 180 corn flour	32.5	2.0	4.0	5.5	110
70%wheat flour (72%) + 30% yellow 180 corn flour	33.5	3.5	5.0	5	120
90%wheat flour (72%) + 10% yellow 178 corn flour	32.0	1.0	3.0	7	100
80%wheat flour (72%) + 20% yellow 178 corn flour	34.0	1.6	3.5	6	110
70%wheat flour (72%) + 30% yellow 178 corn flour	34.5	2.0	5.0	5	120

Increased softening degree in the Farinograph is associated with poor gluten quality. The results observed that the softening degree of wheat flour (72% extraction) was determined as 100 BU, and the average softening degree of all different corn varieties was ranged from 100 to 130 BU. The main reason was that corn flour free gluten could hinder the formation of gluten network (Feng and Sun, 2013).

3.5. Extensograph of wheat flour substituted with different levels of corn hybrids flour.

Rheologaical measurements are considered the most valuable method to assess the quality of flour; their parameters are designed to monitor the molecular structure, mechanical properties, material composition and to anticipate the quality of end product (Bockstaele *et al.,* 2008). Extensogram represented gluten extensibility resistance to extension, ratio of resistance to extensibility and dough deformation energy (Hadnadev *et al.,* 2011).

Results in Table (8) showed that control wheat dough had high extension resistance (530 BU) than all different wheat flour substituted with corn hybrids flour at a levels 10, 20, and 30% respectively, that ranged from 500 to 230 BU. Maximum extensibility (BU) is reported to be significantly affected by the protein content of flour. In many studies, it stated that the extensibility value increases with increasing protein content (Sahari *et al.,* 2006).

Moreover, the extensograph test as dough extensibility decreased when increasing in all different corn varieties substituted with wheat flour 72% at levels 10, 20, and 30%, where ranged from 120 to 95.0 mm compared with control wheat dough which showed an increase in dough elasticity (130.0 mm). The extensibility (mm) value is related to the elasticity of the dough.

The energy value is an essential parameter in terms of the dough's resistance to processing and the degree of workability. The higher value, the greater the gas holding capacity and fermentation tolerance of the dough. According to the Table data, although the energy value determined in the highest in control wheat dough was 93.0 cm. It is generally found that all different corn varieties were ranged from 85 to 25 cm2. It stated that the energy value of the wheat flour should be higher than 80 cm2 and thus the gas holding capacity and fermentation tolerance of the dough would be high and when added poor gluten corn flour the energy decreased when increasing corn flour was added (Elgün *et al.,* 2001).

3.6. Sensory evaluation

Mean scores of the sensory parameters and the total quality scores are shown in Table (9). The scores of color had an increasing trend with the substitution level of corn flour increasing except in case of yellow 180 substitution levels and 20% substitution level of yellow 178. No significant difference among all the treatment for odor was observed. The values of taste and texture significantly declined with the ratio of corn flour substation increasing except in yellow 180 substitution levels and yellow 178 (10 and 20% substitution levels) and the lowest value was observed on Rsc-1 (30%). Regarding to overall acceptability and total quality scores, there was no significant difference among control and 10 and 20%substitution levels of yellow 178 and 180. for other corn noodles, Moreover, 10% substitution levels of white and red hybrids had accepted scores to overall acceptability with panelists and lower overall acceptability scores for the formulae with high corn flour percentage in the formulation of white and red hybrids.

Ma *et al.,* (2014) reported that, on the basis of color, textural and sensory characteristics, the addition level at 5-10% (w/w) was found to be acceptance for the preparation of corn flour yellow alkaline noodle.

The increasing moisture content of products will result the reducing their shelf life, hence proper drying of the noodles will be required (Omeire *et al.,* 2015). The moisture content of noodle samples ranged from 4.6% to8.35%. The final moisture content of dried noodles is usually less than 14% (Fu2008). Slight decrease was observed in protein content of noodles with fortification with corn flour.

The results showed the protein content of noodles ranged from 11.2% (30% of yellow178) to 12.2% (control). (Pato *et al.,* 2016) showed that protein content of instant noodles decreased when addition of tapioca flour increased and corn flour decreased.

Table 8: Extensograph of wheat flour substituted with different levels of corn hybrids flour.

Samples	Elasticity (B.U)	Extensibility (mm)	Proportion number	Energy (cm)
Control wheat flour (72%)	530	130	4.08	93
90%wheat flour (72%) + 10%white (132) corn flour	500	120	2.41	74
80%wheat flour (72%) +20%white (132) corn flour	440	115	3.83	35
70%wheat flour (72%) +30 %white (132) corn flour	300	90	5.55	20
90%wheat flour (72%) + 10% Red (sc-1) corn flour	230	120	2.00	65
80%wheat flour (72%) + 20% Red (sc-1) corn flour	490	115	2.50	37
70%wheat flour (72%) + 30% Red (sc-1) corn flour	380	100	3.81	25
90%wheat flour (72%) + 10% Red 370 corn flour	280	120	2.15	71
80%wheat flour (72%) + 20% Red 370 corn flour	480	120	2.78	49
70%wheat flour (72%) + 30% Red 370 corn flour	360	95	2.33	44
90%wheat flour (72%) + 10% yellow 180 corn flour	470	120	1.68	74
80%wheat flour (72%) + 20% yellow 180 corn flour	320	100	1.64	63
70%wheat flour (72%) + 30% yellow 180 corn flour	270	85	2.66	48
90%wheat flour (72%) + 10% yellow 178 corn flour	420	120	1.88	85
80%wheat flour (72%) + 20% yellow 178 corn flour	330	105	3.02	82
70%wheat flour (72%) + 30% yellow 178 corn flour	230	100	4.09	51

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Table 9: Sensory evaluation of rehydrated noodles.

Samples	Color (9)	Odor (9)	Taste (9)	Texture (9)	Acceptability (9)	Total (45)
Control (wheat flour (72%)	7.0 ^{c}± 0.81	7.1 ^{a}± 1.61	6.05^{bcd}± 0.83	6.1 ^{bc}± 1.12	6.4 ^{c}±1.14	32.65 ^{c}± 3.93
90%wheat flour (72%) + 10% white (132) corn flour	8.45^{ab}± 0.68	8.2 ^{a}± 0.75	8.2 ^{a}± 0.91	8.4 ^{a}± 0.65	8.3^{ab}± 0.78	41.55 ^{a}±2.76
80%wheat flour (72%) + 20% white (132) corn flour	8.35^{ab}± 0.66	8.15 ^{a}± 0.66	6.55 ^{b}± 1.7	6.5 ^{b}± 0.81	6.7 ^{c}± 1.18	36.25 ^{b}± 3.61
70%wheat flour (72%) + 30 % white (132) corn flour	7.65^{abc}± 1.0	8.1 ^{a}± 1.19	5.8^{bcde}± 0.78	5.55^{bcd}± 1.11	6.4 ^{c}± 0.87	33.5 ^{c}± 2.53
90%wheat flour (72%) + 10% Red (sc-1) corn flour	7.45^{bc}± 1.0	7.40 ^{a}± 1.7	5.4^{cdef}± 0.51	5.16 ^{cd}± b0.70	5.25 ^{dc}± 0.63	30.15 ^{cd}± 2.76
80%wheat flour (72%) + 20% Red (sc-1) corn flour	7.00 ^{c}±1.63	8.30 ^{a}± 0.94	5.65^{bcde}± 0.57	5.8^{bcd}± 1.20	6.05 ^{cd}± 0.92	32.8 ^{c}± 2.65
70%wheat flour (72%) + 30% Red sc-1 corn flour	5.60 ^{d}± 0.96	8.50 ^{a}± 0.62	5.45^{cdef}± 0.64	5.55^{bcd}± 0.59	5.25 ^{de}± 0.63	30.35 ^{cd}± 2.40
90%wheat flour (72%) + 10% Red 370 corn flour	5.15 ^{d}± 0.94	8.10 ^{a}± 0.56	4.6 ^{f}± 0.516	4.75 ^{d}± 0.540	4.55 e± 0.59	27.15 ^{d}± 2.21
80%wheat flour (72%) + 20% Red 370 corn flour	5.90 ^{d}± 0.77	8.30 ^{a}± 0.48	6.25^{bcd}± 0.79	5.65^{bcd}± 0.88	6.15 ^{cd}± 0.57	32.25 ^{c}± 1.55
70%wheat flour (72%) + 30% Red 370 corn flour	5.6 ^{d}±0.96	7.65 ^{a}± 1.10	5.05^{def}± 1.01	5 ^{cd}±0.94	5.2 ^{de}±0.78	28.5 ^{d}± 3.19
90%wheat flour (72%) + 10% yellow 180 corn flour	5.40 ^{d}± 0.69	7.50 ^{a}± 1.43	4.95^{ef}± 0.95	5.20 ^{cd}± 0.91	5.00 ^{e}± 0.94	28.05 ^{d}± 3.74
80%wheat flour (72%) + 20% yellow 180 corn flour	8.7 ^{a}± 0.42	8.2 ^{a}± 0.42	8.2 ^{a}± 0.25	8.45 ^{a}± 0.4	8.45 ^{a}± 0.49	42.00 ^{a}± 1.22
70%wheat flour (72%) + 30% yellow 180 corn flour	8.6 ^{a}± 0.39	8.10 ^{a}± 0.56	7.8 ^{a}± 0.58	7.80 ^{a}± 0.58	8.3^{ab}±1 0.71	40.61 ^{a}± 1.83
90%wheat flour (72%) + 10% yellow 178 corn flour	8.79 ^{a}± 0.41	7.7 ^{a}± 0.42	7.4 ^{a}± 0.51	7.6 ^{a}±0.70	7.4 ^{b}± 0.5	38.89 ^{a}± 1.61
80%wheat flour (72%) + 20% yellow 178 corn flour	7.9^{abc}± 0.81	7.85 ^{a}± 0.52	7.95 ^{a}± 0.68	8.25 ^{a}± 0.75	8.1^{ab}± 0.65	40.05 ^{a}± 2.58
70%wheat flour (72%) + 30% yellow 178 corn flour	8.35^{ab}± 0.41	8.35 ^{a}± 0.63	8.1 ^{a}± 0.21	8.55 ^{a}± 0.43	8.25^{ab}± 0.67	41.6 ^{a}± 2.10

Values are mean of ten replicates ±SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level

Table 10: Chemical composition of instant fried noodles (% dry wet.)

Samples	Moisture	Protein	Oil	Fiber	Ash	Carbohydrate
Control wheat flour (72%)	6.18 ^{c}± 0.10	12.2 ^{a}± 0.28	15.07 ^{b}±0.04	0.49 ^{b}± 0.18	0.71^{bc}± 0.04	71.53 ^{a}± 0.09
90%wheat flour (72% + 10% white(132) corn flour	8.35 ^{a}± 0.18	11.79^{ab}± 0.24	15.12 ^{b}± 0.14	0.66^{ab}± 0.19	0.74^{abc}± 0.05	71.69 ^{a}± 0.63
80%wheat flour72% +20% white(132) corn flour	7.65^{ab}± 0.14	11.5^{ab}± 0.28	15.28 ^{ab}± 0.08	0.83^{ab}± 0.12	0.80^{abc}± 0.02	71.59 ^{a}±0.35
70%wheat flour72%+30 % white(132) corn flour	7.45 ^{b}± 0.24	11.16 ^{b}± 0.22	15.45^{ab}± 0.2	0.92^{ab}± 0.12	0.86^{ab}± 0.05	71.61 ^{a}± 0.62
90%wheat flour 72%+ 10% Red (sc-1)corn flour	5.44^{cde}± 0.28	11.87^{ab}± 0.0	15.22^{ab}± 0.16	0.66^{ab}± 0.14	0.68 ^{c}± 0.03	71.57 ^{a}±0.41
80%wheat flour 72%+ 20% Red (sc-1) corn flour	4.77 ^{e}± 0.21	11.69^{ab}± 0.35	15.43^{ab}± 0.18	0.82^{ab}± 0.09	0.75^{abc}± 0.04	71.34 ^{a}±0.02
70%wheat flour 72%+ 30% Red (sc-1) corn flour	4.67 ^{e}± 0.21	11.43^{ab}± 0.15	15.65^{ab}± 0.24	0.9^{ab}± 0.02	0.81^{abc}± 0.05	71.21 ^{a}±0.48
90%wheat flour 72%+ 10% Red (370) corn flour	5.43^{cde}± 0.31	11.87^{ab}± 0.12	15.23^{ab}± 0.15	0.67^{ab}± 0.15	0.75^{abc}± 0.04	71.46 ^{a}± 0.48
80%wheat flour 72%+ 20% Red (370) corn flour	4.75 ^{e}± 0.18	11.69^{ab}± 0.25	15.46^{ab}±0.20	0.86^{ab}± 0.11	0.82^{abc}± 0.05	71.17 ^{a}±0.65
70%wheat flour 72%+ 30% Red (370) corn flour	4.6 ^{e}± 0.141	11.44^{ab}± 0.28	15.72^{ab}± 0.16	0.92^{ab}± 0.09	0.9 ^{a}± 0.014	71.02 ^{a}±0.56
90%wheat flour 72%+ 10% yellow (180) corn flour	5.95^{cd}± 0.24	11.83^{ab}± 0.12	15.25^{ab}± 0.09	0.69^{ab}± 0.04	0.7^{bc}± 0.014	71.53^{a}±0.19
80%wheat flour 72%+ 20% yellow (180)corn flour	5.15 ^{de}± 0.18	11.63^{ab}±0.29	15.4^{ab}± 0.15	0.9^{ab}± 0.07	0.76^{abc}± 0.04	71.31 ^{a}±0.42
70%wheat flour 72%+ 30% yellow (180) corn flour	4.96 ^{de}± 0.25	11.41^{ab} ±0.21	15.61^{ab}± 0.14	0.98 ^{a}± 0.05	0.84^{abc}± 0.08	71.16 ^{a}±0.38
90%wheat flour 72%+ 10% yellow(178) corn flour	5.45^{cde}± 0.24	11.81^{ab}± 0.08	15.29^{ab}± 0.20	0.63^{ab}± 0.07	0.71^{bc}± 0.04	71.56 ^{a}± 0.15
80%wheat flour 72%+ 20% yellow(178) corn flour	7.75^{ab}± 0.91	11.52^{ab}± 0.14	15.56^{ab}± 0.15	0.79^{ab}± 0.08	0.78^{abc}± 0.04	71.35 ^{a}±0.33
70%wheat flour 72%+ 30% yellow (178) corn flour	4.62 ^{e}± 0.28	11.2 ^{b}± 0.28	15.79 ^{a}± 0.15	0.86^{ab}± 0.11	0.86^{ab}± 0.07	71.29 ^{a}±0.31

Values are mean of three replicates ±SD, number in the same column followed by the same letter are not significantly different at 0.05 level.

Fat content of noodles ranged from 15.07 to 15.79. (LO *et al.,* 2017) found that the fat content of the sorghum noodle samples ranged from 13.66%-16.710%, no significant differences were observed among all corn samples in fat content.

A slight increase in fiber content of corn noodles was observed in relative to control, where fiber content ranged from 0.49 to 92%.

The ash content of noodles increased with addition of corn flour. The highest ash content was found in 30%R370 substation level (0.9%).

Regarding to carbohydrate content in noodles, there were no significant differences among all noodle samples. The carbohydrate content of the noodle samples ranged from 71.02%-71.69%, samples white corn 30% had the highest values of carbohydrate content. The high carbohydrate content of the noodle samples indicates that they will be a good source of energy for the body (LO *et al.,* 2017).

3.7. Cooking quality of different noodles

The cooking test can be influenced by the nature and quality of raw materials, the shape of the final product, the processing system, drying, and the cooking system itself (Garcia *et al.,* 2016). Percentage of volume increase, weight increase and cooking loss of noodles made from wheat flour substituted with different corn hybrids at 10, 20, and 30% are presented in Table (11) The percentage of noodle weight after cooking; represented the ability of the noodles to absorb water from the cooking (Wei *et al.,* 2017). Therefore, the cooking noodle weight was increased with the increased substitution level for different corn hybrids until 30%. The results showed increasing in the percentage weight in noodles white corn from 156 to 175%, corn red sc-1 from 147 to 178%, red corn 370 was 150 to 170%, yellow corn 180 was 151 to 175% and yellow corn 178 was 146 to 178%, respectively compared with control noodles was 143%.this may be due to the higher amount of amylose content in corn starch. Same finding was reported by Majzoobi *et al.,* (2011).

Results shows that cooking loss of noodles increased by increasing substitution corn hybrids level. Noodles containing 10% of white corn (132), and yellow corn hybrid (180) increased non significantly in cooking loss value compared with control. Concern noodles substituted with 10, 20% red corn hybrids (sc-1- 370), and yellow corn hybrids (178) increased non significantly relative to control. This might be due to the fact that polymer interaction in the protein–gluten network can encapsulate the starch granules. Nevertheless, competing for water, protein can speed up the loss of starch (Pu *et al.,* 2017). Previous studies also demonstrated that cooking loss could be due to the disruption of the protein starch matrix through diluted gluten fraction in the case of oat flour (Aydin *et al.,* 2011).

Color is an important quality parameter of noodles. Color is a quality key trait because of the visual impact at the point of sale. It provides some indication of the quality of the starting materials and, in some cases, the age of the product. The *L*, *a*, *b* values of the noodle samples with different level of corn flour are presented in Table (12).The *L* is the measure of the bright from black to white. Compared to control, corn blending flour significantly decreased in noodle *L* value at 0 resting time, while the non-significant difference was only observed between white corn 10% and Control. The results indicated that noodle became dark with increasing corn flour substitution level. (Ma *et al.,* 2014) reported That *L* value of fresh noodle slightly declined as the addition level of corn and millet flour were increased. Regarding to a values, corn flour noodles had a higher *a* value than control particularly red hybrid noodles. In addition, results indicated that corn blending noodle had high *b* value, which indicated that adding corn flour to wheat flour would increase the yellowness of noodles the highest *b* value was observed in yellow hybrids. This was due to the higher carotene content of corn flour as compared to that of wheat flour. Ugarčić-Hardi *et al.,* (2006) reported that adding corn flour to wheat flour would increase pasta yellowness.

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Table 11: Cooking quality of cooked noodles

Samples	Percentage of volume increase	Percentage of weight increase	Cooking loss %
Control wheat flour (72%)	166 ^{e} ± 1.98	143.03 ^{d} ± 0.33	4.04 ^{d} ±0.05
90% wheat flour (72%) + 10% white (132) corn flour	175 ^{de} ± 6.0	156^{bcd}± 7.0	4.83^{bcd}±0.07
80% wheat flour (72%) +20% white (132) corn flour	191.66^{cd} ± 7.02	166. 7^{ab}±	5.85^{ab} ± 0.76
70% wheat flour (72%) +30 % white (132) corn flour	222.67^{ab}± 12.50	175 ^{a} ±5	6.38^{a} ± 0.2
90% wheat flour (72%) + 10% Red (sc-1)corn flour	170 ^{de} ± 4.0	147 ^{cd} ± 7.0	4.52 ^{cd} ± 0.50
80% wheat flour (72%) + 20% Red (sc-1) corn flour	177 ^{de} ± 7.0	152.74^{cd} ±0.23	4.92^{bcd} ±0.39
70% wheat flour (72%) + 30% Red (sc-1) corn flour	202 ^{bc} ±18.0	178.16 ^{a} ± 6.77	5.78^{ab}±0.51
90% wheat flour (72%) + 10% Red (370) corn flour	204^{bc}± 7.211	150^{bc}± 6.0	4.45^{bc}± 0.45
80% wheat flour (72%) + 20% Red (370) corn flour	209.33^{bc}± 11.50	168^{ab}± 3.0	4.87 ^{bcd}±0.33
70% wheat flour (72%) + 30% Red (370) corn flour	232 ^{a} ± 8.0	170 ^{a} ± 10	5.87^{ab} ±0.29
90% wheat flour (72%) + 10% yellow(180) corn flour	176 ^{de} ± 7.0	151 ^{cd} ± 5.57	4.85^{bcd} ± 0.29
80% wheat flour (72%) + 20% yellow(180) corn flour	188.33^{cde}± 9.50	164^{abc} ± 0	5.48^{abc} ± 0.10
70% wheat flour (72%) + 30% yellow(180) corn flour	235^{a} ± 7.0	175.93 ^{a} ± 5.1	5.78^{ab}± 0.46
90% wheat flour (72%) + 10% yellow(178)corn flour	181 ^{de} ±9.0	146.4^{d}±0	4.48 ^{cd} ± 0.49
80% wheat flour (72%) + 20% yellow (178) corn flour	205^{bc}± 6.0	166.23^{ab}± 4.77	4.85^{bcd} ± 0.85
70% wheat flour (72%) + 30% yellow (178) corn flour	237 ^{a} ±8.0	178.21 a ±4.36	5.56 ^{abc} ± 0.40

Values are mean of ten replicates ±SD, number in the same column followed by the same letter are not significantly different at 0.05 level.

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Table 12: Color measurement of instant fried noodle.

Samples	*L*	*a*	*b*
Control wheat flour (72%)	67.93 ^{a}± 0.31	0.45 ^{g}± 0.04	24.36 ^{c}± 0.678
90% wheat flour (72%) + 10% white (132) corn flour	67.25^{ab}± 0.64	0.46 ^{g}± 0.03	24.91 ^{c}± 0.10
80% wheat flour (72%) +20% white (132) corn flour	66.34 ^{b}± 0.65	0.49 ^{g}± 0.01	24.89 ^{c}± 0.13
70% wheat flour (72%) +30 % white (132) corn flour	64.39 ^{c}± 0.28	0.49 ^{g}± 0.01	28.03 ^{b}± 1.16
90% wheat flour (72%) + 10% Red (sc-1)corn flour	66.12 ^{b}± 0.72	0.68^{fg}± 0.04	28.04 ^{b}± 1.16
80% wheat flour (72%) + 20% Red (sc-1) corn flour	59.39 ^{d}± 0.42	1.15^{ef}±0.03	31.25 ^{a}± 1.05
70% wheat flour (72%) + 30% Red (sc-1) corn flour	58.48 ^{d}± 0.59	1.16^{ef}±0.12	32.89 ^{a}± 0.40
90% wheat flour (72%) + 10% Red (370) corn flour	63.59 ^{c}±0.00	0.77^{efg}± 0.03	31.25 ^{a}± 1.04
80% wheat flour (72%) + 20% Red (370) corn flour	58.88 ^{d}± 1.15	1.21 ^{e}± 0.06	32.08^{a}± 0.13
70% wheat flour (72%) + 30% Red (370) corn flour	55.21 ^{e}± 0.20	2.09 ^{d}± 0.22	32.88 ^{a} ± 0.41
90% wheat flour (72%) + 10% yellow (180) corn flour	55.56 ^{e}± 0.28	1.87 ^{d}± 0.08	20.03 ^{e}± 0.26
80% wheat flour (72%) + 20% yellow (180) corn flour	54.15^{e}± 0.54	2.87 ^{c}± 0.08	20.07 ^{e}± 0.21
70% wheat flour (72%) + 30% yellow (180) corn flour	49.48 ^{g}± 0.15	4.05 ^{a}± 0.05	23.09 ^{cd}± 0.02
90% wheat flour (72%) + 10% yellow(178) corn flour	55.06 ^{e}± 0.42	1.87 ^{d}± 0.09	19.81 ^{e}± 1.08
80% wheat flour (72%) + 20% yellow(178) corn flour	54.26 ^{e}±0.39	3.51 ^{b}± 0.60	20.46 ^{e}± 1.47
70% wheat flour (72%) + 30% yellow (178) corn flour	51.59 ^{f}± 0.56	4.12 ^{a}± 0.06	21.77 ^{de}± 0.38

Values are mean of three replicates ±SD, number in the same column followed by the same letter are not significantly different at 0.05 level

Conclusions

R370 hybrid had the highest content of protein and phenolic content in relative to other corn hybrids. Yellow178 had the highest oil, P, Fe and Zn contents among other hybrids. A high content of K and anthocyanin was observed in Rsc-1. Yellow corn hybrids had high content of carotenoids. High antioxidant activity was observed in red hybrids.

Substitution with hybrid corn flour as a component for noodles production improved the quality product and increase the nutritional value particularly using yellow hybrids flour. Noodles prepared with hybrid corn flours presented a chemical composition richer than the control noodle, particularly in fiber and ash. The current study showed that composite blends of pigmented corn flour, has the potential to produce an acceptable novel product which is capable of meeting demands in the noodles with improved nutritional composition quality.

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