Australian Journal of Basic and Applied Sciences
2018 February; 12(2): pages 31-35
DOI: 10.22587/ajbas.2018.12.2.6
Research Article
AENSI Publications

Fortification of Macaroni with Pomegranate Peels as Dietary Fiber and Natural Antioxidant for the Treatment of Obesity and High Cholesterol in Rats

[1]Ebtihal Y. Khojah and [2,3]Dalia A. Hafez

[1]Department of Food Science and Nutrition, College of Science, Taif University, Saudi Arabia
[2]Food Science and Nutrition Department, College of Science, Taif University, kingdom of Saudi Arabia.
[3]Home Economics Department, Faculty of Education, Suez Canal University, Ismailia-Egypt.

Correspondence Author: Dalia A. Hafez Food Science and Nutrition Department, College of Science, Taif University, kingdom of Saudi Arabia.
E-mail: daliaij_2000@yahoo.com

Received date: 10 January 2018, **Accepted date:** 28 February 2018, **Online date:** 10 March 2018

Abstract

Pomegranate (*Punica granatum*) is rich with medicinal properties and extensively used in traditional medicines. Pomegranate peels were dried in an air circulatory tray at 60°C for 48 h. Dried Pomegranate peels were powdered and added to macaroni as dietary fiber and natural antioxidant at different levels to give different blends. The first, second, third and fourth blends had added at levels 10, 15, 20 and 25% of peel powder which was compared with macaroni control had contained 100% semolina wheat flour considerable as control. Chemical, physical and organoleptic properties were determined in different macaroni blends. The results showed that the pomegranate peel had the highest in crude, total dietary fiber, insoluble dietary fiber, soluble dietary fiber, total phenolic acid and total flavonoids compounds. The sensory characteristics of macaroni made from blends at different levels from pomegranate peel give the acceptability results At the end of the biological experiment of duration for four weeks all the measurements for the analysis of blood lipids in rats fed with macaroni blends and compare the results from two negative and positive control groups. The results reported that when the pomegranate peel increased in macaroni the cholesterol was lowered in rats hypercholesterolemia. From the resultant it could be concluded that the uses peel pomegranate powder as dietary fiber and natural antioxidant to produce macaroni blends at different levels gives the best results for sensory characteristics till 20% peel pomegranate and lowering cholesterol in rats hypercholesterolemia.

Key words: Pomegranate peel - natural antioxidant - biological experiment – parameters of blood lipids

INTRODUCTION

The pomegranate (*Punica granatum*) belongs to the Punicaceae family and is a nutrient dense food source rich in phytochemical compounds. Pomegranates are popularly consumed as fresh fruit and juice, beverages, food products (jams and jellies) and extracts wherein they are used as botanical ingredients in herbal medicines and dietary supplements. Several studies reported that phytochemical have been identified from various parts of the pomegranate tree and from pomegranate fruit: peel, juice and seeds (Elfalleh *et al*., 2011). Pomegranate is an important source of bioactive compounds and has been used in folk medicine for many centuries. Most pomegranate fruit parts are known to possess enormous antioxidant activity. In India, pomegranate arils are used as such or are made into juice. Pomegranate juice has been demonstrated to be high in antioxidant activity and is effective in prevention of atherosclerosis, low-density lipoprotein oxidation, prostate cancer, platelet aggregation and various cardiovascular diseases (Adhami and Mukhtar, 2006). Antioxidant potential of pomegranate in vivo and in vitro has been proved (Singh *et al*., 2002). In addition to its antioxidant activity, it has antimicrobial, antibacterial, antiviral, antifungal and antimutagenic properties as well as beneficial effects on the oral and cardiovascular diseases. Besides this, Pomegranate peels have been reported to have pronounced antioxidant activity (Nagi and Jayprakasha, 2003).

Pomegranate fruits peel is an inedible part obtained during processing of pomegranate juice. Pomegranate peel is a rich source of tannins, flavonoids and other phenolic compounds (Li *et al*., 2006). Antioxidant and antibacterial properties of pomegranate peel in in-vitro model systems have been reported (Reddy *et al*., 2007 and Al-Zoreky, 2009). However, pomegranate peel has received less attention as natural preservatives in meat (Devatkal and Naveena, 2010). Pomegranate peel extract has both antioxidant and antimutagenic properties and may be exploited as bio-preservative in food applications and nutraceuticals (Naveena *et al*., 2008).

In addition to their nutritional value, pomegranate peels were used since ancient times as anti-thelmintic, anti-tracheobronchitis, for healing wounds, ulcers, bruises, stomatitis, diarrhea, vaginitis, and against excessive bleeding Ross (2003). In recent years, more medicinal values of pomegranate peel have been investigated such as abortifacient, analgesic, antiameobic, antibacterial, anticonvulsant, antifungal, antimalarial, anti-mutagenic, antiviral, antispasmodic, diuretic, hypoglycemic, hypothermic, and antioxidant activities Seeram *et al*. (2006). The major class of pomegranate phytochemicals is the polyphenols that are predominant in the fruit and includes flavonoids (flavonols, flavanols, and anthocyanins), condensed tannins (pro-anthocyanidins) and hydrolysable tannins (HTs) (ellagi-tannins and gallo-tannins) Seeram *et al*. (2005). These tannins are highly susceptible to both enzymatic and non-enzymatic hydrolysis. The hydrolysis products include glucose and ellagic acid or gallic acid. Additional phytochemicals present in pomegranate peel include organic and phenolic acids, sterols and triterpenoids, and alkaloids Fischer *et al*. (2011). The ellagi-tannins present in the pomegranate peel accounts for approximately 92% of the total antioxidant activity of pomegranate fruit Gil *et al*. (2000). Therefore, the health benefits of pomegranate peel are accredited for the pharmacological activities exhibited by bioactive photochemical like polyphenols.

One method to reduce lipid oxidation is the application of antioxidants. Antioxidants are the chemical substances that reduce or prevent oxidation and have ability to counteract damaging effects of free radicals in tissues and thus are believed to protect against cancer, arteriosclerosis, heart disease and several other diseases Barlow (1990).

The aim of this study was to evaluate the effect of macaroni blends made from peel pomegranate powder from pomegranate fruit at different levels as dietary fiber and natural antioxidant on sensory evaluation of different macaroni blends and also, the effect of different macaroni formulae on serum total lipids, total cholesterol and triglycerides in hypercholesterolemia rats.

MATERIALS AND METHODS

Materials:

Fresh pomegranate fruit (Punica granatum) and semolina wheat (Triticum aestivum) were obtained from the local market at Kingdom Saudi Arabia.

Kits of glucose and lipid parameters were obtained from Bicon Diagnosemittel GmbH and Co. KG Hecke 8 made in Germany.

Methods:

Preparation of peel pomegranate powder:

Mature pomegranate fruits were washed and cut manually to separate the peel (rind) and arils. Powder from pomegranate peel was prepared by drying in an air circulatory tray drier (WT-bimder Tuttlingen / Germany) at 60 ºC for 48 h. The dried pomegranate peel was powdered in a kitchen grinder and sieved using a 60 mesh sieve, and packed into high density polyethylene bags and stored at – 4 ºC in refrigerator until used according to Singh and Sethi (2003) and Devatkal and Naveena (2010).

Chemical analysis of raw materials:

Moisture, protein content, ash, crude fiber, lipids content and total carbohydrates were determined in pomegranate peel according to AOAC (2010). Total dietary fibers, soluble and insoluble dietary fibers were determined in raw materials according to Prosky *et al*. (1988).

Determination of total phenolic compounds:

Total phenolic compounds were determined using the Folin–Ciocalteu method (Ragazzi and Veronese, 1973). One mL of the extract was added to 10.0 mL distilled water and 2.0 mL of Folin–Ciocalteu phenol reagent (Merck- Schuchardt, Hohenbrun, Germany). The mixture was allowed to stand at room temperature for 5 min and then 2.0 mL sodium carbonate was added to the mixture. The resulting blue complex was then measured at 680 nm. Catechin was used as a standard for the calibration curve. The phenolic compound contents were calibrated using the linear equation base on the calibration curve. The contents of phenolic compounds were expressed as mg gallic acid equivalent/g dry weight.

Determination of total flavonoids content:

The $AlCl_3$ method (Lamaison and Carnet, 1990) was used for determination of the total flavonoids content of the sample extracts. Aliquots of 1.5 mL of extracts were added to equal volumes of a solution of 2% $AlCl_3.6H_2O$ (2 g in 100 mL methanol). The mixture was vigorously shaken, and absorbance at 367 nm was read after 10 min of incubation. Catechin was used as a standard for the calibration curve. The flavonoids content were calibrated using the linear equation base on the calibration curve. Flavonoids content were expressed as mg quercetin equivalent/g dry weight.

Determination of minerals content:

Macro elements (calcium and magnesium) and Microelements (iron, zinc, manganese, selenium, aluminum and copper) of pomegranate peel were determined according to the method of the AOAC. (2010), using Atomic Absorption Spectrophotometer (Perkin Elmer, Model 3300, Germany). Phosphorus was determined by spectrophotometer using molybdovan date method according to the AOAC. (2010), while sodium and potassium contents were determined by Flame Photometer (CORNING 400, serial No. 4889.UK).

Macaroni preparation processing:

The ingredients preparation processing macaroni are reported in Table (1). The ingredients were mixed in Hobert mixture at high speed until uniformly (10 min.) and the required amount of water was added. Macaroni was processed using a Demaco (De Francise Machine Corporation) Semi commercial scale Laboratory extruder, according to the method described by Dexter *et al*. (1990). The macaroni was dried at 60^{o}C for 24h and the relative humidity was 75 to 85% according to Dexter *et al*. (1990).

Table 1: The ingredients macaroni blends (on dry weight bases/100g).

Blends	Semolina wheat	Peel pomegranate
Blend 1	100	-
Blend 2	90	10
Blend 3	85	15
Blend 4	80	20
Blend 5	75	25

Physical characteristics of macaroni blends:

Cooking quality was determined namely weigh, volume and the amounts of absorption water during cooking macaroni blends according to Dexter *et al*. (1990). Moreover, total soluble solids of cooking liquor were determined according to the method of Walsh and Gills (1971).

Sensory evaluation of macaroni blends:

The macaroni at different blends after cooking were organoleptically evaluated for their taste, odor, stickiness, color and appearance according to Dexter *et al*. (1990) by twenty experienced panelists.

Nutritional experiments:

Male adult rats (42 rats) weight ranging 150-160g were purchased from Central Animal House in Jeddah, Saudi Arabia. Animals were housed in individual cages with screen bottoms and fed on basal diet for eight days. The basal diet consisted of corn starch 70%, casein 10% corn oil 10%, salt mixture 4%, vitamin mixture 1% and cellulose 5% according AOAC (2010). After feeding on basal diet for eight days, rats were divided into two groups. The first group (6 rats) was fed on the basal diet for another four weeks (30 days) and considered as negative control. The second main group (36 rats) was fasted overnight and injected with strepto zootocin (was dissolved in 0.1M citric acid buffer and adjusted at pH 4.5) into the leg muscle (5mg /100g body weight) to induce diabetic rats according to Madar (1983). After 48 h of injection the second main group was divided into six subgroups (6 rats for each). The first one (6 rats) was continued to be fed on basal diet and considered as positive control. From the second to six subgroups (6 rats for each) were fed on 20% from macaroni after cooking prepared from five blends contained obviously ingredients. Each rat was weighted every two days and the gain body weight was calculated.

At the end of experimental period (four weeks), the blood samples were taken with drawn from the orbital plexus and centrifuged at 3000 rpm to obtain the sera. After that, the sera were kept on a deep freezer at -20^{o}C until their analyses.

Serum glucose, total lipids, total cholesterol and triglycerides were determined according to knight *et al*. (1972), Allain *et al*. (1974), Fossati and Prencipe (1982) and Tietz (1986), respectively. High and low density lipoprotein- cholesterol in serum was determined according to Burstein (1970) and Fruchart (1982).

Citation: Ebtihal Y. Khojah and Dalia A. Hafez, 2018. Fortification of macaroni with pomegranate peels as dietary fiber and natural antioxidant for the treatment of obesity and high cholesterol in rats. Australian Journal of Basic and Applied Sciences., 12(2): 31-35.

Statistical analysis:

The obtained data were exposed to analysis of variance. Duncan's multiple range tests at ($P \leq 0.05$) level was used to compare between means. The analysis was carried out using the PRO ANOVA procedure of Statistical Analysis System (SAS, 2004).

RESULTS AND DISCESSION

Nutrition compounds of pomegranate peel powder:

The gross chemical components; namely crude protein, crude fat, ash content, crude fibers and carbohydrates, content of pomegranate fruits peel powder are represented as in Table (2).From the resultant in Table (2), it could be noticed that the moisture content of produced pomegranate fruits peel powder was found to be 13.7 %. In addition, crude protein, crude fat, ash, crude fibers and carbohydrates contents for pomegranate fruits peel powder were 3.10, 1.73, 3.30, 11.22 and 80.50 %, on dry weight basis; respectively. Thereupon, the pomegranate fruits peel powder is considered a good source of crude fibers, ash and carbohydrates. Therefore, pomegranate fruit peels powder should be utilized in fortification of foodstuffs. These results are nearly in according with those found by Fadavi *et al*. (2006) and Kingsly *et al*. (2006).

The total dietary fiber, soluble and insoluble dietary fibers were determined in pomegranate fruits peel powder and the results are reported in the same table. The results showed that the pomegranate fruits peel powder had the highest amounted from total dietary fiber; soluble and insoluble dietary fibers were 56.23, 43.54 and 12.69%, respectively. These results are agreement with Figuerola *et al*. (2005) who found the soluble/insoluble fiber ratios are important from both dietary and functional perspectives. It is generally accepted that those fiber sources suitable to be used as a food ingredient should have an SDF/IDF ratio close to 1/2. Dietary fibers from cereals are more frequently used than those from fruits, even though, fruit fibers, in general, have better nutritional qualities because of their higher levels of associated bioactive compounds and more balanced composition (higher overall fiber content and greater IDF/SDF ratio).

Total phenolic acid and flavonoids compounds were determined in pomegranate fruits peel powder and the results are reported in the same table. From the resultant it could be notice that the pomegranate fruits peel powder had higher amounted from total phenolic acid and flavonoids compounds were 58.63 mg/g GAE and 47.32 mg/g Q E, respectively. Pomegranate is rich in antioxidant of polyphenolic class which includes tannins and anthocynins and flavonoids (Ricci *et al*., 2006 and De Nigris *et al*., 2007). Pomegranate is useful for cases of high fever, chronic diarrhea and expelling intestinal worms especially tapeworms and treatment of hemorrhoids, as it is beneficial to cold and treatment of skin disease, scabies and a mix powder peel with honey and used daily in the form of paint.

Table 2: Gross chemical composition of pomegranate peel (on dry weight basis).

Chemical components	Pomegranate peel powder
Moisture	13.7
Protein	3.10
Fat	1.73
Crude fibers	11.22
Ash content	3.30
Total carbohydrates	80.65
Total phenolic mg/100g	27.92
Total dietary fiber	56.23
Soluble dietary fiber	43.54
Insoluble dietary fiber	12.69
Total phenolic GAE mg/g	58.63
Total flavonoids Q E mg/g	47.32

Minerals content of pomegranate peel:

The nutritional quality of pomegranate peel powder with regards their minerals content was evaluated and the obtained results are recorded as in Table (3). From the obtained data Table (3), it could be showed that the pomegranate fruits peel powder had contained at all test minerals, with the exception of Mg which was not detected in them. The fruits peel powder had contained the most determined minerals at adequate concentration and the predominant minerals in it were found to be Ca, K, P and Na at level of 338.5, 146.4, 117.9 and 66.4 mg/100g dry matter; respectively. In addition, the pomegranate peel powder had contained a considerable content of Fe, Zn and Cu at level of 5.93, 1.01 and 0.60 mg/100g dry matter; respectively. In general, it could be concluded that pomegranate fruits peel were characterized with their richness with the most determined nutritious minerals and they are considered a good source of macro and micro elements. Therefore, they should be utilized in food fortification.

Iron is an important trace element in the human body. It plays crucial roles in haemopoiesis, control of infection and cell mediated immunity Beard, (2001).The deficiency of iron has been described as the most prevalent nutritional deficiency and iron deficiency anemia is estimated to affect more than one billion people worldwide Trowbridge and Martorell (2002). Zinc is an essential micronutrient for human growth and immune functions Black (2003). Manganese (Mn) plays an important role in a number of physiological processes as a constituent of some enzymes and an activator of other enzymes Nielsen (1999).

Table 3: Minerals content (mg/100g dry matter) of pomegranate peel:

Minerals content	Pomegranate peel powder	RDA* (mg/day)	
		Children	Adults
Ca	338.5	800	800-1200
Mg	--	--	--
K	146.4	--	--
Na	66.43	808	800-1200
P	117.9	10	10-15
Fe	5.93	10	12-15
Zn	1.01	--	---
Mn	0.80	--	---
Cu	0.60	--	---

RDA*: Recommended dietary all allowances from minerals reported by Food and Nutrition Board, (1989).

Physical properties of macaroni blends:

Data of the cooking test parameters (volume, weight and total soluble solids) of the macaroni blended are shown in Table (4). The volume and weight cooking parameters of macaroni prepared from 75% wheat flour 72% extraction and 25% pomegranate peel powder blend (5) were 340.52 and 284.24%, respectively followed by macaroni blend (4) was 310.36 and 256.76% was significant increased than macaroni blend (3) was 261.56 and 229.51%, respectively. The cooking parameters for pomegranate peel powder composites were increased with increasing ground of pomegranate peel powder contents in all blends. However, there was significant decreased between 100% semolina wheat flour macaroni blend (1) was 218.17 and 215.69% and 10% pomegranate peel powder macaroni blend (2) was 242.85 and 227.36%, respectively than other blends. Pomegranate peel powder composites in the macaroni blends by increasing cooking parameters could be widely used for their thickening and gelling properties and emulsion stabilization in food industries. Whereas, total soluble solids in macaroni blends were paralleled cooking test parameters.

Table 4: Percentage of cooking test parameters of macaroni blends.

Blends	Volume increase	Weight increase	Total soluble solids
Blend 1	218.17±5.12[b]	215.69±4.21 [b]	7.62±1.24 [b]
Blend 2	242.85±6.04[ab]	227.36±5.33 [ab]	10.85±1.22 [ab]
Blend 3	261.56±5.37[ab]	229.51±5.46 [ab]	12.28±1.83 [ab]
Blend 4	310.36±7.11[a]	256.7±4.68 [a]	14.63±1.49 [a]
Blend 5	340.52±6.82[a]	284.24±5.83 [a]	16.54±2.41 [a]

Sensory evaluation for different blends of macaroni:

Pomegranate peel powder was incorporated in macaroni blends with semolina wheat flour. The macaroni products after cooking were color, taste, appearance, odor and stickiness) after cooking, the results are reported in Table (5). From the data in Table (5), it could be noticed that the overall quality values of tested blends were found. The blends 1, 2 and 3 were high acceptability and score (48.7, 48.6 and 48.2, respectively) and was significantly different from the blends 4 and 5 (47.9 and 47.6, respectively). Moreover, it is possible to observe that the overall quality decreased with the increasing of the amount of pomegranate peel powder. This result is due to the fact that the score of attributes such as color and stickiness decreased with the increase of evaluated for sensory characteristics may be caused the pomegranate peel powder amount influencing positively the overall quality of the macaroni blends. Moreover, the slightly decrease during overall acceptability in blends (4 and 5) followed by blend (3) than blends 1and 2 may be due to pomegranate peel powder had contained high amounts of total dietary fiber 56.23%. Dietary fibers which is highly water-binding macromolecules is competing with starch for water absorption and hence limiting starch swelling and gelatinization resulting in a higher endothermic peak temperatures value (Singh *et al.*, 2003).

Table 5: Sensory evaluation for different blends of macaroni:

Blends	Color (10)	Taste (10)	Appearance (10)	Odor (10)	Stickiness (10)	Over all acceptability
Blend 1	9.8±0.87[a]	9.8±0.51[a]	9.7±0.19 [a]	9.7±0.42[a]	9.7±0.37 [a]	48.7±29 [a]
Blend 2	9.8±0.68[a]	9.8±0.50[a]	9.7±0.17[a]	9.6±0.34[a]	9.7±0.13[a]	48.6±2.8[a]
Blend 3	9.6±1.19[a]	9.8±0.50[a]	9.6±0.21[a]	9.5±0.53[a]	9.7±0.56[a]	48.2±3.7[a]
Blend 4	9.5±0.74[a]	9.8±0.53[a]	9.8±0.14[a]	9.8±0.70[a]	9.0±0.44[a]	47.9±4.2[a]
Blend 5	9.3±0.41[ab]	9.7±0.47[a]	9.8±0.12[a]	9.8±0.41[a]	9.0±0.34[a]	47.6±3.6[a]

Effect macaroni blends after cooking on body weight in rats:

The results in Table (6) showed that effect of macaroni blends after cooking on body weight of hyperglycemic rats. The results concerning the initial, finial and gain body weight at the end of experiment are recorded in Table (6). The results showed that in case of rats fed on diet contained 20% from blend (5) made from 25% pomegranate peel powder and 75% semolina wheat flour and 20% pomegranate peel powder as blend (4) followed by 15% pomegranate peel powder as blend (3) the gain body weight were decreased from 156.6, 126.0g in control negative and positive to70.5, 77.6 and 91.8g respectively. This decrease in gain body weight in the blends containing pomegranate peel powder may not be palatable to rats due to the presence of dietary fiber there by leading to poor food intake. Dietary fiber consists of non-digestible carbohydrates and lignin that are intrinsic and intact in vegetal products. They have beneficial physiologic effects in humans (Slavin, 2005).

Table 6: Effect of different diets on body weight in the rats.

Groups	Body weight			
	Initial (g)	Finial (g)	Gain (g)	Daily gain(g)
Control negative	155.0 ± 2.70[a]	312.0 ± 1.58[a]	156.6 ± 2.70[a]	5.22 ± 0.05[a]
Control positive	153.2 ± 2.58[a]	279.2 ± 4.43[a]	126.0 ± 2.44[b]	4.20 ± 0.04[b]
Blend 1	156.23±2.34[a]	276.53±3.51 [a]	120.3±1.954[b]	4.01±0.04[b]
Blend 2	154.98±2.13[a]	260.48±2.05[ab]	105.5±1.213[ab]	3.52±0.08[ab]
Blend 3	153.8 ± 3.49[a]	245.8 ± 1.92[b]	91.8 ± 5.10[b]	3.06 ± 0.08[c]
Blend 4	155.4 ± 2.6[a]	233.0 ± 2.34[c]	77.6 ± 4.04[c]	2.59 ± 0.07[d]
Blend 5	157.36±3.95[a]	227.9±1.58[d]	70.5±4.54[c]	2.35±0.05[d]

Effect of macaroni blends after cooking on hyperglycemic in rats:

Total lipid, triglycerides, total cholesterol, low density lipoprotein, high density lipoprotein and blood sugar were determined in hyperglycemic rats fed on all blends macaroni after cooking and the results are reported in Table (7). The results illustrated that the macaroni made from 25% pomegranate peel powder and 75% semolina wheat blend (5) was significant decreased in lipids profile and blood sugar on hyperglycemic in rats and also, 20% pomegranate peel powder as blend (4) followed by 15% pomegranate peel powder as blend (3) showed that lowering lipid profile and blood sugar compared with positive control fed on basal diet.

Soluble dietary fibers are believed to slow the release of reducing sugars from food and hence lower postprandial blood glucose level by several mechanisms, including reduced amylolysis, but more specifically at the gastrointestinal level, through delayed gastric emptying (Colonna *et al*., 1990).

In this concern, pomegranate fruits peel can be used as functional ingredient as a good source of crude fibers and natural antioxidants which provide numerous health benefits such as their ability to decrease serum LDL-Cholesterol level, improve glucose tolerance and the insulin response, reduce hyperlipidemia and hypertension, contribute to gastrointestinal health and the prevention of certain cancers such as colon cancer (Lansky and Newman, 2007 and Viuda-Martos *et al*., 2010 a,b).

Table 7: Effect macaroni blends on lipid profile and blood sugar:

Groups	Total Lipid (g/dl)	Triglyceride (mg/dl)	Total cholesterol (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	Blood sugar (mg/dl)
Control negative	0.65 ±0.03[d]	112.3 ±6.1[d]	86.3 ±1.1[d]	83.7 ±10.0[a]	25.0 ±5.56[d]	115.3 ±5.7[d]
Control positive	1.42 ±0.17[a]	245.7 ±27.9[a]	196.3 ±6.5[a]	47.3 ±7.2[d]	131.7 ±20.2[a]	169.3 ±3.8[a]
Blend 1	1.12±0.59[a]	190.4±15.3[b]	150.2±3.4[b]	60.1±5.2[c]	85.4±12.3[b]	140.2±3.5[b]
Blend 2	0.97±1.02[b]	170.5±10.5[b]	140.6±4.1[b]	67.5±3.1[c]	77.3±9.8[b]	130.1±2.3[b]
Blend 3	0.73 ± 0.06[c]	158.7 ±9.07[c]	12.3 ± 3.5[c]	72.0 ±3.0[b]	58.3± 6.03[c]	125.6 ±1.2[c]
Blend 4	0.78 ±0.13[c]	141.0 ±30.0[c]	117.0 ±7.0[c]	74.0 ±5.3[b]	49.67 ±10.0[c]	120.3 ±1.2[c]
Blend 5	0.68±0.19[d]	120.1±7.5[d]	100.0±6.3[d]	80.0±4.2[a]	30.7±6.34[d]	116.7 ±2.8[a]

Conclusion:

From the above results it may be concluded that the macaroni properties of pomegranate peel powder composites revealed some interesting properties and useful information on their potential nutritional food applications. Pomegranate peel powder composites were unique because they provide the total dietary fiber and natural antioxidants that is beneficial for food and coronary heart disease prevention along with the health benefits. Besides the nutritional aspects of the pomegranate peel powder composites, these composites have improved cooking, taste parameter and overall acceptability. These technologically developed products could be valuable for new functional foods having improved nutritional value and desirable texture qualities for health concerned consumers and hypoglycemic.

REFERENCES

Adhami, V.M. and H. Mukhtar, 2006. Polyphenols from green tea and pomegtanate for prevention of prostate cancer. Free Radical Research, 40: 1095-1104.

Al-Zoreky, N.S., 2009. Antimicrobial activity of pomegranate (*Punica granatum* L.) fruit peels. International J. Food Microbiology, 134: 244-248.

Allain, C.C., L.S Poon, C.S. Chan, W. Richamand and P.C. Fu, 1974. Enzymatic determination of total serum cholesterol.Clin. Chem., 20(4): 470.

AOAC. 2010. Official Methods of Analysis of Association of Official Chemists. 18th Ed., Washington, D.C., USA.

Barlow, S.M., 1990. Toxicological Aspects of Antioxidants Used as Food Additives, in: B.J.F. Hudson (Ed.), Food Antioxidants, Barking, England, Elsevier Science Publishers Ltd., pp: 253-307.

Beard, J.L., 2001. Iron biology in immune function, muscle metabolism and neuronal functioning. J. Nutr., 131: S568-S579.

Black, R.E., 2003. Zinc deficiency, infectious disease Black, R.E., 2003. Zinc deficiency, infectious disease, 133: S1485-S1489.

Burstein, M., 1970. HDL Cholesterol determination after separation of high density lipoprotein. Lipids Res., 11: 583-589.

Colonna, P., J.L. Barry, D. Cloarec, F. Bornet, S. Gouilloud and J.P. Galmiche, 1990. Enzymatic susceptibility of starch from pasta. J. Cereal Sci., 11: 59-70.

Devatkal, S.K. and B.M. Naveena, 2010. Effect of salt, kinnow and pomegranate fruit by-product powders on color and oxidative stability of raw ground goat meat during refrigerated storage. Meat Science., 85: 306-311.

De Nigris, F., M.L. Balestrieri, S. Williamsignarro, F.P. D'Armiento, C. Fiorito, L.J. Ignarro and C. Napoli, 2007. The influence of pomegranate fruit extract in comparison to regular pomegranate juice and seed oil on nitric oxide and arterial function in obese Zucker rats. Nitric Oxide, 17: 50-54.

Dexter, J.E., R.R. Matsuo and J.E. Kruger, 1990. The spaghetti-making quality of commercial durum wheat samples with variable α-amylase activity. Cereal Chem., 67: 405-412.

Elfalleh, W., N. Tlili, N. Nasri, Y. Yahia, H. Hannachi, N. Chaira, M. Ying and A. Ferchichi, 2011. Antioxidant capacities of phenolic compounds and tocopherols from Tunisian pomegranate (*Punica granatum*) fruits. J. Food Sci., 76(5): 707-713.

Fadavi, A., M. Barzegar and M.H. Azizi, 2006. Determination of fatty acids and total lipid content in oilseed of 25 pomegranates varieties grown in Iran. J. Food Comp. Anal., 19: 676-680.

Figuerola, F., M.L. Hurtado, A.M. Estévez, I. Chiffelle and F. Asenjo, 2005. Fibre concentrates from apple pomace and citrus peel as potential fiber sources for food enrichment. Food Chemistry. 91 : 395-401.

Fischer, U., R. Carle and D. Kammerer, 2011. Identification and quantification of phenolic compounds from pomegranate (*Punica granatum* L.) peel, mesocarp, aril and differently produced juices by HPLC-DAD–ESI/MSn. Food Chem., 127: 807-821.

Food and Nutrition Board, 1989. United States Recommended Dietary Allowances (USRA). National Res.Councils. National Academy of Science, Washington, Dc.

Fossati, P. and L. Prencipe, 1982. The determination of triglyceride using enzymatic methods. Clin. Chem., 28: 2077.

Fruchart, J.C., 1982. LDL Cholesterol determination after separation of low density lipoprotein. Rev. Fr. Des Lab., 103: 7-17.

Gil, M., F. Tom-Barbern, B. Hess-Pierce, D. Holcroft and A. Kader, 2000. Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. J Agri Food Chem., 48: 4581-4589.

Knight, J.A., S. Anderson and J.M. Rowle, 1972. Chemical bases of the sulpfo-phospho vanillin reaction for estimating total serum lipids. J. Clin. Chem., 18: 199.

Kingsly, A.R.P., D.B. Singh, M.R. Manikantan and R.K. Jain, 2006. Moisture dependent physical properties of dried pomegranate seeds (Anardana). J. Food Engin., 75(4): 492-496.

Lansky, E.P. and R.A. Newman, 2007. *Punica granatum* (pomegranate) and its potential for prevention and treatment of inflammation and cancer. J. Ethnopharmac., 109: 177-206.

Lerman, L., E. Crimi and C. Botti, 2005. Beneficial effects of pomegranate juice on oxidation-sensitive genes and endothelial nitric oxide synthase activity at sites of perturbed shear stress. *Proceedings of the National Academy of Sciences of the United States*, 102(3): 4896- 4902.

Li, Y., C. Guo, J. Yang, J. Wei, J. Xu and S. Cheng, 2006. Evaluation of antioxidant properties of pomegranate peel extract in comparison with pomegranate pulp extract. Food Chemistry, 96: 254-260.

Mader, Z., 1983. Effect of brown rice and soybean dietary fiber on the control, glucose and lipid metabolism in diabetic rats. Am. M. J. Clin. Nutr., 388-393.

Naveena, B.M., A.R. Sen, R.P. Kingsly, D.B. Singh and N. Kondaiah, 2008. Antioxidant activity of pomegranate rind powder extract in cooked chicken patties. Inter. J. Food Science Techn., 43: 1807-1812.

Negi, P.S. and G.K. Jayaprakasha, 2003. Antioxidant and antibacterial activities of *Punica granatum* peel extracts. Journal of Food Science., 68(4): 1473-1477.

Nielsen, F.H., 1999. Ultra Trace Minerals. In: M. Shils, J.A. Olson, M. Shike and A.C. Ross, eds. Nutrition in Health and Disease. 9th Ed. Baltimore: Williams and Wilkins, pp: 283.

Prosky, L., N.G. Asp, T.F. Schweizer, J.W. Devries and I. Furdal, 1988. Determination of insoluble and soluble and total dietary fiber in food products: Inter laboratory study. J. Assoc. Off. Anal. Chem., 71: 1017-1023.

Reddy, M.K., S.K. Gupta, M.R. Jacob, S.I. Khan and D. Ferreira, 2007. Antioxidant, antimalarial and antimicrobial activities of tannin-rich fractions ellagitannins and phenolic acids from *Punica granatum* L. Planta Med., 73: 461-467.

Ragazzi, E. and G.Veronese, 1973. Quantitative analysis of phenolics compounds after thin-layer chromatographic separation. J. Chromatogr, 77: 369-375.

Ricci, D., L. Giamperi, A. Bucchini, D. Fraternale, 2006. Antioxidant activity of *Punica granatum* fruits. Fitoterapia, 77: 310-312.

Ross, I., 2003. Medicinal plants of the world. 1st ed. Totowa: New Jersey.

SAS Institution 2004. SAST user statistics, var 6.04, 4 th Ed.SAS. Institution.Cary,N.C.

Seeram, N., R. Schulman and D. Heber, 2006. Pomegranate: Ancient Roots to Modern Medicine. 2nd ed. Boca Raton: New York.

Seeram, N., R. Lee, M. Hardy and D. Heber, 2005. Rapid large scale purification of ellagitannins from pomegranate husk, a by-product of the commercial juice industry. Sep Purif. Technol., 41: 49-55.

Singh, R.P., K.N.C. Murthy and G.K. Jayaprakasha, 2000. Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using in vitro models. Journal of Agricultural and Food Chemistry, 50: 81-86.

Singh, D. and V. Sethi, 2003. Screening of pomegranate genotypes for the preparation of quality grade anardana. J. Food Sci. Techn., 40(2): 236-238.

Slavin, J.L., 2005. Dietary fiber and body weight. Nutrition., 21: 411-418.

Tietz, N.W., 1986. Text Book of Clinical Chemistry. P.796.Saunders, W. B. Co., London-Pheladelphia.

Trowbridge, F. and R. Martorell, 2002. Forging effective strategies to combat iron deficiency. Summary and Recommendations. J. Nutr., 85: S75-S80.

Viuda-Martos, M., J. Fernandz-Lopez and J.A. Perez-Alvarez, 2010*a*. Pomegranate and its many functional components as related to human health: A review. Comprehensive Reviews in Food Science and Food Safety, 9: 635-654.

Viuda-Martos, M., M.C. Lopez- Marcos, J. Fernandz-Lopez, E. Sendra, J.H. Lopez-Vargas and J.A. Perez-Alvarez, 2010*b*. Role of fiber in cardiovascular diseases. A review. Comprehensive Reviews in Food Science and Food Safety, 9: 240-258.

Walash, R.A. and K.A. Gilles, 1971. The influence of protein composition on spaghetti quality. Cereal Chem., 48: 544-553.