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Pumpkin and chia seed as dietary fibre source in meat products: A review

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Abstract
Pumpkin seeds (*Cucurbita* sp.) are usually considered as agro-industrial wastes and discarded in spite of having nutritious and best quality oil and rich source of protein and dietary fibre. Moisture, protein, fat, ash and crude fibre content of pumpkin seeds are 5.26%, 24.46%, 38.53%, 3.26% and 14.77% respectively. Regular consumption of pumpkin seed added products can improve nutrition and health. Chia seeds have become one of most popular super foods in the health community. It is a great source of dietary fibre which is good for the digestive health and also having higher concentration of beneficial unsaturated fatty acids, gluten free protein, vitamin, minerals, and phenolic compounds. It is also a superb source of omega-3 fatty acid because of higher proportion of α-linolenic acid. So this review summarizes the nutritional, physicochemical and therapeutic influence of pumpkin and chia seeds in meat and meat products.

Keywords: Pumpkin seeds, chia seeds, meat products, nutritional value, water holding capacity, proximate composition and dietary fibre

Introduction
Pumpkin (*Cucurbita maxima*) is grown under a wide range of agro climatic conditions in India. After harvesting, the seeds are often used as animal feed, for decoration purposes, ground up for fertilizer or even discarded in spite of having very nutritious and best quality oil and rich source of protein (Mishra *et al*., 2019) [46]. Pumpkin seeds are located at its central hollow cavity; interspersed in between net like mucilaginous network. The seed content of pumpkin fruit varies from 3.52% to 4.27% (Devi *et al*., 2018) [24]. When ripe, fruit is rich in carotenoids and ascorbic acid (Sirohi *et al*., 1991) [72]. Several pumpkin cultivars (*Cucurbita maxima* D.) were studied for their seed oil content, fatty acid composition and tocopherol content and it was found that the oil content ranged from 11 to 31%. Total unsaturated fatty acid content ranged from 73 to 81%. The predominance of linoleic, oleic, palmitic and stearic acids was observed. The tocopherol content of the oils ranged from 27.1 to 75.1 µg/g of oil for alpha-tocopherol, 74.9 to 492.8 µg/g for γ-tocopherol and 35.3 to 1109.7 µg/g for δ-tocopherol. The total phenolic content in the pumpkin seed oil ranged from 25 to 51mg GAE/kg of oil (Andjelkovic *et al*., 2010) [7]
Cucurbit seeds from different regions in Cameroon contained protein content of 28-40%, fat 44-53% and carbohydrate 7-10%, showing that they could be exploited as oil and protein sources (Achu *et al*., 2011) [1]. Pumpkin seed oil can be a valuable source of edible oil as the seeds contained 41.59% oil and 25.4% protein. Moisture, crude fibre, total ash and carbohydrate contents were 5.20%, 5.34%, 2.49% and 25.19% respectively (Ardabili *et al*., 2010) [8]. Moisture, protein, fat, ash and crude fibre content of pumpkin seeds were found to be 5.26%, 24.46%, 38.53%, 3.26% and 14.77% respectively (Milovanovic *et al*., 2014) [45].

Health benefit of pumpkin seed
The pumpkin is economical and a nutrient dense source. The pumpkin seed flour fortified complementary food mix has highly acceptable sensory qualities and possess rich nutritive value. The consumption of flax/pumpkin or purslane/pumpkin seed mixtures results in significant decrease in lipid parameters suggesting the antiatherogenic potential of the seed mixture (Barakat and Hussain, 2011) [13]. Pumpkin seeds play an important role in relaxing vessels and lowering the blood pressure presenting its antihypertensive and cardio protective effects. Also, pumpkin seed consumption helps in management of cancer (Patel, 2013) [57]. Pumpkin seed also has anthelmintic effect. The biscuits prepared by incorporating flax seed powder and pumpkin seed powder were enriched with protein and fibre and were more nutritious than control biscuit (Saraswathi *et al*.,2018) [65].

It was also reported that pumpkin seeds were rich in omega 3 and omega 6 fatty acids needed for hormonal balance, brain function and skin health. Tryptophan present in these seeds aids in milk production in lactating mothers and used to reduce postpartum swelling of the hands and feet. Hence pumpkin seeds serve as a good nutritious snack and promote good health. Pumpkin has high nutritive value and thus can be used in treatment of pregnant women and children affected by infestation of tape worms (Sharma and Lakhawat, 2017) [71]. It is also used in promoting prostate health. So adequate and frequent consumption of pumpkin added products can improve our nutrition and health besides serving as delicious food possessing therapeutic values.

Table 1: Chemical composition and bioactive components of pumpkin seed

Principle	Nutrient Value	Percentage of RDA	Principle	Principle Nutrient Value	Percentage of RDA
Energy	559Kcal	28%	Electrolytes		
Carbohydrates	10.71 g	8%	Sodium	7 mg	0.5%
Protein	30.23 g	54%	Potassium	809 mg	17%
Total Fat	49.05 g	164%	Minerals		
Cholesterol	l 0 mg	0%	Calcium	46 mg	4.5%
Dietary Fibre	6 g	16%	Copper	1.343 mg	149
Vitamin			Iron	8.82 mg	110%
Folates	58 µg	15%	Magnesium	592 mg	148%
Niacin	4.987 mg	31%	Manganese	4.543 mg	198%
Pantothenic acid	0.750 mg	15%	Phosphorus	1233 mg	176%
Pyridoxine	0.143 mg	11%	Selenium	9.4 µg	17%
Riboflavin	0.153 mg	12%	Zinc	7.81 mg	71%
Thiamine	0.273 mg	23%	Phytonutrients		
Vitamin A	16 IU	0.5%	Carotene-ß	9 µg	--
Vitamin C	1.9 µg	3%	Cryptoxanthin-ß	1 µg	--
Vitamin E	35.10 mg	237%	Luteinzeaxanthin	74 µg	--

***Source*:** USDA National Nutrient data base, 2018 [74].

Chia seed

Salvia hispanica L. or chia is an annual herbaceous plant belonging to the Lamiaceae family native to Mexico and Guatemala. This plant grows up to 1.75 metres (5.7 feet) height. Its flowers are purple or white and are produced in numerous clusters in a spike at the end of each stem. Chia is grown commercially for its black and white seeds which are naturally rich in omega-3 fatty acids, antioxidants, dietary fibre, protein, calcium and various other essential nutrients (Ixtaina *et al*., 2008) [35]. Typically, chia seeds are tiny, oval with a diameter of around 1 mm (0.039 in). They are mottle coloured with brown, grey, black and white. Seed yield varies depending on cultivars, mode of cultivation and growing conditions by geographic region. Being hydrophilic, they can absorb liquid up to 12 times of their weight when soaked. When chia seeds are soaked in water, a clear mucilaginous gel is released forming a highly viscous solution. (Munoz *et al.*, 2012; Salgado-Cruz *et al*., 2013) [47, 64].

Chia seeds are rich in omega-3 fatty acids with a yield of 25–30% extractable oil, including α-linolenic acid. The composition of the fat of the oil may be 55% omega-3, 18% omega-6, 6% omega-9 and 10% saturated fat (National Nutrient Database USDA, 2010) [75]. Chia seeds have become one of most popular super foods in the health community. Consumption of chia seeds can promote proper intestinal functioning, decrease blood cholesterol and glucose levels and decrease the incidence of diseases related to metabolic syndrome because of its great nutritional properties (Puig and Haros, 2011) [61]. The chia seed is becoming increasingly important because of its nutritional and functional properties and it is described as ―the seed of the 21st century‖ and ―new gold and super nutrient.

Table 2: Chemical composition and bioactive component

Nutrient	USDA	Comparison of fibre content of some foods (Fernandez *et al.*, 2006b) [30]	
Energy (100 g)	486	Chia	37.7
Protein%	16.54	Walnuts	5.2
Fat%	30.47	Fava Beans	19.0
Vitamin C mg	1.6	Figs and Plums	17.0
Thiamine mg	0.62	Dried Peas	4.4
Riboflavin mg	0.17	Breakfast Cereals	4.0
Niacin mg	883	Banana	4.0
Folate µg	49	Lentils	12–15
Calcium mg	631	Almond	14.0
Potassium mg	407	Carrots	2.9
Magnesium mg	335	White Bread	2.2
Phosphorus mg	860	Cauliflower	2.1
Selenium (µg)	55.2	Peanut	8.1
Iron mg	7.72	Quince	6.4
Zinc	4.58	Kiwi	1.6

***Source*:** USDA National Nutrient Database for Standard Reference, 2011 [76].

Table 3: Fatty acids composition in chia seed oil

Fatty acids	Content of individual fatty acids [% of total fat content]					
	Ciftci *et al.* (2012) [17]	**Ayerza and Coates (2001) [11]**	**Alvarez-Chaveza *et al.* (2008) [6]**	**Ixtaina *et al.* (2011) [34]**	**Coelho and Salas-Mellado (2014) [18]**	**Sargi *et al.* (2013) [66]**
Palmitic acid 16:0	7.10	9.66	6.30	7.2	6.69	5.85
Stearic acid 18:0	3.24	4.34	3.10	3.8	2.67	2.49
Oleic acid 18:1	10.53	6.84	7.50	15.2	10.55	6.16
ω-6 α-linolenic acid 18:2	20.37	17.65	19.90	19.1	17.36	17.47
ω-3 α-linolenic acid 18:3	59.76	64.08	63.4	64.7	62.02	54.49

Table 4: Mineral content in chia seed

Minerals	Content of minerals (mg/100 g)		
	for Standard Reference (2011) [53]	**Bolanos *et al.* (2016) [14]**	**Llorent-Martuinez *et al.* (2013) [40]**
Calcium	631	624	580
Phosphorus	860	799	696
Potassium	407	666	870
Magnesium	335	369	403
Iron	7.7	24.4	10.9
Zinc	4.6	6.9	6.0
Selenium*	55.2	78.0	-

Chia seed contains 30 - 33.5 g oil/100 g with high concentrations of polyunsaturated fatty acids (PUFA), α linolenic acid (57 - 65 g/100 g) being the main essential fatty acid present in it (Ayerza and Coates, 2011) [12]. Additionally, it does not have any toxic substance and gluten. So it can be easily consumed by people with gluten intolerance. The fibre rich fraction (FRF) of chia seed obtained by dry processing of its defatted parts has 29.56 g/100 g crude fibre content and 56.46 g/100 g total dietary fibre (TDF) content, out of which 53.45 g/100 g is insoluble dietary fibre (IDF) and 3.01 g/100 g is soluble dietary fibre (SDF) (Alfredo *et al.*, 2009) [5]. The FRF water holding capacity, water absorption capacity and organic molecule absorption capacity was 15.41 g/g, 11.73 g/g and 1.09 g/g respectively. The FRF also had low oil holding (2.02 g/g) and water adsorption (0.3 g/g) capacities.

Chia seeds contain healthy omega-3 fatty acids, polyunsaturated fatty acids, dietary fibre and protein including all essential amino acids, vitamins, calcium and other important minerals (Deka and Das, 2017) [23]. Additionally, it is known that the chia seeds contain immense amount of polyphenolic compounds with potent antioxidant activity, mainly flavonoids such as quercetin, kaempferol, myricetin and others (Ixtaina *et al.*, 2011) [34]. Due to its mucilaginous gel, chia seeds can be used in cosmetic, pharmaceutical and food companies as protective agent against moisture, foam stabilizer and emulsifier agents for its particular composition rich in carbohydrates (De falco *et al.*, 2017) [22]. Foods such as frozen products, bakery products, meat products, beverages, sweets, pasta and sausages can be enriched with chia seeds and chia oil can be used as fat replacer for these products.

Health benefits of chia seed

Due to high dietary fiber and low carbohydrate content chia seed has demonstrated the ability to increase satiety and reduce the desire to eat, ultimately helping in weight control (Ayaz *et al*., 2017; Vuksan *et al*., 2017a) [9, 79]. Antioxidant property of chia seeds can protect the organism from pathologies like neurological diseases, inflammation, immune deficiency, ischemic heart disease, strokes, Alzheimer‘s and Parkinson‘s diseases and cancer (Marcinek and Krejpcio, 2017) [42]. Also, being most potent antioxidant foods, adding chia seeds to diet may help fight premature aging and protect the skin cells against free radical damage to optimize the health of skin. Richness in dietary fibre and unsaturated omega-3 fatty acids in chia seeds leads to reduction in the level of serum cholesterol (Da Silva *et al*., 2017) [21]. Chia seeds also have hypotensive, hypoglycaemic and anthropometric effect (Grancieri *et al.*, 2019) [32].

Table 5: Show the table of Therapeutic value and Reference

Therapeutic value	Reference
Cardiac protective	Munoz *et al*. (2012b) [48]
Helps to control diabetes	EFSA (2009) [27]
Potential source of several bio-active peptides, Repair of damaged tissue and general well-being	Segura-Campos *et al.* (2013) [68]
Control of dyslipidaemia)	Chicco *et al.* (2009) [16]
Potential to lower the bad LDL cholesterol and increase beneficial HDL cholesterol	Ayerza, and Coates (2005) [10] Brenna *et al.* (2009) [15]
Control of hypertension and triglycerides and Anti-inflammatory	Rodea-Gonzalez *et al.* (2012) [62]
Antioxidant activity for commercial uses	Nadeem *et al.* (2015a) [49]
Chia is non-allergic (whole/ground)	EFSA 2005[26]; EFSA 2009 [27]
Antiplatelet, Antiplatelet, anti-carcinogenic, laxative, hypotensive, cardiac tonic, cardiovascular protector, treatment of anaemia, improves dermatitis, analgesic	Ayerza and Coates, 2005 [10]
Antidepressant, antianxiety, vision and immune improver	http://animales-campo.vivavisos.com.ar
EPA and DHA improver in blood	Nieman *et al.* 2009 [51]
Antineoplastics	Adams *et al.* (2006) [3]
Hypotensives	Vuksan *et al.* (2007) [78]
Celiac disease, constipation and vasodilatation	Adams *et al.* (2005) [2]
Joint pain, kidney disorders	Wojcikowski *et al.* (2006) [80]
Antiviral	Jiang *et al.* (2005) [37]

Effect of incorporation of pumpkin seed and chia seed on quality attributes of meat and meat products

pH

pH influences the functional and keeping quality of meat. Addition of ingredients of nonmeat origin changes the pH of meat products depending upon the source of plant material. Mansour *et al.* (1996) [41] reported that Bologna type sausage containing 3% pumpkin seed and rape seed had no significant difference in the pH in comparison to control samples. Perez (1997) [58] also reported a significant decrease in pH of the chicken sausage with increase in level of incorporation of pumpkin which might be due to the ascorbic acid content of pumpkin and acid terminal residues in the starch molecules produced by depolymerisation of starch granules during cooking. Zargar *et al*. (2014) [82] reported that pH of chicken sausage developed by replacing lean meat with pumpkin at three different levels *viz*. 6, 12 and 18 followed a significant decreasing trend after 7th day of storage. However, the mean pH values of the control and treatments were comparable throughout the storage period. The decrease in pH might be attributed to the lactic acid produced from readily available carbohydrate molecules by the microbes (Jay, 1996) [36]. Scapin *et al*. (2015) [67] reported that the pH value of pork sausage treated with different concentrations of chia seeds extract were not significantly different between treatments during 28 days of storage at 4°C. Pintado *et al.* (2018) [60] noticed that fresh sausage formulated with chia emulsion gel and oats emulsion gel resulted in increase in the pH values of the formulated sausage.

Serdaroglu *et al.* (2018) [69] reported that incorporation of 5% dried pumpkin pulp and seed increased the pH value of both uncooked and cooked beef patties compared to control group. Addition of 3% dried pumpkin pulp and seed had lower and 2% dried pumpkin pulp and seed had similar pH values compared to control samples in cooked treatments. Pineapple jam fortified with chia seed at the rate of 6.25, 12.25, 25, 50% w/w had pH values between 3.2 and 3.7 whereas control had pH of 3.5 (Nduko *et al.*, 2018) [50]. Fernandesa and Mellado (2018) [29] reported that substitution of oil in mayonnaise with 0.5%, 1% and 1.5% of chia mucilage results in higher pH of the chia seed mucilage added mayonnaise with the exception of 1% addition level where pH did not differ significantly from the control sample.

Chicken sausage prepared by incorporating chia seeds at 2, 4 and 6% level had higher pH values as compared to the control sample. pH values declined significantly for control as well as chia seed powder treated sausage during 21days of refrigerated storage at 4±1°C (Limam and Mohamed, 2019) [39]. According to Fernandez *et al*. (2019) [31], chia seed addition at the level of 3% in the form of whole seed, flour or coproduct did not have any effect on pH or water activity of frankfurters on 0day. During the first 7 days of storage, the pH behaved similarly in all the samples but decreasing trend was noted between the pH of the control and chia treated frankfurters on 14th and 21st days of chilled storage. The decreasing trend in pH could be due to a substantial increase in lactic acid bacteria during storage. The carbohydrates present in the frankfurter formulations might promote such growth even in vacuum packaged products stored under refrigeration. At the end of storage, some basic compounds released during proteolysis may counteract the pH decrease.

Water holding capacity (WHC)

Mansour *et al.* (1996) [41] reported that WHC of the bologna type sausage containing 3% pumpkin seed had no significant difference when compared with the control samples. According to Sharma and Lakhawat (2017) [71], water absorption capacity is the ability to retain water against gravity and include bound water, hydrodynamic water, capillary water and physically entrapped water. Water absorption capacity of pumpkin seed was found to be 189% while its oil absorption capacity was 168%. Serdaroglu *et al*. (2018) [69] noticed that 5% pumpkin pulp and seed mixture treated beef patties had higher WHC as compared to control and 2% pumpkin pulp and seed mixture treated samples.

Ding *et al.* (2018) [25] observed that chia seed can improve the water holding capacity and emulsifying ability in cookies, bread and other desserts due to gum like characteristic of polysaccharides consisting mainly of crude fibre and carbohydrate. Chicken sausage prepared by incorporating chia seeds at 2, 4, and 6% level leads to significant increase in the cooking yield percentage and water holding capacity of the product (Limam and Mohamed, 2019) [39].

Emulsion stability (ES)

Alfredo *et al.* (2009) [5] observed that fibre rich fraction in chia (obtained by dry processing of defatted chia flour) has higher water holding capacity (15.41 g/g), water absorption capacity (11.73 g/g and organic molecule absorption capacity (1.09 g/g) with great emulsifying activity (53.26 mL/100 mL) and emulsion stability (94.84 mL/100 mL) while the oil-holding (2.02 g/g) and water adsorption (0.3 g/g) capacities are low. Zargar *et al.* (2014) [82] found that emulsion stability of the chicken sausage followed a decreasing trend with increasing levels of pumpkin in the formulation with significant decrease noticed at 12 and 18 percent level of incorporation in comparison to control. The probable reasons for the decreased emulsion stability due to pumpkin inclusion could be lowering of the pH value of emulsion, poor fat binding capacity of pumpkin and interference in the formation of uniform and stable emulsion.

Serdaroglu *et al*. (2017) [70] reported that model system chicken meat emulsions (MSME) produced by replacing 25% and 50% of beef fat with pumpkin seed oil in water emulsion (PSO/W) resulted in a significant improvement in emulsion stability, oxidative stability and cooking yield of MSME. Use of PSO/W formulation resulted in decreased total expressible fluid values and increased cooking yields of the emulsions. Highest cooking yield and lowest total expressible fluid were found in the sample containing 50% PSO/W.

Cooking yield

Cooking yield of the bologna type sausage containing 3% pumpkin seed had no significant difference when compared with the control samples without pumpkin seed incorporation (Mansour *et al.*, 1996) [41]. Zargar *et al.* (2014) [82] observed a significantly decreasing trend in the cooking yield of chicken sausages with increasing levels of pumpkin which might be due to formation of comparatively less stable emulsion for the formulations containing pumpkin. An increase in cooking yield of chicken meat patties with incorporation of pumpkin pulp was noticed which was due to water retention properties of fibre content of pumpkin (Verma *et al*., 2015) [77].

Serdaroglu *et al.* (2018) [69] reported no significant differences in cooking yield and diameter change of the beef patties treated with 2%, 3% and 5% pumpkin pulp and seed. The results showed that dried pumpkin pulp and seed mixture could compensate for the decrease in the meat amount in the formulation without loss of any technological quality. Ding *et al.* (2018) observed that a combination of chia and carrageenan increased the cooking yield of restructured ham like carrageenan products.

Proximate composition

Coorey *et al*. (2012) [19] reported that chia flour incorporated chips had significantly higher values for the protein, fat, dietary fibres and ash content as compared to the control. Also, antioxidant activity of the chips increased significantly with increasing percentage of chia inclusion. Chicken sausage prepared by incorporating pumpkin seed had significantly lower crude protein, ether extract and ash whereas moisture and crude fibre content had significantly higher values. The increase in crude fibre might be due to high fibre level present in pumpkin (Zargar *et al.*, 2014) [82]. Pintado *et al.* (2015) [59] reported that incorporation of chia flour (10%) and olive oil to the frankfurters results in increase in total dietary fibre and minerals while fat and energy content decreased in all the treated samples.

Romankiewicz *et al.* (2017) [63] observed that chia seeds incorporated bread crumb had a higher value for protein, ash and dietary fibre as compared to the control bread. Fresh sausage formulated with emulsion gels prepared from chia and oats resulted in reduction of fat and energy content while there was an increase in the moisture, total dietary fibre and mineral content. Protein values of treated samples were almost equal to the control samples (Pintado *et al.*, 2018) [60]. Saraswathi *et al.* (2018) [65] reported that flax seed powder and pumpkin seed powder incorporated biscuits had more protein, fibre and ash content in comparison to wheat flour and flax seed powder treated biscuits. Moisture content of the cooked beef patties formulated with dried pumpkin pulp and seed mixture (PM) had significantly lower moisture content than control samples. Protein content of control and treated samples were similar (Serdaroglu *et al.*, 2018) [69]. Fortification of pineapple jam with chia seeds improved the protein content from 0.53% in control to 8.60% in treated samples. Also fibre content increased from 4.83% in control to 21.02% in the treated samples without affecting texture (Nduko *et al.*, 2018) [50].

Total phenolic content

Parry *et al.* (2008) [56] reported that total phenolic content of pumpkin seed flour was 1.58 mg GAE/g. Olszanska *et al.* (2013) [55] reported that polyphenol content of the seeds of the *Cucurbita pepo* and *Cucurbita maxima* varieties varied from 46.8 to 113 mg GAE/100 g and 48.8 to 68.8 mg GAE/100 g respectively. Martinez Cruz and Paredes Lopez (2014) [43] reported that total phenolic content of Chilean and Mexican chia seeds was 0.94 and 1.64 mg GAE/g respectively. Akomolafe *et al.* (2016) [4] reported that total phenolic and flavonoid content of methanolic extract of pumpkin seed was 32.90 mg GAE/g and 21.50mg QE/g of seed respectively.

Total phenolic content in chia seeds, chia fibre flour and chia oil was 1.16, 1.11 and 0.02 mg GAE/g respectively (Oliveira-Alves *et al*., 2017) [54]. Limam and Mohamed (2019) [39] reported that total phenolic content of chia seed flour is 4.58 mg GAE/g.White and black defatted chia seeds had total phenolic content of 3.52 and 3.42 mg GAE/g, respectively (Tuncil and Celik, 2019) [73].

Thiobarbituric acid (TBA) value

Sargi *et al*. (2013) [66] observed that chia seed had higher antioxidant activity in comparison to flax seed. Zargar *et al.* (2014) [82] observed that thiobarbituric acid reactive substances (TBARS) value of chicken sausage containing pumpkin increased significantly but was significantly lower than control samples on all days of storage. A comparatively slow increase in TBARS value of pumpkin treated sausages might be due to lower fat percent and increased fibre and carotenoid content of the pumpkin which acted as antioxidant.

Costantini *et al*. (2014) [20] observed that the addition of chia flour at 10% level increased the total antioxidant capacity of wheat breads. However, Melo *et al.* (2015) [44] found that TBARS value increased in all hamburger samples treated with chia seed extract as compared to control during frozen storage at -18°C. Pork sausage treated with different concentration of chia seed extract resulted in increase in TBA value during initial 7 days of storage at 4°C while TBA values decreased from 14 days onward till 28 days of storage (Scapin *et al*., 2015) [67]. Camel burger incorporated with chia seed had significantly lower TBA value as compared to the control sample during 12 days storage at 4°C (Zaki, 2018) [81]. Kulczynski *et al.* (2019) [38] reported that chia seed has high antioxidant property.

Instrumental colour and texture profile

Incorporation of pumpkin seeds and peels at the level of 10% resulted in stiffness of the extruded snack foods (Norfezah *et al.*, 2011) [52]. Zettel *et al*. (2014) [83] noticed that chia addition in the form of gel decreased the firmness of wheat bread. Pintado *et al.* (2015, 2018) [59, 60] noticed a significant increase in puncture force and gel strength of chia and oat formulated emulsions resulting in hardening of product during chilled storage. Romankiewicz *et al.* (2017) [63] noticed that chia seeds incorporated bread crumb had a darker colour and the values for yellow colour were also lower as compared to the control bread.

Incorporation of dried pumpkin pulp and seed mixture resulted in a decrease in redness (a) values while no significant difference was observed in lightness (L) and yellowness (b) values between control and treated beef patties (Serdaroglu *et al.*, 2018) [69]. Nduko *et al.* (2018) [50] reported that pineapple jam fortified with chia seeds had golden colour as compared to the control pineapple jam which had yellow colour. Zaki (2018) [81] reported that addition of 1 and 3% chia seeds significantly improved the colour stability and retention of red colour in camel burger during cold storage for 12 days. Fernandez *et al.* (2019) [31] observed that addition of chia coproduct to the meat sample resulted in lowest L* values and the highest b* values. The increase in b* values following the addition of chia coproduct could be related with the yellow components present in the coproduct.

Sensory attributes

Zargar *et al.* (2014) [82] reported that juiciness scores were significantly higher for chicken sausage containing 18 percent level of pumpkin in comparison to control. Higher juiciness scores were attributed to higher moisture content of pumpkin pulp. Saraswathi *et al.* (2018) [65] observed that biscuits incorporated with blend of flax seed powder (15%) and pumpkin seed powder (15%) resulted in better sensory quality. Addition of chia seed at 6.25% and 12.5% level in pineapple jam decreased the sensory rating with moderate acceptance while addition of chia seed at 25% and 50% level adversely affected the sensory quality of jam (Nduko *et al.*, 2018) [50]. Zaki (2018) [81] reported that camel burger formulated with 3% chia seeds recorded higher score for sensory attributes in comparison to control burger. However, burger formulated with 5% chia seeds showed lower scores for all sensory attributes. No significant difference was observed in sensory scores between control and 1% chia seed formulated burger.

Microbiological evaluation

Ibrahim *et al*. (2010) [33] reported a remarkable increase in aerobic plate count throughout cold storage especially in control patties on 6th and 9thdays as compared to patties treated with chia seed. Zargar *et al.* (2014) [82] reported that total plate count (TPC) of fresh control and pumpkin treated chicken sausage were comparable. Psychrophiles were observed from day 7th of storage and yeast and mold were observed from day 14th of storage in both control and treated products. All the counts followed a significantly increasing trend as the storage progressed and were significantly higher in treatments in comparison to control on each day of storage. Scapin *et al.* (2015) [67] found no significant difference in microbial count in control or pork sausages treated with chia seeds extract during 14 days of cold storage at 4°C.

Pintado *et al.* (2018) [60] noticed that fresh sausage formulated with chia emulsion gel (CEG) and oats emulsion gel (OEG) resulted in increase in the total viable count and lactic acid bacteria (LAB) count for the samples treated with CEG while OEG treated samples had microbial count almost equivalent to the control samples. Enterobacteriaceae counts decreased for both CEG and OEG treated samples after 13 days of storage at chilled temperature. Zaki (2018) [81] reported significant decrease in total bacterial count and psychotropic count in camel burgers formulated with 3 and 5% levels of chia seeds in comparison to control samples during cold storage for 12 days. Elshafie *et al*. (2018) [28] noticed that chia seeds essential fatty acids exhibit antimicrobial effect against some phytopathogenic fungi. Kulczynski *et al.* (2019) [38] reported that chia seed has high antimicrobial property. Significant increase was noticed in microbial counts of control and chia seed treated chicken sausage during 21 days of cold storage but the increase was within standard limits (Limam and Mohamed, 2019) [39].

Conclusion

The above discussion highlights that pumpkin and chia seeds incorporation in meat and meat products not only obliges as delicious food but also possesses therapeutic values. Their inclusion leads to increase in emulsion stability, cooking yield and water holding capacity of the meat products. These ingredients enhance total phenolic contentwhich further improves shelf life of meat products. Enrichment of these seeds leads to increase in total dietary fibre content of the final products which surely improves the overall health of the consumers. So, it can be concluded that pumpkin and chia seed addition leads to production of healthy, nutritious, microbiologically safe meat products with great consumer acceptability.

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