J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (1): 318-337
Print: ISSN 1687-1464 Online: 2735-5098

The impact of adding Psyllium seeds (*Plantago indica*) on the quality attributes of rabbit meat luncheon.

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ABSTRACT:

Psyllium seeds are recognized for their mucilage content, a complex polysaccharide that forms a gel when bound with water, making them effective binding agents in food products. Their potential as fat substitutes is notable, alongside their rich profile of proteins, minerals, and phenolic compounds, contributing to substantial nutritional value. This study was conducted to investigate the impact of adding Plantago seeds on the quality attributes of rabbit meat luncheons. Different propertions of seeds (1, 2 and 3%) were incorporated. The luncheon samples were also stored for 2 months at 4 ±1°C.Theresults revealed an increase in moisture, ash, and fiber content with higher concentrations of Plantago seeds compared to the control sample (Plantago seeds free). and during the storage periods, there was a noticeable improvement in hardness, gumminess, and chewiness. These samples also exhibited a homogeneous distribution of mixture particles, and reduced air void size, moreover, the samples containing Plantago seeds exhibited a distinct sensory advantage over the control sample in flavor, juiciness, and tenderness, all improving significantly over storage periods.

Keywords: Psyllium seeds, Food texture enhancement, Gel formation.
https://doi.org/ 10.21608/jaesj.2024.261792.1144

INTRODUCTION:

Psyllium, also known as *Plantago indica*, belongs to the *Plantaginaceae* family. The Psyllium genus comprises approximately 200 species **(Ali *et al.*,2017).**India is the leading global producer and exporter of psyllium **(Verma *et al.*, 2013).** Psyllium seeds are believed to have been introduced to India during the Mughal era when the country was focused on agricultural development, and its cultivation eventually spread to surrounding areas **(Shahriari *et al*., 2018).**Currently, around 90% of psyllium production is exported, with the United States of America being the primary importer of psyllium husks and seeds **(Shahriari *et al*. ,2018and Franco et al.,2020).** The Psyllium plant is known for its ability to thrive in dry environments and requires minimal water. It can grow well in various soil types, including fertile clay soil and sandy soil **(Franco *et al*.,2020).** These characteristics suggest that Psyllium seeds can grow successfully in the soil of Egypt, as they possess the necessary components and the Egyptian government has made significant efforts to advance agriculture, improve the land, and develop new agricultural methods and instruments **(El-Ramady *et al*., 2018)**.Psyllium seeds have a unique chemical composition, including significant amounts of protein (17.4%) and carbohydrates (46.6%), with the majority being D-xylose and L-arabinose **(Romero-Baranzini *et al*., 2006).** The Plantago seeds encompass a rich array of flavonoids, including protocatechuic acid (0.67 mg/100 g), catechol (37.67 mg/100 g), caffeic acid (1.9 mg/100 g), Syringic acid (1.6 mg/100 g), Ferulic acid (5.32 mg/100 g), Cholchecien (234.01 mg/100 g), pyrogallol (12.07 mg/100 g), coumarin (2.73 mg/100 g), cinnamic acid (1.49 mg/100 g), and P-benzoic acid (0.08 mg/100 g), constituting a cumulative content of 297.54 mg/100 g. Additionally, these seeds boast an abundance of phenolic compounds, notably hesperidin (442.4 mg/100 g), rosmarinic acid (4.55 mg/100 g), rutin (0.82 mg/100 g), hespertin (26.74 mg/100 g), quercitrin (58.77 mg/100 g), quercetin (0.23 mg/100 g), kamferol (2.61 mg/100 g), and luteolin (0.34 mg/100 g), totalling 536.46 mg/100 g. These constituents endow Plantago seeds with potent antifungal and antibacterial properties **(Osheba *et al*., 2013).** Additionally, Psyllium seeds contain 6.7% fat, predominantly polyunsaturated fats (86.6%), including oleic, linoleic, and linolenic acids**(Romero-Baranzini *et al*.,2006).**Due to their water-holding capacity and gel-forming properties, Psyllium seeds have a laxative effect, as they can absorb approximately 10 grams of water per gram of seeds **(Sosulski and Cadden 1982).**Psyllium seeds offer various health benefits, including lowering LDL cholesterol levels in the blood plasma **Vega-López *et al*., (2001)** and being used to treat conditions such as frequent urination, mouth and gum irritation, headaches, and sore throat **(Nuerxiati *et al*., 2022).** The gel-forming properties of Psyllium seeds also help regulate blood sugar levels and reduce the prevalence of constipation and intestinal diseases **(Franco *et al*. 2020).**Psyllium seeds have been used in the production of various food products to enhance texture due to their unique structural qualities and health benefits. These products include gluten-free pasta **Faheid*et al*., (2022),** yogurt **(Ladjevardi *et al*.,(2015),** biscuits **(Fradinho *et al*., (2015)**, sausages**Osheba *et al*., (2013)** and gluten-free bread **(Zandonadi *et al* .,2009).**

Rabbit meat is known for its lowfat content, with about 60% of the fat being unsaturated fatty acids. It also has a low cholesterol level of approximately 47 mg per 100 g of meat **(Dalle Zotte 2014).** Rabbit meat is rich in protein, with a content ranging from 19% to 23%. It is distinguished by its high concentration of essential amino acids, setting it apart from other meats **(Gidenne 2000, Nistor *et al*.,2013 and Dalle Zotte, 2014).** In addition, it is a good source of vitamins and minerals and has a low sodium content **(Gidenne 2000).** Nutritionists recommend rabbit meat for various age groups, particularly the elderly, children, and individuals with high blood pressure, heart disease, and blood vessel disorders. Rabbit meat is tender, juicy, and considered one of the best white meats, providing essential nutrients in sufficient quantities to meet daily dietary needs **(Gidenne 2000 and Nistor *et al*., 2013).** In response to the demand for fast-cooked food items that provide necessary nutrients, there has been a recent increase in the market for convenient food options. This has led to the development of various rabbit meat products, including ready-to-eat and ready-to-cook options such as canned goods, smoked and grilled products, salted and dried rabbit meat, and rabbit sausages **(Li *et al*.,2018).**

Given the low-fat content of rabbit meat**(Gidenne, 2000 and Dalle Zotte,2014),** Psyllium seeds were used as a fat alternative and to improve the rheological properties of the product through their emulsifying action **(Faheid *et al*.,2022).** Hence, the objective of our study was to investigate the effect of adding Psyllium seeds (*Plantago indica*) on the quality attributes of rabbit meat luncheon.

MATERIALS AND METHODS:

In the present study, we purchased V-line rabbits from El-Bostan Poultry Farm, Animal and Poultry Production Department, Faculty of Agriculture, Damanhour University at four months of age and 4 up to 4.5 kg of weight. Notably, advancing age tends to decrease organ proportion while enhancing muscle growth, consequently elevating meat production rates **(North *et al*.,2017).** This phenomenon was observed in the animals under study. After the animal had been slaughtered with the bones manually removed, the meat was kept in the refrigerator for 24 hours at a temperature of 4°C **(Rasinska *et al.*, 2019).**

Eggs, flour, and cheese triangles (teama milk) were also bought from the local retail shop, Carrefour, Alexandria, Egypt.

The spices used in the luncheon were bought from Abu El-Ela Company for Importing and Exporting Spices, Cairo, Egypt. They are represented by (garlic powder, onion powder, corn starch, paprika, cardamom, salt, black pepper, and psyllium seeds.

Prepare the rabbit meat luncheon:

The meat was minced using a French-made meat mincing machine (ME682827/35A-2420). The ingredients were added to the minced meat as specified in Table 1, and a German-made mixer) Braun Food Processor FX3030) was used to combine the components for 5 minutes. Four identical treatments were created, with the only difference being the amount of ground psyllium seeds added.

Table 1: Ingredients of different treatments of rabbit meat luncheon.

	Treatment			
Ingredients(g)	control	P1	P2	P3
Rabbit meat	100	100	100	100
Wheat flour	5	5	5	5
Corn starch	1	1	1	1
Paprika	0.5	0.5	0.5	0.5
Cardamom	0.4	0.4	0.4	0.4
black pepper	0.25	0.25	0.25	0.25
Onion powder	0.5	0.5	0.5	0.5
garlic powder	0.5	0.5	0.5	0.5
Albumin	18	18	18	18
Processed cheese	11	11	11	11
Salt	2	2	2	2
Sugar	0.25	0.25	0.25	0.25
Plantago seeds	0	1	2	3

Control (Luncheon meat free from psyllium seeds),P1: Luncheon meat containing 1% ofpsyllium seeds P2: Luncheon meat containing 2% – P3: Luncheon meat containing 3%.

Thermal polyethylene bags were used to wrap the luncheon mixture for the aforementioned tests, giving it a cylindrical form before being covered with aluminum foil **(Al-Zaidan and Al-Hussainy. 2023).** The wrapped mixture was then cooked in a water bath for 90 minutes at 90 to 95 °C **(Al-Bachir and Mehio 2001).** Aftercooking, the luncheon was chilled and kept in the refrigerator at 4±1℃ until analysis was conducted **(Al-Zaidan and Al-Hussainy.2023).**

1-Chemical analysis:

The moisture content was assessed through weight loss after subjecting the samples to desiccation in an electrically heated air oven, maintaining a temperature of 105°C until a consistent weight was achieved. To determine the crude protein content, the Micro-Kjeldahl method was employed, utilizing the nitrogen-to-protein conversion factor of 6.25. To estimate the fat content, a Soxhlet apparatus was utilized, and an extraction process was carried out for six hours using petroleum ether as the solvent, with a boiling point range of 40 to 60 °C. The ash content was determined following a pre-ashing procedure, followed by the direct ignition method in a muffle furnace at 550°C until white ash was obtained. Lastly, the crude fiber content was determined in samples devoid of moisture and fat, which remained after digestion with a mild acid and base solution. Carbohydrate (by difference) content was subtracted from 100% – (Moisture + Protein + Fat + Ash+ Fibers). It’s worth noting that all the procedures mentioned above were conducted according to the protocols outlined in the **(AOAC 2005)** guidelines.

2-Microbiological analyses:

The total bacterial count in the luncheon meat samples was assessed following the methodology stipulated in **(ICMSF 1996).** The enumeration of fungal count within the luncheon meat samples was conducted utilizing the spread plate method as outlined by **(ICMSF 1996).** The enumeration of coliform bacteria, including Escherichia coli, within the luncheon meat samples, was carried out according to the guidelines provided by **(ICMSF 1996).**

3-Rheological analyses:

Texture Analysis: Instrumental texture analysis was conducted using a (TexturePro CT V1.2 Build 9) device equipped with appropriate probes. The analysis was performed at a test speed of (1mm/s), return Speed of(1mm/s), and trigger Load of(7g). Measurements were taken at multiple locations on each sample to obtain representative results. The texture attributes assessed include hardness, cohesiveness, gumminess and chewiness, derived from the obtained data. The analyses were conducted at three different time points: (T0) immediately after manufacturing, (T1) after one month of storage, and (T2) after two months of storage.

4-Scanning electron microscopy (SEM):

According to the research conducted by **Tahmasebi. (2015).** Small pieces of fresh specimens of rabbit meat luncheon were removed and fixed by immersing them immediately in 4F1G (Fixative, phosphate buffer solution) at pH 7.4 and 4°C for 3 hours. Then, the specimens were postfixed in 2% OsO4 in the same buffer at 4°C for 2 hours. After that, the samples were washed in the buffer and dehydrated at 4°C through a graded series of ethanol. Samples of rabbit meat luncheon were dried using a critical point method, mounted using carbon paste on an AL-stub and coated with gold up to a thickness of 400 A using a sputter-coating unit (JFC-1100 E). Observations of the morphology in the coded specimens were performed using a Jeol JSM-5300 scanning electron microscope operated between 15 and 20 keV.

5-Sensory Evaluation:

A sensory assessment was conducted with a group of twenty participants using an 8-point rating scale. On this scale, a rating of 8 represented a highly desirable attribute, while a rating of 1 indicated a highly undesirable characteristic, as outlined by **(Parrish *et al*.(1973).**

6-Statistical analysis:

The experiments were conducted in triplicate. The data were subjected to statistical analysis using Analysis of Variance (ANOVA), and the means were subsequently differentiated using Duncan's

Multiple Range tests, following the procedure outlined by **(Steel and Torrie 1980).**

Results and discussion:

1-Chemical analyses:

The chemical composition of rabbit meat luncheon samples is presented in Table 2.The moisture content in the luncheon samples ranged between 57.851% in the control sampleand 62.95% in sample P3. They are significantly different, andtherefore, the results indicate an increase in moisture content with higher proportions of Plantago seeds in the luncheon samples. This can be attributed to the seeds' capacity to retain water **Fradinho *et al.* (2015),** stemming from several factors. Firstly, the husk of Plantago seeds serves as a rich source of soluble fibers that absorb and swell upon water contact, this interaction leads to the formation of a three-dimensional network, enhancing the product's viscosity and aiding in moisture retention, ultimately reducing water loss, and improving product quality **(Faheid *et al*.,2022).** Additionally, Plantago seeds boast significant levels of polyphenols and flavonoids, which possess substantial water-retaining capabilities, elucidating the observed rise in moisture content **(Osheba *et al*., 2013).**

The protein content decreased with an increase in the proportion of added Plantago seeds, ranging from 16.452% in the control sample and 15.932% in sample P3. Despite the seeds' high protein content, reaching 17.4% **Romero-Baranzini *et al.* (2006),** this decline in luncheon samples can be attributed to increased moisture in samples containing Plantago seeds. This increase in moisture, facilitated by the seeds' water-binding capacity **(Fradinho *et al*., 2015),** contributed to a decrease in the dry matter content in the samples.In contrast, the dry matter showed a real increase in protein with the increase in the rate of adding Plantago seeds.

The fat content showed a very apparently slight decrease with an increase in the proportion of added Plantago seeds; however, no statistically significant differences were observed among the samples in fat content. Despite the seeds' fat content reaching 12.4% **(Romero-Baranzini *et al.*, 2006).** This aligns with the previously explained rationale observed in the case of protein content in wet weight and dry matter.

The ash content increased with an increase in the added proportion of Plantago seeds, ranging from 2.4% in the control sample and 2.91% in the sample (P3). Consequently, the ash content did not follow the same trend observed in protein and fat content. This difference can be attributed to the nature of minerals present in Plantago seeds, characterized as water-soluble. Plantago seeds contain approximately 8.6% of minerals **(Bukhsh *et al*., 2007),** which likely contributed to the observed increase in mineral content across the samples. It is worth noting that these results are consistent with what was found by **Beikzadeh *et al*. (2016),** who found that adding an increasing amount of Plantago seeds increased the percentage of ash and fiber in sponge cake. This correlation emphasizes how the inclusion of Plantago seeds significantly impacts the nutritional composition of food products, augmenting their ash and fiber content. Such research underscores the versatile and beneficial nature of incorporating Plantago seeds into food formulations.

The fiber content exhibited a considerable increase with a higher proportion of added Plantago seeds, ranging from 0.404% in the control sample and 1.147% in sample P3. Consequently, fibers followed a similar trajectory as observed in the mineral content. This can be attributed to fibers being a fundamental factor in water binding. Hence, the rise in moisture content with increased seed proportion can be explained by Plantago seeds being an excellent source of both soluble and insoluble fibers, described as natural polysaccharides forming a gel-like substance due to their remarkable water retention capacity, which can exceed 80 times their weight **(Franco *et al*. ,2020)**.It's worth noting that the majority of fibers in Plantago seeds concentrate in the husk **(Anderson *et al*., 2000 and Van Craeyveld *et al* .,2008).** The predominant monosaccharides are abundant in these fibers are xylose and arabinose, accounting for approximately 45.6% and 19.8% of the total carbohydrates, respectively. These sugars amalgamate to form arabinoxylan, comprising 63% of the total carbohydrates. This compound significantly contributes to water binding, in addition to its manifold health benefits for the digestive system, being considered a prebiotic **(Van Craeyveld, *et al*., 2008).**It is worth noting that minerals and fibers recorded a clear increase in dry matter with an increase in the concentration of Plantago seeds.

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Table 2. Chemical composition of different rabbit meat luncheon samples

	Wet Weight Basis						Dry Weight Basis				
Samples	Moisture	Protein	Fat	Ash	Fibers	Carbohydrates	Protein	Fat	Ash	Fibers	Carbohydrates
control	57.851±0.86[c]	16.452 ± 0.23[a]	7.43 ± 0.11[a]	2.40±0.04[d]	0.404 ± 0.001[d]	15.003 ± 0.48[a]	39.03±0.23[d]	17.63±0.11[c]	5.69±0.04[d]	0.96±0.001[d]	35.6±0.48[a]
P1	60.089 ±0.411[bc]	16.257 ± 0.212[a]	7.368 ± 0.161[a]	2.53 ± 0.01[c]	0.646 ± 0.005[c]	12.222 ± 0.053[a]	41.22±0.212[c]	18.46±0.161[b]	6.34±0.01[c]	1.62±0.005[c]	30.62±0.053[b]
P2	62.243 ±0.701[ab]	16.188 ± 0.111[ab]	7.363 ± 0.05[a]	2.65±0.02[b]	0.895 ± 0.002[b]	9.265 ± 0.562[b]	43.57±0.111[b]	19.50±0.05[ab]	7.02±0.02[b]	2.37±0.002[b]	24.54±0.562[c]
P3	62.954 ±0.654 [a]	15.932 ± 0.105[b]	7.357 ± 0.215[a]	2.91±0.02[a]	1.147 ± 0.003[a]	7.943 ± 0.33[c]	44.41±0.105[a]	19.86±0.215[a]	7.86±0.02[a]	3.10±0.003[a]	21.44±0.33[d]

The results are presented as the mean value ± SD. Values expressed with different superscripts are significantly different at $P<0.05$. Control (Luncheon meat free from psyllium seeds),P1: Luncheon meat containing 1% ofpsyllium seeds P2: Luncheon meat containing 2% – P3: Luncheon meat containing 3%..

The carbohydrate content decreased with an apparentincrease in the proportion of added Plantago seeds, ranging from 7.943% in sample P3 and 15.003% in the control sample. This decline is attributed to the same reason previously elucidated concerning the protein content, which is linked to the heightened moisture content in samples containing Plantago seeds.It is noteworthy that the percentage of carbohydrates in the dry matter recorded a clear decrease with an increase in the concentration of Plantago seeds. It appears that the reason for this decrease is the increase in the percentage of protein, fat, minerals, and fiber in dry matter with an increase in concentration compared to the control sample.

2-Microbiological analyses:

For detecting the microbial content of the samples, a serial dilutions method and then streaks on the surface of selective and semi-selective media, like TBX Agar media to detect the presence of E. coli, and on a PDA media to detect the presence of yeasts or fungi. After incubation for 48 hours, it was not found any bacterial or fungal growth in the samples, which means the samples were completely free of any microbial content. The reason for this adherence lies in our manufacturing process for luncheon meat, which complies meticulously with the guidelines of Good Manufacturing Practices (GMPs) established by**(ESS(2005/1114).**

3-Rheological analyses:

Table 3 illustrates the rheological properties of luncheon samples across different storage periods.

Regarding hardness, the obtained results indicate significant differences among the samples over time and with varying percentages of added Plantago seeds. Control Sample exhibited the highest hardness during storage period T2, recording a value of 323 ± 1g. Additionally, an observed trend shows an increase in hardness with the duration of storage from T0 to T2.Contrarily, sample P3 demonstrated the lowest hardness during storage period T3, registering a value of 201 ± 1g. Notably, there was a gradual decline in hardness with an increase in the storage duration. The results corroborate with **Noguerol *et al*. (2022)**

study, emphasizing the notable water-absorption capacity exhibited by fibers within Plantago seeds. These characteristics influence hardness negatively, correlating with the water storage and retention abilities. The chemical analysis of the luncheon samples indicated a direct relationship between moisture levels and the concentration of Plantago seeds. Consequently, the decrease in hardness observed in the luncheon samples can be attributed to the increased concentration of Plantago seeds, elucidating the connection between moisture content and hardness variation.

The table data indicates notable differences in cohesiveness within the same samples across storage periods. Across these intervals, there's a consistent increase in cohesiveness, with the control sample registering the highest cohesiveness at time T2. Sample P3, however, initially displayed the lowest cohesiveness at time T0(0.49-0.393 respectively) yet exhibited a more pronounced increase in cohesiveness throughout the storage periods compared to the control sample.

Cohesiveness is defined as the internal bond strength within the samples.**Trinh and Glasgow (2012),** appeared to draw the samples closer in this attribute. The decrease in moisture within the control sample seemed to enhance molecular bonding. conversely, the rise in moisture in samples P1, P2, and P3 didn't hinder molecular bonding but rather augmented it. This bonding stems from the interaction between water's hydroxyl groups and the substantial polysaccharide molecules present in the gum derived from various monosaccharides found in Plantago seeds, including xylose, arabinose, raffinose, and galactose. Consequently, this interaction bolstered the intermolecular bonding, fostering increased molecular cohesion **(Noguerol *et al*., 2022).** Interestingly, there wasn't a decline in cohesion despite the escalation in the concentration of Plantago seeds.

The gumminess results revealed statistically significant differences among the samples, notably showcasing higher gumminess in the control sample across all three time periods. Conversely, sample P3 consistently exhibited the least gumminess. Remarkably, gumminess increased over storage in the control sample, reaching its peak (178g) at Time T2. In contrast, all other samples experienced a decrease in gumminess over the storage periods, with sample P3 recording the lowest gumminess (106g) at Time T2. Gumminess, synonymous with the amount of energy required to break down a partially solid food substance until it reaches a state suitable for ingestion, involves both hardness and stickiness **(Trinh and Glasgow, 2012).** The results of this study are consistent with the research conducted by **Faheid *et al.* (2022)** their study found that the gluten-free pasta that was fortified with psyllium husk had a lower gumminess content compared to the control sample made with wheat flour. Another study highlighted that hardness and stickiness were contingent on the concentration of Plantago seeds in pasta. The pasta containing Plantago seeds exhibited decreased stickiness due to the substance's crystallization properties, aiding in the formation of a more cohesive structure with minimal cooking loss **(Fradinho *et al*.,2020).** As a result, the increase in Plantago seeds concentration led to a decrease in gumminess, thereby improving the desired characteristics in the luncheon samples.

The chewiness followed a similar trajectory as the gumminess, as it was observed that there were notable distinctions among the various samples. The control sample exhibited the highest chewiness across the three temporal intervals, and this chewiness further escalated during the storage periods to attain a peak value of 11.5 ±0.1 at time T2. Conversely, the remaining samples displayed a decline in chewiness as the concentration of Plantago seeds increased. This trend persisted throughout the three time periods, with sample P3 registering the lowest chewiness value of 6.7 ±0.2 at time T2. The concept of chewiness revolves around the energy needed to chew solid food until it's ready for swallowing **(Trinh and Glasgow, 2012).** The observed decline in chewiness with increasing concentrations of Plantago seeds aligns with the findings of **(Faheid *et al*., 2022).** Their study noted reduced chewiness in gluten-free pasta enriched with Plantago seeds compared to wheat flour pasta. Food adhesion to the oral cavity often leads to dissatisfaction among consumers, demanding considerable effort to disengage before swallowing. The fibers found in Plantago seeds notably enhance water retention and binding capabilities, consequently improving food viscosity, texture, and overall quality **(Noguerol *et al*., 2022).** The higher fiber content resulting from increased concentrations of Plantago seeds significantly reduces the energy required for food mastication, as evidencedby the obtained results. This reduction in chewiness indicates an improvement in food texture and oral processing, likely contributing to a more satisfactory eating experience.

Table 3:The rheological properties of different luncheon samples during storage.

Rheological properties	Samples / Time	control	P1	P2	P3
Hardness (g)	T0	286 ± 3^{bc}	268 ± 4^{e}	264 ± 2^{f}	253 ± 3^{h}
	T1	324 ± 2^{a}	284 ± 1^{c}	288 ± 3^{b}	251 ± 1^{h}
	T2	323 ± 1^{a}	280 ± 1^{d}	259 ± 1^{g}	201 ± 1^{i}
Cohesiveness:	T0	0.44 ± 0.02^{abc}	0.4 ± 0.015^{bc}	0.44 ± 0.01^{abc}	0.393 ± 0.015^{c}
	T1	0.48 ± 0.03^{a}	0.46 ± 0.02^{ab}	0.45 ± 0.01^{abc}	0.453 ± 0^{abc}
	T2	0.49 ± 0^{a}	0.44 ± 0.049^{abc}	0.45 ± 0.01^{abc}	0.453 ± 0.1^{abc}
Gumminess: (g)	T0	160 ± 2^{c}	157 ± 1.73^{d}	134 ± 1^{g}	135 ± 2^{g}
	T1	171 ± 1^{b}	150.33 ± 0.577^{e}	145.33 ± 2.516^{f}	131 ± 1^{h}
	T2	178 ± 1^{a}	145.33 ± 1.154^{f}	133 ± 2^{gh}	106 ± 1^{i}
Chewiness:(mJ)	T0	10.1 ± 0.1^{c}	9.8 ± 0.3^{c}	9.2 ± 0.4^{d}	8.5 ± 0.2^{e}
	T1	10.8 ± 0.3^{b}	9.2 ± 0.1^{d}	8.8 ± 0.3^{e}	7.9 ± 0.1^{f}
	T2	11.5 ± 0.1^{a}	7.8 ± 0.1^{f}	8.1 ± 0.1^{f}	6.7 ± 0.2^{g}

The results are presented as the mean value ± SD. Values expressed with different superscripts are significantly different at P<0.05.(control, P1, P2 and P3)as in table 1.T0(after manufacturing),T1(after 1month),T2(after 2 month)

4-Scanning electron microscopy (SEM):

Figer. 1 illustrates microscopic imaging aimed at comparing the surface structure of the luncheon samples. The observed images portray the presence of substantial air voids in the control sample, with a gradual reduction in voids from P1 to P3. Furthermore, the particle size in the control sample displays heterogeneity and inconsistency, in contrast to the enhanced homogeneity and consistency observed in samples P1 to P3, which exhibit small, equally sized, and homogeneous grains.

The SEM results align perfectly with these identified characteristics. Increasing the concentration of Plantago seeds hascontributed to the creation of rabbit meat luncheon with several advantageous features. The SEM revealed very fine air voids, reduced in number, along with a uniformly distributed particle arrangement. This led to the development of consistently sized and distributed homogeneous structures throughout the product. These observed characteristics collectively enhance the quality of the final rabbit meat luncheon product, indicating that the incorporation of Plantago seeds has significantly improved its overall quality, texture, and structural integrity.

The utilization of Plantago seeds has been shown in prior research to create dense and uniform structures in food, enhancing both its physical consistency and texture. These seeds are notable for their high concentration of soluble fiber, enabling them to dissolve and contribute to superior viscosity. This dissolution leads to the formation of gel substances that act as emulsifiers, aiding in stabilizing emulsions by increasing the continuous phase. Overall, their properties contribute to improved texture and stability in various food products **(Noguerol *et al.*, 2022).**

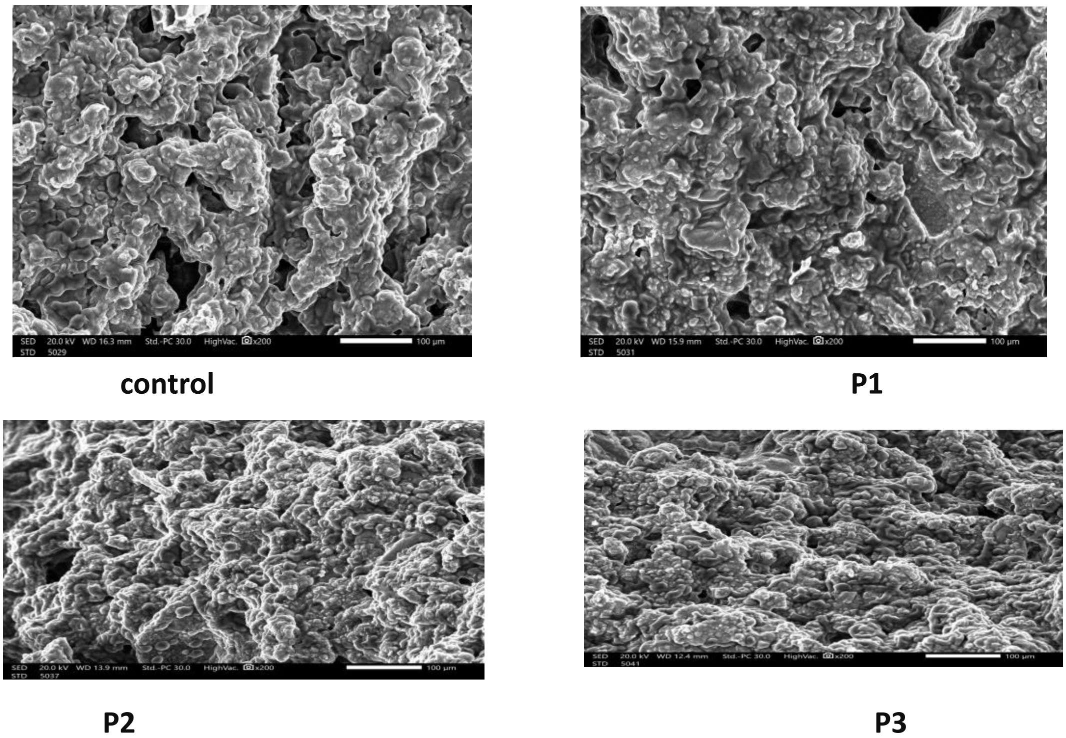

Fig 1: SEM (Scanning Electronic Microscope) Images for the comparison of surface structures of rabbit meat luncheon.(control, P1, P2 and P3)as in table2

5-Sensory Evaluation:

Table 4 exhibits the sensory evaluation of the luncheon samples based on their color, flavor, juiciness, and tenderness. The findings acquired revealed that sample P2 outperformed the others in terms of flavor, juiciness, and tenderness, followed by sample P1, then sample P3. However, the control sample excelled solely in terms of color, while the sensory evaluation remained unaffected by the storage conditions.

Table 4: Sensory Evaluation observed in luncheon samples across different periods.

	Samples / Time	control	P1	P2	P3
color	T1	7.35 ± 0.745^{ab}	7.15 ± 0.686^{bc}	6.45 ± 0.686^{d}	5.55 ± 0.716^{e}
	T2	7.6 ± 0.875^{ab}	7.15 ± 0.680^{bc}	7.55 ± 0.523^{ab}	6.8 ± 0.967^{cd}
	T3	7.7 ± 1.316^{a}	7.25 ± 0.587a^{bc}	7.1 ± 0.656^{bc}	6.35 ± 0.875^{d}
flavor	T1	6.85 ± 0.988^{fg}	7 ± 0.875^{efg}	7.8 ± 0.598^{bc}	7.65 ± 0.510^{bcd}
	T2	6.65 ± 1.076^{gh}	8.3 ± 0.489^{a}	8.4 ± 0.510^{a}	7.45 ± 0.640^{cde}
	T3	6.2 ± 0.767^{h}	7.05 ± 0.571^{efg}	8.1 ± 0.833^{ab}	7.25 ± 0.850^{def}
Juiciness	T1	6 ± 0.917^{d}	7.15 ± 0.444^{c}	7.6 ± 0.604^{b}	7.25 ± 0.523^{bc}
	T2	6.2 ± 0.812^{d}	7.4 ± 0.833^{bc}	8.55 ± 0.680^{a}	7.6 ± 0.512^{b}
	T3	5.5 ± 0.502^{e}	7.2 ± 0.502^{c}	8.5 ± 0.512^{a}	7.6 ± 0.680^{b}
Tenderness	T1	6.15 ± 0.489^{e}	7.3 ± 0.604^{d}	8.45 ± 0.307^{b}	7.55 ± 0.638^{d}
	T2	5.95 ± 0.656^{e}	7.3 ± 0.686^{d}	8.9 ± 0.552^{a}	7.9 ± 0.444^{c}
	T3	5.55 ± 0.510^{f}	7.25 ± 0.470^{d}	8.75 ± 0.510^{ab}	7.5 ± 0.512^{d}
Overall acceptability	T1	6.6 ± 0.575^{fg}	7.3 ± 0.371^{de}	7.75 ± 0.296^{c}	7.05 ± 0.443^{e}
	T2	6.7 ± 0.454^{f}	7.7 ± 0.439^{c}	8.5 ± 0.342^{a}	7.55 ± 0.357^{cd}
	T3	6.3 ± 0.473^{g}	7.2 ± 0.317^{e}	8.15 ± 0.329^{b}	7.3 ± 0.354^{de}

The results are presented as the mean value ± SD. Values expressed with different superscripts are significantly different at $P<0.05$.(control,P1,P2 and P3),(T0,T1 and T2)as in table 3

These results are entirely in line with the findings of numerous prior studies, which demonstrated that Plantago seeds do not exert any influence on the alteration in taste, but rather function to enhance the desirable attributes in food materials via their constituent elements that possess the capacity to ameliorate the properties of food materials and consequently enhance them **(Franco *et al.* ,2020, Faheid*et al*.,2022 and Noguerol *et al*., 2022).** It also enhances consistency, excellence, and thickness, as well as elevates the flavor of food products. Moreover **Faheid *et al*. (2022)** discovered that there is a propensity to favor foods to which Plantago seeds are added in comparison to other substances, as demonstrated by **Ladjevardi *et al.* (2015)** when it was observed that the sensory evaluation of skimmed yogurt supplemented with Plantago seed dye was superior to other additives.

Adding Plantago seeds to food products has been observed to intensify their darker hue(**Noguerol *et al*., 2022).** This phenomenon was notably evident in our samples, where the depth of the dark color correspondingly increased with higher concentrations of Plantago seeds. Consequently, luncheon samples containing Plantago seeds received a lower sensory evaluation.

Conclusion:

The results of the current study showed that the addition of 3% Plantago seeds to rabbit luncheon led to an increase in moisture, ash, and fiber content. Moreover, it significantly improved the quality attributes of the luncheon, enhancing its rheological properties. Overall, samples containing Plantago seeds were favoured in sensory evaluation.

REFERENCES:

Al-Bachir, M., and Mehio, A. (2001). Irradiated luncheon meat: microbiological, chemical and sensory characteristics during storage. *Food Chemistry*, 75(2), 169-175.

Al-Zaidan, S. A. A. H., and Al-Hussainy, K. S. J. (2023). Studying the antioxidant activity of oregano and maui rose powders and their effect on lipid oxidation indicatores of cold-preserved beef luncheon. *British Journal of Global Ecology and Sustainable Development*, 13, 87-100.

Ali, B., Al-Shedfat, R. I., Fayed, M. H., & Alanazi, F. K. (2017). New methodology for developemnt of orodispersible tablets using high-shear granulation process. *Acta Pol. Pharm*, 74(3), 969-981.

Anderson, J. W., Allgood, L. D., Lawrence, A., Altringer, L. A., Jerdack, G. R., Hengehold, D. A., & Morel, J. G. (2000). Cholesterol-lowering effects of psyllium intake adjunctive to diet therapy in men and women with hypercholesterolemia: meta-analysis of 8 controlled trials. *The American journal of clinical nutrition,* 71(2), 472-479.

Association of Official Analytical Chemists.(2005). Official methods of analysis of the Association of Analytical Chemists International. *Official Methods: Gaithersburg, MD, USA*.

Beikzadeh, S., Peighardoust, S. H., Beikzadeh, M., & Homayouni-Rad, A. (2016). Effect of psyllium husk on physical, nutritional, sensory and staling properties of dietary prebiotic sponge cake. *Czech Journal of Food Sciences*, 34(6), 534-540.

Bukhsh, E., Malik, S. A., & Ahmad, S. S. (2007). Estimation of nutritional value and trace elements content of Carthamus oxyacantha, Eruca sativa and Plantago ovata. *Pakistan Journal of Botany*, 39(4), 1181.

Dalle Zotte, A. (2014). Rabbit farming for meat purposes. *Animal Frontiers*, 4(4), 62-67.

El-Ramady, H., Alshaal, T., Bakr, N., Elbana, T., Mohamed, E., & Belal, A. A. (Eds.). (2018).*The soils of Egypt*. Springer .

Egyptian Standard Specification. (2005/1114). Egyptian Standard Specification for Traditional Egyptian luncheon (beef luncheon). Published and updated by Egyptian Standard organization for specification(.

Fradinho, P., Nunes, M. C., & Raymundo, A. (2015). Developing consumer acceptable biscuits enriched with Psyllium fibre. *Journal of food science and technology*, 52, 4830-4840.

Fradinho, P., Soares, R., Niccolai, A., Sousa, I., & Raymundo, A. (2020). Psyllium husk gel to reinforce structure of gluten-free pasta?. *LWT*, 131, 109787.

Franco, E. A. N., Sanches-Silva, A., Ribeiro-Santos, R., & de Melo, N. R. (2020). Psyllium (Plantago ovata Forsk): From evidence of health benefits to its food application. *Trends in food science & technology*, 96, 166-175.

Faheid, S. M.M., Rizk, I. R.S., Kishk, Y. F.M., Ragab, GH., & Mostafa, S. (2022). Carboxymethyl cellulose and psyllium husk in gluten-free pasta. *Foods and Raw materials*, 10(2), 329-339.

Gidenne, T. (2000). Recent advances in rabbit nutrition: emphasis on fibre requirements. A review. *World Rabbit Science*, 8(1), 23-32.

Gupta, R. A. J. E. N. D. R. A. (1982). Recent advances in cultivation of Isabgol (Plantago ovata Forsk) in India. *Cultivation and Utilization of Medicinal Plants*, 406-417 .

International Commission on Microbiological Specifications for Foods. (1996). Microorganisms in foods 5: Characteristics of microbial pathogens (Vol. 5). *Springer Science & Business Media*.

Ladjevardi, Z. S., Gharibzahedi, S. M. T., & Mousavi, M. (2015). Development of a stable low-fat yogurt gel using functionality of psyllium (Plantago ovata Forsk) husk gum. *Carbohydrate polymers*, 125, 272-280.

Li, S., Zeng, W., Li, R., Hoffman, L. C., He, Z., Sun, Q., & Li, H. (2018). Rabbit meat production and processing in China. *Meat science*, 145, 320-328.

Nistor, E., Bampidis, V. A., Păcală, N., Pentea, M., Tozer, J., & Prundeanu, H. (2013). Nutrient content of rabbit meat as compared to chicken, beef and pork meat. *Journal of animal production advances*, 3(4), 172-176.

Noguerol, A. T., Igual, M. M., & Pagan, M. J. (2022). Developing psyllium fibre gel-based foods: Physicochemical, nutritional, optical and mechanical properties. *Food hydrocolloids*, 122, 107108 .

North, M. K., Nkhabutlane, P., & Hoffman, L. C. (2017). The effect of age on the carcass composition, portion yield and proximate composition of two rabbit genetic types in South Africa. *World Rabbit Science*, 25(3), 281-288.

Nuerxiati, R., Mutailifu, P., Lu, C., Abuduwaili, A., Aierken, A., Yang, Z., ... & Yili,A. (2022). Optimization of alkali extraction, structure, and antioxidant activity of protein-bound polysaccharide from seeds of Plantago ovata Forssk. Industrial Crops and Products, 183, 114920.

Osheba, A. S., Hussien, S. A., & El-Dashlouty, A. A. (2013). Research Article Evaluation of Some Vegetal Colloids on the Quality Attributes of Beef Sausage. *Advance Journal of Food Science and Technology*, 5(6), 743-751.

Parrish Jr, F. C., Olson, D. G., Miner, B. E., & Rust, R. E. (1973). Effect of degree of marbling and internal temperature of doneness on beef rib steaks. *Journal of Animal Science*, 37(2), 430-434.

Rasinska, E., Rutkowska, J., Czarniecka-Skubina, E., & Tambor, K. (2019). Effects of cooking methods on changes in fatty acids contents, lipid oxidation and volatile compounds of rabbit meat. *Lwt*, 110, 64-70.

Romero-Baranzini, A. L., Rodriguez, O. G., Yanez-Farias, G. A., Barron-Hoyos, J. M., & Rayas-Duarte, P. (2006). Chemical, physicochemical, and nutritional evaluation of Plantago (Plantago ovata Forsk). *Cereal chemistry*, 83(4), 358-362.

Shahriari, Z., Heidari, B., & Dadkhodaie, A. (2018). Dissection of genotype× environment interactions for mucilage and seed yield in Plantago species: Application of AMMI and GGE biplot analyses. *PloS one*, 13(5), e0196095 .

Sosulski, F. W., & Cadden, A. M. (1982). Composition and physiological properties of several sources of dietary fiber. *Journal of Food Science*, 47(5), 1472-1477.

Steel, R. G., and Torrie, J. H. (1980). Principles and procedures of statistics: *a biometrical approach*.

Tahmasebi, P., Javadpour, F., & Sahimi, M. (2015). Three-dimensional stochastic characterization of shale SEM images. *Transport in Porous Media*, 110, 521-531.

Trinh, K. T., & Glasgow, S. (2012). On the texture profile analysis test. *In Proceedings of the Chemeca* (Vol. 2012, pp. 23-26).

Van Craeyveld, V., Delcour, J. A., & Courtin, C. M. (2008). Ball milling improves extractability and affects molecular properties of psyllium (Plantago ovata Forsk) seed husk arabinoxylan. *Journal of Agricultural and Food Chemistry*, 56(23), 11306-11311.

Vega-López, S., Vidal-Quintanar, R. L., & Fernandez, M. L. (2001). Sex and hormonal status influence plasma lipid responses to psyllium. *The American journal of clinical nutrition*, 74(4), 435-441.

Verma, A., & Mogra, R. (2013). Psyllium (Plantago ovata) husk: a wonder food for good health. *International Journal of Science and Research*, 4(9), 1581-1585.

Zandonadi, R. P., Botelho, R. B. A., & Araújo, W. M. C. (2009). Psyllium as a substitute for gluten in bread. *Journal of the American Dietetic Association*, 109(10), 1781-1784.

تأثير إضافة بذور القاطونة على صفات جودة لانشون لحم الارانب

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تتميز بذور القاطونة بمحتواها الصمغي، وهو عبارة عن سكريات عديدة معقدة تستطيع تشكيل مادة هلامية عندما ترتبط بالماء، مما يجعلها عوامل ربط فعالة في المنتجات الغذائية. إن إمكاناتها كبدائل للدهون ملحوظة، إلى جانب محتواها الغني بالبروتينات والمعادن والمركبات الفينولية، مما يجعلها ذات قيمة غذائية كبيرة. أجريت هذه الدراسة لمعرفة تأثير إضافة بذور القاطونة على صفات جودة لانشون لحم الأرانب. تم اضافة تراكيز مختلفة من البذور (1، 2، 3%). كما تم تخزين عينات اللانشون لمدة شهرين عند درجة حرارة 4 ±1 درجة مئوية. أظهرت النتائج زيادة محتوى الرطوبة والرماد والألياف بزيادة تركيز بزور القاطونة مقارنة بعينة التحكم (الخالية من بذور القاطونة). وخلال فترات التخزين كان هناك تحسن ملحوظ في الصلابة والصمغية والمضغ. أظهرت هذه العينات أيضًا توزيعًا متجانسًا لجزيئات الخليط، وانخفاضًا في حجم الفراغات الهوائية، علاوة على ذلك، حصلت العينات التي تحتوي على بذور القاطونةعلى تقييم حسي أفضل مقارنة بعينة الكنترول في النكهة والعصيرية والطراوة، وكلها تحسنت بشكل ملحوظ خلال فترات التخزين.