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Omar A. Emam

Ghada M. EL-B assyouni

Naglh S. Aied

Faculty of Specific Education, Benha University, Benha, Egypt

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Omar A. Emam, Ghada M. EL-B assyouni and Naglh S. Aied

Faculty of Specific Education, Benha University, Benha, Egypt

Abstract:

The present study aims to prepare sausage formulae with low fat content by the replacers of beef fat with dried cauliflower leaves with different ratio (0, 5, 10 and 15%). Chemical composition, antioxidants content, minerals, vitamins and amino acids were studied. Also, physical properties and microbiological examination during frozen storage period at -180C for three months were also determined. Results indicated that prepared beef sausage formulae supplemented by dried broccoli with different ratio are considered as a good source of carotene, fiber fractions, cellulose, hemicelluloses and lignin contents. Moreover, formula 4 which contained 15% dried broccoli had recorded the highest values of studied antioxidants content, followed by formula 3 (10% dried broccoli), formula 2 (5% dried broccoli), and formula 1(control sausages), respectively. Also, all prepared formulae are rich source of minerals and amino acids. Total bacterial counts, fungi and yeasts were decreased as the level of dried broccoli increased in either at zero time or during frozen storage. Sausage samples are safe for human consumption i.e. going well with the permissible limits as recommended in Egyptian standard. Organoleptic evaluation (color, odor texture, paste and overall acceptability) of the all sausage samples are highly acceptable for the panelists.

Keywords: Sausage, chemical composition, antioxidants content, organoleptic evaluation.

Introduction:

Broccoli (*Brassica oleracea* L. *var. italica*) is a vegetable of important economic value, as well as a source of vitamin C (ascorbic acid) and anticarcinogenic property substances **(Carvalho and Clemente, 2004)**. Dietary antioxidants, such as water – soluble vitamin C and phenolic compounds, as well as soluble vitamin E and carotenoids, present in vegetables contribute both to the first and second defense lines

against oxidative stress. As a result of protect cells against oxidative damage, and may therefore prevent chronic diseases, such as cancer, cardiovascular disease and diabetes **(Anna, 2007)**.

Broccoli has been described as a vegetable with high nutritional value due to its important content of vitamins, antioxidants, anti-carcinogenic effect and health promoting phytochemicals. Qualities of broccoli florets in terms of ascorbic acid, B-carotene and antioxidant activity were found to undertake rapid changes, during post harvest storage **(Nath *et al.*, 2015)**.

Natural components can be found not only in raw materials, but also in agro –industrial wastes. Studies have demonstrated the presence of antimicrobial compounds in vegetal species. Their reuse as source of natural preservatives in food and beverage industry can promote sustainable practices since environmental risks caused by its discard are reduced. **Correa *et al.*, (2014).** Broccoli exhibits a high content of antioxidant and carcinogenic compounds such as polyphenols and selenium **(Andrea *et al.*, 2012)**. Also, broccoli has antioxidant content and antioxidant properties **(Ting *et al.*, 2007; Molay *et al.*, 2009 and Chun-Hsien and Chi-Yue, 2015).**

Elemental analysis of broccoli showed that both the flower and stem contained a significant amount of sodium, calcium, potassium, phosphorous and iron. However, heavy metals were not found in any of the broccoli samples.

Sausage is an ancient food type that is nowadays considered as a delicatessen **(Grabowska *et al.*, 2009).** It is categorized within the deli sector as meat sub products. Sausage is a food product preferred by consumers due to its nutritional value and organoleptic characteristics (wide range of flavors and textures) **(Nunes *et al.*, 2016).** Meat and meat products are essential components in the diets of developed countries. Their consumption is affected by many factors. The most important ones are product characteristics such as sensory, nutritional properties, safety, price and convenience, etc. **(Jimenez-Colmenero *et al.*, 2001)**.

The aim of this investigation is to prepare beef sausage formulae supplemented by dried broccoli powder with different ratio (0.0, 5, 10

and 15%) in order to obtain sausages rich in antioxidant contents such as phenolic compounds and vitamins. Also, it could be obtained sausage formulae with low fat content. Additionally, chemical, physical and microbiological evaluation was also studied during frozen storage at --18^{o}C for 4 months.

Materials and Methods:

Materials:

Local beef meat, spices, sodium chloride were purchased from the local markets, Cairo, Egypt.

Preparation of broccoli :

Broccoli was obtained from Ministry of Agriculture, Giza, Egypt. Broccoli flower was washed several times with clean tap water, cut into small parts, dried in an electric oven at 60^{o}C for 24 hours and crushed into fine powder then sieved through 80 mesh per square inch.

Preparation of natural mutton casings :

Mutton casings was cleaned well, fat and mesentery were removed as possible, the intestinal contents were stripped under spray of water, then slime were removed, soaked in sodium chloride solution for 24 hours and washing several times with tap water.

Preparation of sausages :

Four sausage formulae were prepared as the following methods. Both local beef meat and fat were minced well by an electric minter, then mixed with ice, sodium chloride, and spices mixture and mixed together. The gradient of sausage were 72.5% minced beef meat; 15.0% minced, beef fat, 0.5% spices mixtures sodium, chloride 2.0%, crushed ice 10.0% and supplemented with dried broccoli with different ratio (5.0, 10.0 and 15%). A spices mixture was added according to **Kulshresta and Rhee, (1996)**. All materials were homogenized and packaged in salted mutton casings by using sausage machine then storage at -18^{o}C for 4 months.

Chemical analysis:

Chemical composition (Moisture, protein, lipids, ash, and crude fibers) as g/100g fresh weight was determined of local beef meat, dried broccoli and prepared beef sausage formulae according to the method described by **AOAC (2000)**. Carbohydrates were calculated by the difference. Total energy was estimated as **FAO/WHO, (1985).** Fiber fractions were determined as **Vanscu and Wine, (1968)**. Minerals (Ca, Na, K, Mg, Fe and Z) (mg/100g dry weight) of sausages were determined by Atomic Absorption in Agricultural Research Center according to the method described by **Anerican Association of Cereal Chemists, (1983),** and **Kirleis *et al.*, (1984)**. Amino acids composition (g/100g dry weigh) of sausages was determined by Amino Acid Analyzer in Agricultural Research Center as the method of **Winder and Eggum, (1966)** and **AOAC, (2012**). Phenolic compounds (µg/100g dry weight) of dried broccoli and sausage formulae were determined by using HPLC in Agricultural Research Center according to the method described by **Whittle *et al.*, (1999).** Vitamin A, β-carotene of sausages (µg/100g fresh weight) determined as the method of **Danish Official, (1996)**. Vitamin C (mg/100g fresh weight) was determined as the method of **Danish Official, (1999)**. Peroxide value of sausage formulae was determined as the method of **AOAC, (2000).** Total bacterial counts, fungi and yeasts of sausages were determined according to **ICMSF, (1978)**. Organoleptic evaluation of sausages was evaluated as **Watts *et al.*, (1989)**. Statistical analysis of the obtained data was calculations as **SPSS, (1998)**.

Results and Discussion:

Table (1): Chemical composition of beef meat and broccoli.

Constituents	Beef meat (g/100 fresh weight)	Broccoli	
		g/100 fresh weight	g/100 dry weight
Moisture (%)	74.1	87.0	-
Crude protein (%)	18.4	3.3	25.4
Fat (%)	6.1	0.5	3.85
Crude fibers (%)	0.55	1.2	9.23
Ash (%)	0.61	1.0	7.69
Carbohydrate (%)	0.24	7.0	53.83
Total energy (Kcal/100g)	129.5	45.7	351.6

Table (1) shows the chemical composition of beef meat and broccoli. Results showed that beef meat contained 74.1% moisture, 18.4% crude protein, 6.1% fat, 0.55% crude fibers, 0.61% ash, 0.24% carbohydrate (on fresh weight basis) and total calories was 129.5 kcal/100 g fresh weight bases. These results are in agreement with those found by **Emam, (1990) and El-Sayed, (1998).** On the other hand, dried broccoli consists of 25.4% crude protein, 3.85% fat, 9.23% crude fibers, 7.69% ash, 53.83% carbohydrate, while total calories was 351.6 (kcal/100g on dry weight basis). These results are confirmed by **Diksha and Awashi (2003); Ferraria *et al.*, (2014) and Anwar, (2015).**

Table (2) shows HPLC analysis of phenolic compounds in aqueous extract of dried broccoli. Results indicated that dried broccoli consists of twenty compounds were identified.The major compounds are pyrogallol 57721.85, followed by protocatchuic 23111.36, chlorogenic 15073.22, catechin 14711.08, P-OH-benzoic 9360.82 and Benzoic 7590.24 (µg/100g DW), respectively. These results are in agreement with those mentioned by **Tiveron *et al.*, (2012) and Wang *et al.*, (2012)**.

Table (2): HPLC analysis of phenolic compounds in aqueous extract of dried broccoli.

Phenolic Compounds	Amount (µg/100g DW)	Phenolic Compounds	Amount (µg/100g DW)
Gallic	956.67	Ferulic	2390.17
Pyrogallol	57721.85	Iso-Ferulic	589.71
Protocatchuic	23111.36	Alpha-coumaric	338.49
Catechein	14711.08	Bllagic	503.61
Chlorogenic	15073.22	Benzoic	7590.24
Catechol	5155.34	Coumarin	452.96
Caffeine	1926.56	3,4,5-methoxy-cinnamic	1533.57
P-OH-benzoic	9360.82	Salycilic	2230.64
Caffeic	400.40	Cinnamic	98.99
Vanillic	1536.70	Total phenolics	147525.2
P-coumaric	1842.83		

Table (3): Gross chemical composition of prepared beef sausages supplemented by dried broccoli (DB) during frozen storage at -18°C for 4 months.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Moisture (%)				
Zero time	65.5	64.6	63.8	63.0
Four months	62.4	61.2	60.5	60.2
Crude protein (%)				
Zero time	17.0	16.5	15.7	15.0
Four months	16.0	15.4	15.0	14.2
Fat (%)				
Zero time	14.3	14.1	13.5	13.0
Four months	16.8	16.0	15.7	14.0
Ash (%)				
Zero time	1.4	1.8	2.0	2.2
Four months	1.6	1.9	2.4	2.6
Carbohydrates (%)				
Zero time	1.24	2.14	3.78	5.4
Four months	2.53	4.55	5.05	7.5
Crude fibers (%)				
Zero time	0.56	0.86	1.22	1.4
Four months	0.67	0.95	1.35	1.5
Total energy K.cal./100g	201.7	201.5	199.4	198.6

Results expressed as g/100g on fresh weight basis

Gross chemical compositions of beef sausage formulae supplemented by dried broccoli during frozen storage period at -18oC for 4 months are

tabulated in Table (3). Results revealed that moisture content was ranged from 63.0 to 65.5 (g/100 g on fresh weight). crude protein (15.0 to 17.0%) ; fat (13.0 to 14.3 %) ash (1.4 to 2.2%,), Crude fiber (0.56 to 1.4%,) and Carbohydrates (1.24 to 5.4%). Total energy (k.cal./100g on fresh weight basis) was ranged between 198.6 and 201.7. Chemical composition of all prepared beef sausage are in agreement with those found by **Hassan, (2010); and Prica *et al.*, (2013)**. It is worthy to mention that, addition of dried broccoli to beef sausages caused a decrease in moisture, protein and fat contents. In contrast, ash, crude fiber and carbohydrates were increased as the level of dried broccoli increased. This may be due to that broccoli is considered as a good sources of ash, fibers and carbohydrates as shown in the results of table (1). These results are in agreement with those obtained by **Diksha and Awasthi (2003) and Ferreria *et al.*, (2014).** During frozen storage period, both moisture and crude protein of all sausage samples were slightly decreased till the end of storage. This decrease could be due to a part of nitrogenous compounds which escaped in the drip loss during thawing. The same conclusion was noticed by **Hemeida (2002)**.

Table (4): The percentages of fiber fractions analysis of prepared beef sausage formulae supplemented by dried broccoli.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Neutral Detergent Fiber (NDF)	3.32±0.07	3.83±0.08	8.58±0.19	6.49±0.14
Acid Detergent Fiber (ADF)	1. 38±0.03	3.40±0.08	3.44±0.08	4.36±0.26
Acid Detergent Lignin (ADL)	0.57±0.02	1.21±0.04	1.36±0.20	0.68±0.02

Results expressed as mean ±SD (g/100g fresh weight basis).

Fiber fraction analyses of prepared beef sausage formulae supplemented by dried broccoli with different levels (0, 5.0, 10 and 15%) are show in Table (4). Results indicated that neutral detergent fiber (DNF) was ranged from 3.32 ± 0.07to 6.49 ± 0.14 % on fresh weight basis; acid detergent

fiber (1.38 ± 0.03 and 4.36 ± 0.26%), and acid detergent lignin (ADL) (0.57 ± 0.02 and 1.36 ± 0.20%).It is worthy to mention that, NDF, ADF and ADL were increased as the level of dried broccoli increased. This could be due to that broccoli is a rich sources of dietary fibers **(Banerjee *et al.*, 2012 and Ferreria *et al.*, 2014).**

Table (5): Fiber percentage of prepared beef sausages supplemented by dried broccoli.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Cellulose (%)	1.22	1.43	1.93	3.05
Hemicelluloses (%)	0.80	2.18	2.58	2.76
Lignin (%)	0.53	1.02	1.36	1.45

Results expressed as mg/100g fresh weight basis

Table (5) illustrates the percentages of fibers of prepared beef sausage formulae fortified by dried broccoli. The percentage of cellulose of prepared beef sausage was ranged from 1.22% to 3.05 %; Hemicellulose (0.80% - 2.76%) and lignin (0.53% - 1.45 %). The highest percentage of studied fibers was found in formula (4) and the lowest percentage was found in control samples. The addition of dried broccoli to sausage samples during processing caused an increase in cellulose, hemicelluloses and lignin. This increase of crude fibers due to that broccoli is rich sources of dietary fibers as mentioned by **(Diksha and Awasthi, 2003).**

Table (6): Mineral contents of prepared beef sausages supplemented by dried broccoli.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Ca	376.1	410.7	629.4	635.9
K	858.3	970.6	1092	1026
Mg	107.9	86.3	140.6	165.9
Na	2.20	2.63	2.03	2.29
Fe	14.8	12.4	23.9	21.8
Zn	10.8	8.63	14.6	16.59

Results expressed as mg/100g dry weight basis

Macroelements (Ca, K, Mg and Na) and microelements (Fe and Zn) of prepared beef sausages samples supplemented by dried broccoli are illustrated in Table (6). The results showed that Ca ranged from 376.1 to 635.9; K (858.3 – 1026); Mg (107.9-165.9mg); Na (2.2-2.29mg); Fe (14.8-21.8 mg) and Zn (10.8.-16.59), mg/100g on dry weight basis , respectively. It is worthy to mention that all studied minerals were increased as the level of dried broccoli addition increased, the higher addition of dried broccoli to sausages, the higher value of Ca, K, Mg, Na, Fe and Zn was observed. These results are confirmed by **Diksha and Awasthi, (2003) and Grabowska *et al.*, (2009)**.

Amino acids composition of prepared sausage formulae supplemented by dried broccoli with different levels (0, 5, 10 and 15%) was tabulated in Table (7). The obtained results showed that there are seventeen amino acids were identified by amino acid analyzer. The major of EAA were lysine which ranged from 3.27 to 4.23 (g/100g dry weight basis) and leucine (3.48-4.03 g/100g. On the other hand, the major of non-essential amino acids were aspartic acid which ranged form 4.14 to 4.88, (g/100g FW), followed by glutamic acid (7.82 - 9.08), the highest value of total amino acids was found in control sample and the lowest value was found in formula (4). This may be due to that beef meat is

considered as a rich source of animal protein and EAA as noticed by **Emam, 1990 and Hassan, (2010).** Results also indicated that total EAA of prepared sausage formulae was ranged from 19.77 to 23.81 (g/100g protein FW).

Table (7): Amino acids composition of prepared beef sausage formulae substituted by dried broccoli.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Therionine (Thr)	2.31	2.24	2.05	2.03
Valine (Val)	2.70	2.67	2.32	2.38
Isoleucine (Ile)	2.38	2.37	2.06	2.06
Leucine (Luc)	4.03	4.01	3.55	3.48
Phenyl alanine (Phe)	2.28	2.17	1.92	1.99
Tyrosine (Tyr)	1.85	1.69	1.58	1.52
Histidine (His)	1.52	1.63	1.32	1.37
Lysine (Lys)	4.23	4.03	3.60	3.27
Methionine (Met)	1.54	1.29	1.20	1.11
Cysteine (Cys)	0.97	0.90	0.68	0.56
Total EAA	23.81	23.0	20.28	19.77
Essential amino acids (EAA)				
Asparatic (ASP)	4.88	4.63	4.14	4.25
Serine (Ser)	2.09	2.0	1.84	1.88
Glutamic acid (Glu)	9.08	8.73	7.82	8.06
Glycine (Gly)	4.86	4.70	4.11	3.50
Alanine (Ala)	4.78	4.09	3.59	3.88
Proline (Pro)	3.62	3.17	3.05	2.76
Argenine (Arg)	3.88	4.05	3.55	3.24
Total NEAA	33.19	31.37	28.11	27.57
Total amino acids	57.0	54.37	48.33	47.37

Results expressed as g/100g on dry weight basis

Table (8) shows HPLC analysis of phenolic compounds of prepared beef sausages supplemented by dried broccoli with different percentage. The major phenolic compounds are pyrogallol which ranged from 5917-8822.4 (µg/100g on dry weight basis), followed by catchein (600.9-4523), protochatchuic (560.6-3801.2), P-OH-benzoic (445.3-1148.2), Benzoic (342.0 -3650.5) and chlorogenic (290.9-952.5) µg/100g on dry weight basis, respectively. Phenolic compounds of prepared beef sausage samples were increased as the level of dried cauliflower leaves increased. This increase could be due to that dried broccoli is a rich sources of these phenolic compounds as illustrated in the previously results in table (2). In addition, broccoli is a good source of flavonol and hydroxyl cinnaamoyl derivatives **(Podsedek, 2007; Andera *et al.*, 2012) and Anwar, 2015)**.

Table (8): HPLC analysis of phenolic compounds of prepared beef sausages formulae substituted by dried cauliflower leaves.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Gallic	100.99	73.32	74.42	171.86
Pyrogallol	5917.00	5211.04	10985.75	8822.37
4-amino-benzoic	19.93	33.0	27.60	51.69
Protocatchuic	560.59	2488.12	1661.58	3801.24
Catechein	600.88	2911.37	1571.67	4522.95
Chlorogenic	290.94	860.97	144.37	952.53
Catechol	224.97	160.56	--	641.67
Caffeine	89.06	300.66	342.33	633.81
P-OH-benzoic	445.29	1294.65	1710.81	1148.16
Caffeic	49.43	62.03	82.28	103.64
Vanillic	68.15	180.33	243.51	323.17
E-coumaric	31.28	196.90	857.57	900.78

Ferulic	27.72	283.79	488.53	540.69
Iso-Ferulic	53.20	99.89	126.24	114.17
Alpha-coumaric	39.18	110.49	--	277.71
Ellagic	213.68	206.03	276.05	408.13
Benzoic	342.03	2527.38	2918.45	3650.50
Coumarin	--	61.90	326.29	314.66
3,4,5-methoxy-cinnamic	--	--	293.50	134.08
Salycilic	230.26	449.17	596.50	707.81
Cinnamic	47.59	71.35	336.73	65.01
Total phenolics	9352.2	17583.0	23064.2	28286.6

Results expressed as µg/100g on dry weight basis

Vitamins (β-carotene and vitamin C) of prepared beef sausages supplemented by dried broccoli with different percentages (5, 10 and 15%) are illustrated in Table (9). It is clear from the results that β-carotene of prepared beef sausage formulae was raged from 90.12 ± 2.34 to 827.9 ± 21.5 (µg/100g FW). The highest value of β-carotene was found in sausage contained 15% DB, followed by 10% DB and 5% DB, respectively. However, control samples (without any DB addition) showed the lowest value. This may be due to that broccoli is rich source of β-carotene. Such results are confirmed by **Banerjee *et al.*, (2012).** Results also showed that vitamin C of all prepared sausage formulae was ranged from 0.415 ± 0.17 to 0.485 ± 0.019 (mg/100g FW), the highest value of vitamin C was found in sausage contained 15% DB and the lowest value was found in control samples. This may be due to that broccoli is a rich source of vitamin C as reported by **Diksha and Awasthi (2003) and Anna, (2007)**.

Table (9): Vitamins of prepared beef sausages supplemented by dried broccoli (fresh weight basis).

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
B-carotene (µg/100g)	90.12±2.34	428.06±11.1	694.9±18.1	827.9±21.5
Vitamin – C (mg/100g)	0.415±0.17	0.475±0.019	0.470±0.019	0.485±0.019

Table (10) shows Peroxide value (PV) of prepared beef sausages of supplemented by dried broccoli during frozen storage period. Results indicated that PV of sausage samples was ranged from 2.27 to 13.9 mill. equiv./kg lipid. The highest PV value was found in control samples (without addition of broccoli) and the lowest value was found in formula (4). Peroxide value was decreased as the level of addition broccoli increased. This decrease in PV may be due to that broccoli is considered as a good source of phenolic compounds, vitamin C and B-carotene as shown in the previously results in tables. (8 and 9) In addition, broccoli has an antioxidant effect **Anwar, Sara, (2015**).

During frozen storage time, PV (meq/kg lipid) of all prepared sausage formulae were sharply increased till the end of storage. PV was proportionally increased with the same trend, before storing. The PV was higher for control sample. The levels of peroxides were increased till reached from 12.85 to 13.9 meq/kg at the end of storage period. The same conclusion was found by **Mehrem, (2017).**

Table (10): Peroxide value of prepared beef sausages supplemented by dried broccoli during frozen storage at -18°C for 4 months.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Zero time	2.27	2.02	1.90	1.75
One month	7.42	7.10	6.95	6.50
Two months	10.60	10.25	10.0	9.60
Four months	13.90	13.51	13.22	12.85

Results expressed as meq/kg fat

Total bacterial count; fungi and yeasts of prepared beef sausage formulae supplemented by dried broccoli with different ratio during frozen storage are tabulated in Table (11). Total bacterial counts of prepared sausage samples was ranged from $5.1x10^5$ to $6.15x10^5$ (cfu/g) after processing and it's decreased gradually as the prolonged of storage period proceeded till reached from 2.51×10^5 to 4.53×10^5 (cfu/g) at the end of storage.

Table (11): Microbiological changes of prepared beef sausage supplemented by dried broccoli during frozen storage at 18°C for 4 months (cfu/g).

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Total bacterial counts				
Zero time	6.15×10^5	5.62×10^5	5.23×10^5	5.1×10^5
One month	5.9×10^5	5.5×10^5	5.1×10^5	4.8×10^5
Two months	5.24×10^5	4.18×10^5	3.56×10^5	2.94×10^5
Four months	4.53×10^5	3.62×10^5	3.27×10^5	2.51×10^5

Total fungi and yeasts				
Zero time	2.17×10^2	1.90×10^2	1.61×10^2	1.5×10^2
One month	2.04×10^2	1.75×10^2	1.44×10^2	1.32×10^2
Two months	2.0×10^2	1.66×10^2	1.32×10^2	1.21×10^2
Four months	1.80×10^2	1.50×10^2	1.24×10^2	1.1×10^2

During subsequent frozen storage period, total bacterial counts of all prepared sausage samples were slightly decreased upon storage time. This decrease in microbial load during storage might be drastic condition of freezing and frozen storage due to mechanical effect on ice crystal formation of cell proteins in microorganisms resulting from freezing as in addition, broccoli is a rich source in antioxidant content as shown in the previously results. **Correa *et al.*, (2014)** reported that Brassica family of vegetable had an antibacterial effect. Total fungi and yeasts of prepared sausage formulae was ranged from 1.5×10^2 to 2.17×10^2 (cfu/g) just after processing and slightly decreased during storage, the highest number of bacteria was found in control samples and the lowest was found in sausage contained 15% DB in either at zero time or at the end of storage period. It is worthy to mention that, all prepared beef sausage were in the permissible limits according to **Egyptian Standard Specification (ESS) No. 1972, (1991)** which reported that total bacterial counts should not exceed than 10^6 (cfu/g).

Table (12): Organoleptic properties of prepared beef sausage formulae supplemented by dried broccoli during frozen storage at -18°C for 4 months.

Ingredients	Sausage (Control)	Sausages + DB (%)		
		5	10	15
Color				
Zero time	9.3	9.0	9.1	9.0
Two months	8.8	8.8	8.4	8.5
Four months	8.2*	8.1*	8.3*	8.2*

Texture				
Zero time	9.3	9.2	9.1	9.1
Two months	8.4	8.8	8.5	8.6
Four months	8.2	8.4	8.4	8.3
Taste				
Zero time	9.5	9.3	9.4	9.4
Two months	8.9	8.5	8.3	8.1
Four months	8.4*	8.2*	8.0*	7.9*
Odor				
Zero time	9.3	9.3	9.4	9.6
Two months	8.9	8.8	8.6	8.5
Four months	8.2*	8.5*	8.5*	8.4*
Overall acceptability				
Zero time	9.4	9.3	9.0	9.3
Two months	8.8	8.5	8.6	8.8
Four months	8.5*	8.5*	8.4*	8.5*

* Significant at $P \leq 0.05$

Table (12) shows organoleptic evaluation (color, texture, taste, odor and overall acceptability) of prepared beef sausages formulae supplemented by dried broccoli during frozen storage. Results showed that the average score of color characteristic was ranged from 9.0 to 9.3; texture (9.1-9.3); taste (9.3-9.5), odor (9.3-9.6) and overall acceptability (9.0-9.4), respectively. All studied sensory properties of prepared beef sausages were slightly decreased with the increment of storage period. Odor of all prepared sausage formulae was decreased gradually till the end of storage. This may be due to lipid peroxidation as shown in the previously results in Table (10). Lipid peroxidation in muscle foods is one of the major derivative processes which leads to the formation of "stall" or wormed over flavors **(Pearson *et al.*, 1983).**

Statistical analysis of the obtained data showed that there are no significant differences ($p \leq 0.05$) among formulae at zero time, but there are significant differences of sensory properties at the end of frozen storage period. It could be concluded that all prepared beef sausages were highly acceptable for the panelists in either after processing or at the end of frozen storage period.

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إعداد وتقييم السجق المصنع بإضافة البروكلي المجفف

عمر احمد امام، غادة محمود البسيوني، نجلاح سروري عايد

قسم الاقتصاد المنزلى– كلية التربية النوعية – جامعة بنها – بنها – مصر

الملخص:

يهدف البحث إلى إعداد عدينات من السجق وذلك بإضافة مسحوق البروكلي بنسب صفر ، ٥، ١٠، ١٥% . وقد تم دراسة التركيب الكيميائي ومضادات الأكسدة والعناصر المعدنية والفيتامينات والأحماض الأمينية وكذلك التقييم الحسي والميكروبيولوجي للعينات خلال فترة التخزين بالتجميد على درجة –١٨ مْ لمدة ثلاث شهور. ولقد دلت النتائج على أن عينات السجق غنية بمضادات الأكسدة الطبيعية مثل البيتاكاروتين ، فيتامين ج وكذلك المركبات الفينولية والتي من أهمها Pyrogallol, benzoic, catechein, chlorogenic. كما لوحظ أنه كلما زادت نسبة إضافة مسحوق البروكلي إلى السجق كلما زاد المحتوى من مضادات الأكسدة (المركبات الفينولية والبيتاكاروتين وفيتامين C) وأن الخلطة رقم ٤ (السجق المضاف اليه ١٥% من مسحوق البروكلى قد سجلت أعلى نتائج من حيث احتوائها على مضادات الأكسدة. كما إحتوت عينات السجق على نسبة عالية من العناصر المعدنية (كالسيوم – بوتاسيوم– ماغنسيوم– صوديوم– حديد– زنك) وكذلك مشتقات الألياف الحامضية والقاعدية والمتعادلة وأيضًا السليولوز والهميسليولوز واللجنين بالإضافة إلى أنها تعتبر مصدر جيد للألياف وحدث انخفاض في أعداد البكتريا الكلية والفطريات والخمائر كلما زادت نسبة إضافة مسحوق البروكلي سواء عقب التصنيع أو خلال فترات التخزين بالتجميد. وأخيرا.. كانت جميع عينات السجق في حدود المواصفات القياسية المصرية وأمنه لدى المستهلك ومقبولة حسيًا لدى المحكمين.

الكلمات المفتاحية: السجق، التركيب الكيميائى، محتوى مضادات الأكسدة، التقييم الحسى.