EFFECT OF SOME GROWTH PROMOTERS ADDED TO RATIONS OF FRIESIAN CALVES ON QUALITIES AND COOKING PROPERTIES OF MEAT

3. Flavour compounds and cooking properties of fresh and frozen *longissimus dorsi* muscle meat.

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ABSTRACT

The effect of some commercial growth promoters (fibrozyme, moreyeast and pronifer) added to rations of friesian calves on flavour compounds and cooking properties of fresh and frozen (at -20°C for 6 months) *longissimus dorsi* muscle meat were studied.

Data showed that the highest number of aromatic compounds were found in cooked fresh calves meat of pronifer treatment (63 compound), followed by control group (37 compound) and then fibrozyme treatment (31 compound), while the lowest number were detected in moreyeast treatment (14 compound). The pronifer had the greatest effect on the formation of aromatic compound compared with other growth promoters. Ethylbenzene (aromatic hydrocarbon) was found in all cooked samples as a main component of cooked meat flavour.

Generally, the hydrocarbons' components were found the highest portion of aromatic compounds (32.18 : 59.47%) followed by aldhydes (8.69 : 33.82%), alcohols and phenolic compounds (7.80 : 13.65%), ketones (3.42 : 10.48%), while other compound such as acids, sulfur compounds, amines and amides, lactones, furans, ethers, were the lowest portion of aromatic compounds and they were not detected in all samples.

The total number of aromatic components in cooked frozen meat of calves fed on control ration and supplemented groups with growth promoters were decreased as storage time increased in the case of control (13 compound) and pronifer treatments (32 compound), while no changes were found in fibrozyme and moreyeast treatments. Pyrolls, furans, indols and oxygen compounds were disappeared in all samples of cooked frozen meat, while one component of furanones was detected in pronifer treatment in cooked frozen meat.

After frozen storage, acids formed the highest portion of aromatic compounds in meat of control treatment (42.25%), the hydrocarbons in

fibrozyme and pronifer treatments (49.66 and 58.84%, respectively), while aldehydrs formed 65.70% of total aromatic compounds in moreyeast treatment.

Panel scores of tenderness showed some differences due to growth promoters. Moreyeast supplementation scored high value of tenderness, juiciness and flavour, followed by pronifer, while fibrozyme scores were similar to control.

INTRODUCTION

Beside appearance and tenderness, flavour is the most important characteristic of quality perceived by the consumer (**Love, 1994**). Flavour is a very important component of the eating quality of meat. Meat flavour is thermally derived, since uncooked meat has a little or no aroma and only a blood-like taste. During cooking, a complex series of thermally induced reactions occur between non-volatile components of lean and fatty tissues resulting in a large number of reaction products. Although the flavour of cooked meat is influenced by compounds contributing to the sense of taste, it is the volatile compounds formed during cooking, that determine the aroma attributes and contribute most to the characteristic flavours of meat (**Mottram, 1998**). The flavour characteristics of different meat species are generally believed to be derived from lipid sources (**Mottram, 1991**). Polyunsaturated fatty acids are deposited in the phospholipids of ruminants, which are important sources of lipid-derived flavour compounds during cooking (**Mottram, 1996**). The intermediate products capable of further reaction such as α-dicarbonyl compounds or α-amino ketones, form important meat flavour compounds such as pyrazines, oxazoles, thiophenes, thiazoles and other heterocyclic sulphur compounds (**Elmore *et al.*, 1997**). The chemistry underlying beef flavour is complex, with in excess of 140 compounds identified in cooked beef volatile. Flavour of beef is influenced by cattle diet, but assessment of flavour by a taste panel is subject to the previous experience and performances of the panelists (**Moloney *et al.*, 2001**). The development of the flavour of cooked meat is a very complex process in which different components react to produced chemical intermediates of final flavour volatiles. Meat flavour are much more pronounced when cysteine and ribose are also present, i.e. they derived from interactions between Maillard reaction products and fatty acids. On the other hand, some flavour notes were more associated with the fatty acids alone, e.g. oily. The fatty acids $C_{18:1}$, $C_{18:2}$ and $C_{18:3}$ produce different odour profiles, e.g. $C_{18:3}$ produces high scores for fishy, linseed/putty and creosote (**Compo *et al.*, 2003**).

The purpose of this work is to determine the changes in flavour compounds occurred in fresh and frozen *longissimus dorsi* muscle meat of

Friesian calves as affected by some commercial growth promoters added to animals ration and also to evaluate the organoleptic qualities of cooked fresh meat post-mortem.

MATERIALS AND METHODS

This work was carried out at El-Karada Animal Production Research Station and Sakha Animal Production Research Laboratories, Kafr El-Sheikh Governorate, which belong to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Cairo, Egypt and Food Technology Department, Faculty of Agriculture, Kafr El-Sheikh, Tanta University.

Materials :

Twelve Friesian calves with average body weight 233.17 kg and 11 months, 20 days of age were used in this study. Concentrate feed mixture consisted of yellow corn 30%, cotton seed cake 20%, wheat bran 12%, rice bran 16%, soya bean cake 16%, sugar cane molasses 3%, lime stone 2% and salt 1% (Factory of Concentrate Feed Mixture, Shosha, Al-Minia Governorate, Egypt).

Experiment:

Animals were divided into four similar groups (three animals for each group) according to their live body weight and age. Average of initial live body weight were 234.67, 232.00, 229.33 and 236.67 kg for groups control, fibrozyme, moreyeast and pronifer, respectively.

The first group (control) was fed on a basal ration which consisted of concentrate feed mixture, rice straw and berseem hay without any feed additives supplementation.

The calves of the other three groups were fed the same basal ration with fibrolytic enzyme (fibrozyme, obtained of industrial. area, jdeidet El-Metn, Lebanon), yeast (*Saccharomyces cerevisiae*, moreyeast product of norchem.USA) and lactic acid bacteria (pronifer product of P.G.E,Austria), as follow: 15 gm fibrozyme/head/day, 3-5 gm moreyeast/ kg concentrate feed mixture and 5-10 gm pronifer/100 kg live body weight.

Animals were fed to cover the requirements of dry matter, total digestible nutrients and digestible crude protein for growing calves according to **National Research Council (1996)** and the rations were adjusted biweekly according to the body weight changes.

Animals of the different main groups were kept during the experimental period in semi-open sheds and fed individually. The concentrate mixture was offered twice daily at 8 am and 3 pm, berseem hay

was offered once daily at 11 am and rice straw was offered at 9 am. All feed additives were added to the concentrate feed mixture at the time of feeding daily Animals were allowed to drink water twice daily post-feeding in the morning and in the afternoon.

At the end of the feeding trials (six months), all animals were slaughtered after fasting period of 16 hours at an average weights 405, 446.67, 440 and 445 kg for control, fibrozyme, moreyeast and pronifer groups, respectively. Growth promoters supplementation led to significant increase in body weight gain and daily weight gain. Average relative daily body weight gain during the experimental period (180 days) for calves supplemented with fibrozyme, moreyeast and pronifer increased by 125.26, 123.16 and 122.11%, compared with control group, respectively. Upon the completion of bleeding, animals were skinned, dressed out and the hot carcasses were weighted. Samples of meat were taken from *Longissimus dorsi*, muscle meat for determine the changes in flaveur compound occurred in fresh and after freezing for six months at -20°C and also to evaluate the organoleptic qualities of cooked fresh meat..

Methods :

Extraction of total flavour compounds:

Flavour compounds in cooked meat were separated by steam distillation apparatus followed the method of **Nakamura *et al.*, (1978)**. The flavour compound in cooked fresh and frozen *Longissimus dorsi* muscle meat (at -20°C for six months) were estimated. Cooking meat was done in an electric oven at 200°C for 90 min to get an internal temperature of 70°C. About 100 gm of cooked meat was introduced with 100 ml of distilled water in steam distillation apparatus. The flavour compounds were extracted using using 60 ml of pentane: ether (2: 1, v/v) as a solvent. The extraction was carried out for 90 min. The flavour compounds were transferred into separatory funnel and shaken. The organic phase was decanted and the water phase was washed 6 times with 20 ml of solvent. The solvents were combined and dehydrated with anhydrous sodium sulphate. Then the solvent was slightly concentrated to about one ml with stream of purified nitrogen gas. Capillary column gas chromatography (Hewlett Packard Model 6890) was used to determine flavour compounds at Central Laboratory of Food Science and Technology Department, Faculty of Agriculture, Cairo Univ. Temperature program was: oven 40°C for 3 min. to 260°C at 4°C/min., final temperature for 15 min. detector temperature was 32°C. Carrier gas: helium at 0.8 cm/min. capillary column: HP-5 MSHP length 80 m, thickness 0.3. The peaks were identified using Mass spectroscopy Hewlett Packard Model 5973 Mass selective detector.

Identification of separated compounds was by using: Standard library (NIST Version 2.0).

Organoleptic qualities:

Organoleptic qualities of cooked fresh meat was performed by ten panelists. They were asked to judge the samples about tenderness, juiciness and flavour, as described by **Chambaz *et al.* (2003)** using a 5-point scale (tenderness. 1 = very tough. 5 = tender, juiciness. 1= very dry. 5= juicy, flavour, 1= extremely unacceptable. 5 = very acceptable.

RESULTS AND DISCUSSION

Aromatic compounds in cooked fresh meat:

Data present in Tables 1, 2, 3 and 4 showed that the aromatic compounds in cooked fresh *Longissimus dorsi* muscle meat as affected by some different growth promoters supplemented with the experimental ration of Friesian calves. These compounds were identified qualitatively and included a series of aliphatic and aromatic hydrocarbons, aliphatic and aromatic aldehydes, ketones, amines, amides, esters, ethers, alcohols and phenolic compounds, acids, sulfur compounds, pyridines, pyrones, pyrroles, furans, indoles, furanones, lactones, pyrazines and unidentified compounds.

The highest number of aromatic compounds were found in cooked fresh calves meat of pronifer treatment, followed by control group and then fibrozyme treatment, while the lowest number were detected in moreyeast treatment.

Generally, the hydrocarbons components formed the highest portion of aromatic compounds (32.18 : 59.47%), followed by aldehydes (8.69 : 33.82%), alcohols and phenolic compounds (7.80 : 13.65%), ketones (3.42 : 10.48%), while other compounds such as acids, sulfur compounds, amines and amides, pyridines, esters, pyrones, lactones, furans, ethers, pyrazines, pyrrols, oxygen compounds and indoles were the lowest portions of aromatic compounds and they were not detected in all samples (Table 5).

Data showed that growth promoter (pronifer) had the greatest effect on the formation of aromatic compounds (63 component) compared with other growth promoters. The total aromatic compounds in control were 37 components, while they were 31 and 14 in fibrozyme and moreyeast treatments, respectively.

Ethylbenzene (aromatic hydrocarbon) was found in all cooked samples as a main constitute of cooked meat flavour compound, whereas it formed 6.64, 19.43, 10.46 and 2.58% of the total aromatic compounds in cooked fresh calves' meat fed on control ration and supplemented groups with fibrozyme, moreyeast and pronifer, respectively.

Table (1): Aromatic compounds (%) in cooked fresh *Longissimus dorsi* muscle meat of Friesian calves fed ration (control) (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
2-Hexene, 3-5-dimethyl	3.18	2.31
1-peneten	3.48	0.92
Hexane, 3-methyl	4.01	2.70
1-pentadecene	4.48	1.01
Octane (fatty-rancid)	4.61	0.87
Hexane, 2,4-dimethyl	4.77	6.46
Octane, 4-methyl	5.00	2.26
Total		*16.53*
Cyclic aliphatic hydrocarbons		
1-Deuterio-trnas-1,3-dihydroxy-cyc	3.26	3.30
Cyclopentane-1,2,3-trimethyl	3.33	3.08
4,4-dimethyl-4-Silacyclopentene	4.24	6.99
Cyclooctane octamethylene	5.27	1.27
Cyclooctane, methyl	5.44	4.32
Cyclohexane 1, 3,5-trimethyl	5.73	1.47
Cyclopropane, 1-heptyl-2-methyl	5.88	1.94
Total		*22.37*
Aromatic hydrocarbons		
Ethyl benzene (meaty)	6.09	6.64
O-xylene	6.25	5.03
Benzene, 1,2-dimethyl	6.41	1.91
M-xylene (fruity)	7.02	5.59
Benzene, 1-ethyl-3-methyl	9.20	1.40
Total		*20.57*
Aliphatic aldehydes		
4-Methylhex-1-enal	4.55	1.45
Decanal (nutty)	4.90	0.80
Dihydro-citroonellal, 3,7-dimethyl	5.25	2.51
2-Heptanal, 2-methyl (fatty)	6.79	1.47
Total		*6.23*
Aromatic aldehydes		
Benzaldehyde,oxime (Z) (nutty-allmonds)	3.68	1.06
Benzaldehyde (nutty-almonds)	6.47	5.96
Total		*7.02*
Alcohols and phenolic compounds		
1-Decanol	3.24	1.96
5-Azulenemethanol, 1, 2, 3a, 4, 5, 6	3.94	2.89
1-Heptanol, 6-methyl (alcohol-like)	4.10	1.54
2-Octanol (meaty)	4.15	2.04
1-Hepten-4-ol	11.40	2.37
Total		*10.80*
Acyclic aliphatic ketones		
4-heptanone, 2-methyl (buttery)	7.5	4.26
Amines and amides		
Benzenamine, N-hydroxy	3.81	1.67
1,2-propanediamine	11.45	0.83
Total		*2.50*
Pyridines		
1-D3-Methyl-2-pyridine	5.34	4.02
Furans		
Furan, 2,3-dihydro-4 (1-methyl prop)	5.65	1.36
Ethers		
Chloromethyl octyl ether	5.16	2.58
Lactones		
d-Lyxo-d-manno-nononic-1,4-lactone	10.88	1.76
37		*100.00*

Table (2): Aromatic compounds (%) in cooked fresh *Longissimus dorsi* muscle meat of Friesian calves fed ration supplemented with fibrozyme (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
Octane (fatty-raincid)	3.93	2.93
Nonane (meaty-fatty)	6.86	1.56
1-hexylethanoate	18.53	1.35
Total		*5.84*
Cyclic aliphatic hydrocarbons		
Cyclohexane, 1,3-dimethyl-trans	3.48	1.63
Aromatic hydrocarbons		
Ethyl benzene (meaty)	5.93	19.43
Benzene, 1, 2-dimethyl	6.64	2.15
C3-Benzene	10.20	2.68
D-xylose	11.56	1.64
Total		*25.90*
Aliphatic aldehydes		
2-propanal, 3-(dimethyl amino)	12.95	2.44
Tridecanal	36.61	11.80
Dodecanal	41.60	4.06
Total		*18.30*
Alcohols and phenolic compounds		
2-Hexanal-trans (green)	8.72	2.24
Beta Sedoheptitol	10.78	6.62
2- (Propyl amino) ethanol	13.41	1.44
Phenol, 2, 6-bis (1,1-dimethyl ethyl)	28.17	3.35
Total		*13.65*
Acids		
Cyclopropanetetradecanoic acid, 2	11.29	6.02
Benzoic acid, 2-hydroxy-phenyl	34.71	1.21
11-Hexadecenoic	41.00	1.27
Total		*8.50*
Acyclic aliphatic ketones		
S-indecene-1,7-dione, 2,3,5,6-tetra	3.27	2.03
Ethanone, 1-phenyl-aceto	9.02	2.07
Total		*4.10*
Cyclic alihatic ketoens		
2,5-cyclohexadiene-1,4-dione	26.78	1.36
Amines and amides		
1-Butanamine, N-(1-methyl propyl-N)	5.53	1.26
Cyclopropanamine, 2-phenyl, trans	5.64	3.21
Total		*4.47*
Esters		
Butanoic acid, octyl ester	9.57	1.19
Pyrones		
2-H-pyran, letrahydro-2-methoxy	11.81	1.39
Sulfur compounds		
3, 5-dimethyl 2-thio-benzo	28.20	4.28
Furans		
4-aminobenzofurazone	21.28	1.27
Indoles		
5, 6-indolediol	37.93	1.18
Lactones		
d-lyxo-d-manno-nononic, 1,4-lactone	11.36	3.92
Pyrazines		
2,5-dimethyl-3,6-dipropionyl pyrazin	26.96	1.59
Oxygen compounds		
Lauroyl peroxide	30.56	1.48
31		*100.01*

Table (3): Aromatic compounds (%) in cooked fresh *Longissimus dorsi* muscle meat of Friesian calves fed ration supplemented with moreyeast (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
Oxirane, decyl-dodecane, 1,2-e	41.01	2.38
Cyclic aliphatic hydrocarbons		
Cyclohexane, 1-(2,2-dimethyl propyl)	26.96	2.14
2,2,3-trimethyl-6-oxa-1-Azabicyclo	38.44	1.98
8-Azabicyclo (5.1.0) octane	41.64	15.22
Total		***19.34***
Aromatic hydrocarbons		
Ethyl benzene (meaty)	5.91	10.46
Aliphatic aldehydes		
Tridecanaldehyde	36.67	32.12
Undecanal	39.14	1.70
Total		***33.82***
Alcohols and phenolic compounds		
6-methyl-2,4-di-tert-butyl-phenol	28.19	7.80
Acids		
1,2-Benzenedicarboxylic acid dibutyl	37.95	2.60
1,2-Benzenedicarboxylic acid dioc	43.05	3.10
1,2-Benzenedicarboxylic acid bis	43.21	11.94
Total		***17.64***
Acyclic aliphatic ketones		
Methanone	34.71	3.42
Esters		
Benzyl benzoate	6.35	2.89
Sulfur compounds		
2-acetamido-1-thio-4-chromone	26.80	2.23
14		***99.98***

Table (4): Aromatic compounds (%) in cooked fresh *Longissimus dorsi* muscle meat of Friesian calves fed ration supplemented with pronifer (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
Dimethyl cetazine	5.61	1.24
3-hexene, 3,4-dimethyl	5.83	0.79
M-xylene (fruity)	6.96	5.97
Propylene trimer	7.08	0.57
O-xylene	7.27	2.14
Nonane (meaty, fatty)	7.64	2.59
(E) 2-Nonane	8.37	0.86
Octane, 2,6-dimethyl	8.51	0.72
Nonane, 2-methyl	9.50	1.26
Decane (sweet-fragrant)	10.78	1.21
Octan, 1-propoxy-propyl	11.79	1.97
Total		***19.32***
Cyclic aliphatic hydrocarbons		
Cyclohexane, 1,1-dimethyl	3.25	0.92
Cyclohexane, 1-methoxy	4.44	0.63
Cyclohexane, 1,1,3-trimethyl	5.87	0.91
Cyclohexane	5.92	1.51
Cyclohexane, 1-ethyl-4-methyl, trnas	7.20	2.39
Cyclohexane, 1-ethyl-3-methyl, cis	7.21	1.44
Cyclohexane, methyl	7.83	0.73
Total		***8.53***
Aromatic hydrocarbons		
Ethylbenzene (meaty)	6.47	2.58
Benzene, 1, 3-dimethyl	6.51	0.56
Benzene, 1,4-dimethyl	7.39	3.51
Ethyl benzene (meaty)	7.44	2.72
Benzene, (1-methyl ethyl)	8.22	1.69
Propylbenzene (woody)	9.15	2.12
Benzene, 1, 3, 5-trimethyl	9.45	2.09
Total		***15.27***
Aliphatic aldehydes		
Hexanal (grassy)	3.36	0.60
Propanal-N-methyl-N-	5.23	1.24
formylhydrazan 2-Heptanal (fatty)	5.43	0.77
Total		***2.61***
Aromatic aldehydes		
Acetaldehyde	4.65	1.01
Benzaldehyde (nutty-almonds)	6.65	0.92
Benzaldehyde phenylmethan (nutty)	7.32	3.45
Dichloroacetaldehyde	8.72	0.70
Total		***6.08***

Cont. : Table 4.

Aromatic compounds	Retention time (min.)	%
Alcohols and phenolic compounds		
Piperidinol, 3-hydroxypi	3.68	1.36
2-cyclohepten-1-o1	4.68	1.03
1-methyl cycloheptanol	5.36	0.67
Heptadecanol	5.50	1.52
5-(Ethylcyclopent-1-enyl) methanol	6.09	0.64
1-Undecanol	6.29	1.85
Cyclododecanol	8.02	0.98
Ethanol, 2-[(1-methyl ethyl) amino]	9.92	0.83
1,2,3,4-Butanetetrol	11.25	0.65
Phenol, 2, 6-bis (1,1-dimethyl ethyl)	28.19	0.51
Octadecanol	36.63	0.61
Total		*10.65*
Acids		
Cyclopropan tetradecanoic acid	11.58	1.60
1,2-Benzendicarboxylic acid dioc	42.00	0.64
Total		*2.24*
Acyclic aliphatic ketones		
3-Ethyl pentane, 2-one	5.13	0.98
3-Octen-2-one, (E) trans (caramel)	5.96	2.13
2 (1H)-pyrimidinone	6.18	2.90
4-Octanone	7.69	1.37
4-Octen-3-one (Caramel)	7.78	1.08
2-Hepten-4-one-2-methyl	8.08	0.84
Total		*9.30*
Cyclic aliphatic ketones		
Cyclohexanone. 2,3-dimethyl	8.36	1.18
Amines and amides		
3-(dimethyl amino)-2,2, dimethyl	4.96	4.23
cyclohexanamine. N-methyl	8.48	0.90
Total		*5.13*
Pyridines		
Pyridinium, 3-mercapto-1-methyl	7.13	1.22
Pyridine. 2-ethenyl-2-Vi	10.54	1.92
Total		*3.14*
Pyrones		
2-Ethyl-5.6-dihydro-2H-pyran	5.72	0.59
Pyrrols		
1H-pyrrole-2-acetonitrile. 1-methyl	9.70	1.84
Sulfur compounds		
Thiophene. 2. 4-dimethyl	5.67	0.79
9-thianoradamantane	6.04	0.96
Dihexylsulfide	7.59	4.73
1-Ethoxy-1-(ethylthio) ethane	11.10	1.37
Total		*7.85*
Pyrazines		
Piperazine-2-methyl	3.34	2.83
Unidentified compounds		
-	4.12	2.40
-	11.2	1.05
63		*100.1*

Table (5): Total numbers and percentage of aromatic compounds in cooked fresh *Longissimus dorsi* muscle meat of Friesian calves fed ration supplemented with different growth promoters..

Aromatic compounds	Growth promoters							
	Control		Fibrozyme		Moreyeast		Pronifer	
	Total	%	Total	%	Total	%	Total	%
Acyclic aliphatic hydrocarbons	7	16.53	3	5.84	1	2.38	11	19.32
Cyclic aliphatic hydrocarbons	7	22.37	1	1..63	3	19.34	7	8.53
Aromatic hydrocarbons	5	20.57	4	25.90	1	10.46	7	15.27
Aliphatic aldehydes	4	6.23	3	18.30	2	33.82	3	2.61
Aromatic aldehydes	2	7.02	0	0	0	0	4	6.08
Alcohols and phenolic compounds	5	10.80	4	13.65	1	7.80	11	10.65
Acids	0	0	3	8.50	3	17.04	2	2.24
Acyclic aliphatic ketones	1	4.26	2	4.10	1	3.42	6	9.30
Cyclic aliphatic ketones	0	0	1	1.36	0	0	1	1.18
Amines and amides	2	2.50	2	4.47	0	0	2	5.13
Esters	0	0	1	1.19	1	2.89	0	0
Pyridines	1	4.02	0	0	0	0	2	3.14
Pyrones	0	0	1	1.35	0	0	1	0.59
Pyrrols	0	0	0	0	0	0	1	1.84
Sulfur compounds	0	0	1	4.28	1	2.23	4	7.85
Furans	1	1.36	1	1.27	0	0	0	0
Furanones	0	0	0	0	0	0	0	0
Indoles	0	0	1	1.18	0	0	0	0
Ethers	1	2.58	0	0	0	0	0	0
Lactones	1	1.76	1	3.92	0	0	0	0
Pyrazines	0	0	1	1.59	0	0	1	2.83
Oxygen compounds	0	0	1	1.48	0	0	0	0
Unidentified compounds	0	0	0	0	0	0	2	3.45
Total	37.00	100.00	31.00	100.01	14	99.98	63	100.01

It is known that raw meat has very little aroma and it is generally agreed that desirable meat flavour developed during cooking (**Macleod and Seyyedian, 1981**). This was confirmed by **Owon (1991)** on lamb meat, who reported that the raw lamb meat contained a poor flavour, whereas desirable meaty flavour appeared only after cooking and fats contribute extensively to the flavour of the meat. Also, **Insausti *et al.* (2005)** reported that intramuscular fat influence texture, juiciness and flavour. The presence of small amounts of intramuscular fat heightens the juiciness and flavour of cooked meat. The degree of marbling of the muscle is significantly related to flavour intensity and meat with a describe flavour tends to have higher levels of intramuscular fat.

The results given in Tables (1, 2, 3, 4 and 5) revealed that the hydrocarbons, aldehydes, alcohols, acids, ketones and sulfur compounds which play an imported role in the flavour of cooked meat whereas formed 87.78, 83.56, 97.09 and 83.03% of aromatic compounds of cooked fresh calves' meat fed on control ration and supplemented groups with fibrozyme, moreyeast and pronifer, respectively.

The aromatic compounds are formed mainly in cooked meat during thermal degradation of lipid and the Maillard reaction (**Mottram, 1994 and 1998**). Heat induced oxidation of fatty acids, particularly unsaturated fatty acids, produces degradation products, such as aliphatic aldehydes, ketones and alcohols which may have intrinsic flavour. These degradation products may react further with Maillard products to give other compounds that may contribute to flavour (**Elmore *et al.*, 1997**). They indicated also, that intermediate products such as α-dicarbonyl compounds or α-amino ketones capable of further reaction form important meat flavour compounds such as pyrazines, oxazoles, thiophenes, thiazoles and other heterocyclic sulfur compounds.

Min *et al.* (1979) reported that volatile compounds play an important role in the overall flavour of meat, even though none is individually responsible for meat odour.

Elmore *et al.* (1999) indicated that aldehydes may contribute to the flavour of the cooked beef samples. Also, amounts of aliphatic alcohols reflected the levels of unsaturated fatty acids in the cooked beef. The polyunsaturated fatty acids induce the thermal degradation of oleic and linoleic acids. This is suggested by the higher levels of aldehydes, derived from these fatty acids. The relative levels of linoleic and α-linolenic aids in grain and forage are largely responsible for the differences in volatile composition, and hence the flavour of beef finished on these diets.

Lactones are another class of lipid components formed by heating, which contribute to meat flavour. Lactones can be formed by conversion of low molecular weight saturated fatty acids, aldehydes and alcohols during heating of meat fat (**Owon, 1991**). Lactones were identified and isolated only from meat samples of control and fibrozyme treatments (one component of both treatments).

It is known that heterocyclic compounds containing nitrogen, sulfur and/or oxygen atom in their structure, such as pyrazines, thiozoles, and oxazoles contribute to meat flavours (**Shibamoto, 1980**).

The obtained data showed that meat flavour could be characterized by odour impressions of some aromatic components like meaty, fatty, nutty,

rancid, green, buttery, caramel, fruity, alcohol-like, sweet, fragrant and grassy **(Owon, 1991)**.

Aromatic compounds in cooked frozen meat :

The aromatic compounds present in cooked frozen *Longissimus dorsi* muscle meat as affected by frozen storage time at -20°C for 6 months and by some different growth promoters supplemented with the experimental ration of Friesian calves were identified qualitatively and were tabulated in Tables (6, 7, 8, 9 and 10).

The total number of aromatic compounds in cooked frozen meat of calves fed on control ration and supplemented groups with growth promoters were decreased as storage time increased in the case of control and pronifer treatments, while no changes were found in fibrozyme and moreyeast treatments.

Table (6): Aromatic compounds (%) in cooked frozen *Longissimus dorsi* muscle meat (at -20°C for six months) of Friesian fed ration (control) (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Aromatic hydrocarbons		
Ethylbenzene (meaty)	5.87	5.71
Aliphatic aldehydes		
Undecanal	36.63	25.32
Hexadecanal	41.63	12.06
Total		***37.38***
Alcohols and phenolic compounds		
6-methyl, 2,4-di-tert-butyl-phenol	28.20	11.76
Tetradecanol	39.14	1.31
Total		***13.07***
Acids		
1, 2 benzene dicarboxylic acid dioc	37.84	1.31
1, 2 benzene dicarboxylic acid mono	38.36	10.57
1, 2 benzene dicarboxylic acid bis	38.40	4.38
1, 2 benzene dicarboxylic acid diss	38.43	3.49
1, 2 benzene dicarboxylic acid diss	38.45	6.64
1, 2 benzene dicarboxylic acid bis	38.52	6.59
1, 2 benzene dicarboxylic acid 3-ni	38.56	11.27
Total		***42.25***
Lactones		
Muskolactone		-
11		***100.00***

Table (7) :Aromatic compounds (%) in cooked frozen *Longissimus dorsi* muscle meat (at -20°C for six months) of Friesian calves fed ration supplemented with fibrozyme (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
Propane, 1-chloro-2,2-difluro	3.54	5.16
2-Pentene, 3,4,3-trimethyl	3.91	3.06
5,6-Dideuterio-8-trans-methylhydri	4.18	2.38
1-Hexene, 2,4-dimethyl	5.17	4.11
Nonane (meaty, fatty)	7.08	1.22
Total		*15.43*
Cyclic aliphatic hydrocarbons		
Cis-1-Butyl-2-methyl cyclopropane	3.17	3.54
Cyclopentane, 1, 2, 3-trimethyl	3.28	1.83
Cyclohexane, 1,4-dimethyl, cis	3.97	6.49
4-methyl-2-hydroxyclopent-2-en	4.03	3.61
Cyclooctane	4.33	4.25
1,3-cyclopentadiene	6.26	9.61
Total		*29.33*
Aromatic hydrocarbons		
Benzene, 1,2-dimethyl	5.90	2.74
Ethyl benzene (meaty)	6 85	1.66
Total		*4.40*
Aliphatic aldehydes		
2-Heptanal (Z and E) (fatty)	4.10	2.25
Butanol, dimethyl hydrazone	4.50	2.00
Total		*4.25*
Aromatic aldehydes		
Benzaldehyde (nutty-almonds)	3.62	1.58
Alcohols and phenolic compounds		
1-Decanol	3.27	1.76
Phenol, 2-fluoro	3.60	1.18
Tridecanol	4.28	2.40
1-Octanol, 2,7-dimethyl	4.98	1.55
3,5-Dimethyl-2-Octanol	5.69	0.50
Total		*7.39*
Acyclic aliphatic ketones		
S-Indacene-1,7-dione-2, 3, 5, 6, tetra	3.44	6.01
(+)-(S)-5-ethyl-octane-4-one	4.43	4.64
Heptanone, 5-methyl	4.80	0.66
Total		*11.31*
Amines and amides		
Benzenamine, N-hydroxy	3.57	2.53
Esters		
3-methyl-azapine-methyl ester	3.68	3.76
Pyridines		
4(1H) pyridinone, 2,3-dihydro-1-me	5.23	2.10
Pyrones		
2H pyran-2-one, tetrahydro-4 methyl	4.52	1.02
Sulfur compounds		
Thiophene, 3-ethyl	4.55	1.26
Ethers		
Methyl 1-ethyl-2 (E)-butenyl ether	3.84	1.03
Pyrazines		
Pyrazine, ethenyl 2-vinyl	6.05	0.48
Unidentified compounds		
-	3.78	13.65
32		*100.02*

Table (8) : Aromatic compounds (%) in cooked frozen *Longissimus dorsi* muscle meat (at -20°C for six months) of Friesian calves fed ration supplemented with moreyeast (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
2-N-Butyl-3-N-hexyldecahydronaphth	41.02	2.13
Aromatic hydrocarbons		
Ethylbenzene (meaty)	5.88	3.55
Aliphatic aldehydes		
Tridecanal	33.90	1.25
Nonanal	35.60	0.89
Tetradecanal	36.48	1.79
Tridecanal	36.75	40.23
Dodecanal	39.17	2.18
Octadecanal (fatty)	41.70	19.36
Total		*65.70*
Alcohols and phenoic compounds		
Phenol, 2, 6-bis (1,1-dimethyl ethyl)	28.24	16.17
1-tetradecanal	36.52	1.18
Total		*17.35*
Acids		
1,2-Benzenedicarboxylic acid, 3-ni	38.40	0.91
1,2-Benzenedicarboxylic acid, bis	38.44	2.97
1,2-Benzenedicarboxylic acid, dioc	38.58	3.94
1,2-Benzenedicarboxylic acid, dibu	40.27	1.14
Total		*8.96*
Esters		
Diisooctylphthalate	*38.23*	*2.30*
15		*99.99*

Table (9) : Aromatic compounds (%) in cooked frozen *Longissimus dorsi* muscle meat (at -20°C for six months) of Friesian calves fed ration supplemented with pronifer (% of total aromatic compounds).

Aromatic compounds	Retention time (min.)	%
Acyclic aliphatic hydrocarbons		
Azocine, octahydro	4.24	2.96
Hexane, 2, 4-dimethyl	4.91	1.23
Hexane, 3,methyl ethyl	4.96	10.50
1-Heptenen, 6-methyl	5.14	1.57
Nonane (meaty, fatty)	7.47	8.49
Total		*24.75*
Cyclic aliphatic hydrocarbons		
Cyclohexane, 1,1-dimethyl	4.54	1.48
Cyclohexane, 1, 2-dimethyl, cis	5.37	3.69
Cyclohexane, 1,1,2-trimethyl	5.68	1.64
Cyclohexane, 1,3,5-trimethyl	5.97	1.89
Cis-1-ethyl-3-methyl-cyclohexane	7.01	1.43
Total		*10.13*
Aromatic hydrocarbons		
Ethyl benzne (meaty)	6.16	5.68
Benzene 1, 4-dimethyl	6.72	5.73
Benzene, 1, 3-dimethyl	7.22	7.83
Benzene, propyl (woody)	9.03	1.30
Benzene, 1,2,3-trimethyl	9.32	2.03
1,2,4-trimethyl benzene (meaty)	10.42	1.39
Total		*23.96*
Aliphatic aldehydes		
2-Heptanal (Z), cis (fatty)	4.56	1.48
Aromatic aldehydes		
Benzaldehyde (nutty)	6.57	2.19
Alcohols and phenolic compounds		
1-Decanol	3.61	1.31
Phenol, 2,6-bis (1,1-dimethyl ethyl)	28.22	1.63
Cycloheptanol, 3(3.3-dimethylbutyl)	36.69	3.40
12-Nonadecyn-1-ol, cis	41.65	1.20
Total		*7.54*
Acyclic aliphatic ketones		
Hexen-2-one, 5-methyl	4.44	1.60
Cyclic aliphatic ketones		
1, 2-cyclohexanedione	5.71	3.54
Bicyclo (6.1.0) nona-5,8-dien-4-one	6.45	2.66
Total		*6.20*
Amines and amides		
1, 3-propanediamine	3.35	3.53
3-(dimethyl amino)-2,2-dimethyl	4.29	1.40
2-butyl- (2-methyl butylidene)-amine	8.24	1.49
Total		*6.42*
Sulfur compounds		
Diisooctylsulfate	5.42	3.37
Thiophenen, 2,4-dimethyl	5.63	2.90
Total		*6.27*
Furanones		
2 (5H)-Furanone	4.49	1.24
Ethers		
Benzyl 4-methyl benzyl ether	6.33	4.72
Unidentified compounds		
-	4.03	3.49
33		*99.99*

Table (10) : Total numbers and percentage of aromatic compounds in cooked frozen *Longissimus dorsi* muscle meat (at -20°C for six months) of Friesian calves fed ration supplemented with different growth promoters.

Aromatic compounds	Growth promoters							
	Control		Fibrozyme		Moreyeast		Pronifer	
	Total	%	Total	%	Total	%	Total	%
Acyclic aliphatic hydrocarbons	0	0	5	15.93	1	2.13	5	24.75
Cyclic aliphatic hydrocarbons	0	0	6	29.35	0	0	5	10.13
Aromatic hydrocarbons	1	5.71	2	4.40	1	3.55	6	23.96
Aliphatic aldehydes	2	37.38	2	4.25	6	65.70	1	1.48
Aromatic aldehydes	0	0	1	1.58	0	0	1	2.19
Alcohols and phenolic compounds	2	13.07	5	7.39	2	17.35	4	7.54
Acids	5	42.25	0	0	4	8.96	0	0
Acyclic aliphatic ketones	0	0	3	11.31	0	0	1	1.60
Cyclic aliphatic ketones	0	0	0	0	0	0	2	6.20
Amines and amides	0	0	1	2.53	0	0	3	6.42
Esters	0	0	1	3.76	1	2.30	0	0
Pyridines	0	0	1	2.10	0	0	0	0
Pyrones	0	0	1	1.02	0	0	0	0
Pyrrols	0	0	0	0	0	0	0	0
Sulfur compounds	0	0	1	1.26	0	0	2	6.27
Furans	0	0	0	0	0	0	0	0
Furanones	0	0	0	0	0	0	1	1.24
Indoles	0	0	0	0	0	0	0	0
Ethers	0	0	1	1.03	0	0	1	4.72
Lactones	1	1.59	0	0	0	0	0	0
Pyrazines	0	0	1	0.48	0	0	0	0
Oxygen compounds	0	0	0	0	0	0	0	0
Unidentified compounds	0	0	1	13.65	0	0	1	3.49
Total	11	10000	31	10002	15	9999	32	9999

Results revealed that ethylbenzene component (aromatic hydrocarbon) was found as a main aromatic component (meaty taste) in all cooked samples (post-mortem and after frozen storage) but its percentage was reduced after frozen storage except in pronifer treatment whereas slightly increased.

The results cleared that, after frozen storage, acids formed the highest portion of aromatic compounds in cooked frozen meat of control treatment (42.25%). The hydrocarbons in fibrozyme and pronifer treatments reached 49.66 and 58.84%, respectively, while aldehydes formed 65.70% of total aromatic compounds in moreyeast treatment.

Data in Table (10) showed that some of aromatic compounds disappeared during frozen storage such as aliphatic hydrocarbons (acyclic and cyclic), aromatic aldehydes, acyclic aliphatic ketones, cyclic aliphatic ketones, pyridines, furans and ethers in meat of control treatment. Also, acids, furans, indoles, lactones and oxygen compounds were disappeared in

meat of fibrozyme treatment. In meat of moreyeast treatment, cyclic aliphatic hydrocarbons, acyclic aliphatic ketones and sulfur compounds were disappeared; while in meat of pronifer treatment acids, pyridines, pyrones and pyrrols were disappeared.

On the other hand some of aromatic compounds were detected in different treated samples during frozen storage such as acids in control treatment. Aromatic aldehydes, pyridines and ethers in meat of fibrozyme treatment, while furanones and ethers were detected in frozen meat of pronifer treatment.

In general, after frozen storage of meat most of aromatic components disappeared, while some were detected and some decreased and the others increased as shown in Tables (5 and 10).

The presence of these components and their absence as a result of thermal oxidative decomposition of present lipids, carbohydrates and/or proteins, degradation of carotenoids and decomposition of steroids (**Owon, 1991**). The acids present in frozen cooked meat aroma of control treatment formed 42.25% of total aromatic compounds such as 1, 2-benzene dicarboxylic acid. These acids lead to undesirable odours (**Owon, 1991**).

Organoleptic qualities:

Organoleptic qualities of fresh meat of Friesian calves fed the experimental ration supplemented with some growth promoters are summarized in Table (11).

Panel scores of tenderness showed some differences due to growth promoters. Moreyeast supplementation scored the highest value of tenderness, followed by pronifer supplementation, while fibrozyme supplementation scores were nearly similar to control.

Juiciness and flavour differences between treatments and control were in the same trend as tenderness.

Table (11) : Organoleptic qualities of fresh *Longisimus dorsi* muscle meat of Friesian calves fed ration supplemented with different growth promoters.

Properties	Growth promoters				MSE
	Control	Fibrozyme	Moreyeast	Pronifer	
Tenderness	3.47	3.39	3.81	3.63	0.02
Juiciness	3.40	3.28	3.64	3.48	0.02
Flavour	3.78	3.73	4.04	3.98	0.02

MSE: Means of standard error

The differences in tenderness observed by panalists may have been more due to some factors other than shear as measured instrumentally such as softness and adhesion between fibers (**Dawood and Mash'hadi, 1993**).

The initial results showed that meat of moreyeast group had the lowest cooking loss and it was the most accepted (more tender, juicy and had good flavour).

It could be noticed that juiciness were related to the retained moisture and fat in cooked meat as mentioned by (**Dawood and Mash'hadi, 1993**). Intramuscular fat content was considered the main reason for increasing the flavour intensity and juiciness as reported by **Maltin *et al.* (1998)**.

On the other hand, **Owens and Gardner (1999)** mentioned that the age affects on meat flavour through increasing carcass fatness, which was positively associated with flavour desirability. They mentioned also that juiciness was negatively related to moisture and positively related to fat content.

REFERENCES

Campo, M.M.; Nute, G.R.; Wood, J.D.; Elmore, S.J.; Mottram, D.S. and Enser, M. (2003). Modeling the effect of fatty acids in odour development of cooked meat *in vitro*: Part 1-sensory perception. Meat Science, 63, 367-375.V

Chambaz, A.; Scheeder, M.R.L.; Kreuzer, M. and Dufey, P.A. (2003). Meat quality of Angus, Simmental, Charolais and Limousin steers compared at the same intramuscular fat content. Meat Science, 63, 491-500.

Dawood, A.A. and El-Mash'Hadi, A.S. (1993). Effect of breed on properties of lamb carcasses and meat quality. Egypt. J. Appl. Sci., 8(9): 475-490.

Elmore, J.S.; Mottram, D.S.; Enser, M. and Wood, J.D. (1997). Novel thiazoles and thiazolines in cooked beef aroma. J. Agric. and Fd. Chem., 45, 3603-3607.

Elmore, J.S.; Mottram, D.S.; Enser, M. and Wood, J.D. (1999). Effect of polyunsaturated fatty acid composition of beef muscle on the profile of aroma volatiles. J. Agric. and Fd. Chem., 47(4): 1619-1625.

Insausti, K.; Goni, V.; Petri, E.; Gorraiz, C. and Beriain, M.J. (2005). Effect of weight at slaughter on the volatile compounds of cooked beef from Spanish cattle breeds. Meat Science, 70: 83-90.

Love, J. (1994). Product acceptability evaluation. In A.M. Pearson and T.R. Dutson (Eds.). Quality attributes and their measurement in meat poultry and fish products (pp. 337-358). Glasgow: Blackie Academic and Professional.

MacLeod, G. and Seyyedain, M. (1981). Fd Sci. and Nutri., 14: 309 (C.F. Acc Symposium Series, 409, American Chem. Soc. Washington, 1988).

Maltin, C.A.; Sinclair, K.D.; Warriss, P.D.; Grant, C.M.; Porter, A.D.; Delday, M.I. and Warkup, C.C. (1998). The effect of age at slaughter; genotype and finishing system on the biochemical properties, muscle fibre type characteristics and eating quality of bull beef from suckled calves. Animal Science, 66, 341-348.

Min, D.B.S.; Ina, K.; Peterson, R.J. and Chang, S.S. (1979). Preliminary identification of volatile flavour compounds in the neutral fraction of roast beaf. J. Fd. Sci., 44: 639-642.

Moloney, A.P.; Mooney, M.T.; Kerry, J.P. and Troy, D.J. (2001). Producing tender and flavour some beef with enhanced nutritional characteristics. Proc. Nutr. Soc., 60(2): 221-229.

Mottram, D.S. (1991). Meat. In Volatile Compounds in Foods and Beverages. ed. H. Maarse. Marcel Dekker, New York, pp. 107-177.

Mottram, D.S. (1994). Some aspects of the chemistry of meat flavour. In: The Flavour of Meat and Meat Products; Shahidi, F., Ed., Blackie: Glasgow, pp. 210-230.

Mottram, D.S. (1996). The role of phospholipids in meat flavour: an overview. In contribution of low and Non-Volatile Materials to the Flavour of Foods. Pickenhagen, W.; Ho, C-T.; Spanier, A.M., Eds.; Allured Publishing: Carol Stream, IL., pp. 193-206.

Mottram, D.S. (1998). Flavour formation in meat and meat products: a review. Fd. Chem., 62: 415-424.

Nakamura, K.; Iida, H.; Tokunaga, I. and Miwa, K. (1978). Separation and identification of odor in oxidized sardine oil. Bull. Takai Reg. Fish Res. Lab., 93: 95.

National Research Council (NRC) (1996). Diet and health: implication for reducing chronic disease risk. Report of the committee on diet and health. Food and Nutrition board. National Academy Press, Washington DC.

Owens, F.N. and Gardner, B.A. (1999). Ruminant nutrition and meat quality. Proceedings of the Annual Reciprocal Meat Conference, 52: 25-36.

Owon, M.A.M. (1991). Studies on plant and animal oils and fats and their spoilage. Ph.D. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta University.

Shibamoto, T. (1980). Volatile flavour chemicals formed by the Maillard reaction. J. Agric. Food Chem. 28:237.

الملخص العربى

تأثير إضافة بعض محفزات النمو الى علائق عجول الفريزيان على جودة وخواص الطبخ للحم

٣- مركبات النكهة وخواص الطبخ للحم العضلة الطولية الظهرية الطازج والمجمد.

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تم دراسة تأثير إضافة بعض محفزات النمو (فيبروزيم، موربيست، برونيفير) المستخدمة تجاريـا كإضافات غذائية لتحسين خواص وجودة اللحم الى علائق عجول الفريزيان عمر ٣٥٠ يـوم لمدة ١٨٠ يوم على تكوين مركبات النكهة وخواص الطبخ للحم العضلة الطولية الظهرية الطازج والمجمد على درجة –٢٠°م لمدة ٦ شهور حيث أوضحت النتائج ما يلى :

- مـركبات الـنكهة المـتكونة فـى اللحم المطبوخ الطازج لمعاملات الكنترول والفيبروزيم والموربيـست والبرونيفيـر كانت ٣٧، ٣١، ١٤، ٦٣ مركب على الترتيب حيث كان محفز النمو البرونيفير أكثر تأثيراً فى تكوين مركبات النكهة مقارنة بمحفزات النمو الأخرى.
- كانـت أعلـى نـسبة من مركبات النكهة هى الهيدروكربونات (٣٢,١٨: ٥٩,٤٧%) يليها الألدهـيدات (٨,٦٩ : ٣٣,٨٢%) ثم الكحولات والمركبات الفينولية (٧,٨٠ : ١٣,٦٥%)، الكيـتونات (٣,٤٢ : ١٠,٤٨%) بيـنما هناك مركبات نكهة نسبتها منخفضة أو أختفت مثل الأحمـاض، المـركبات الكبـريتية، الأمـينات، الأمـيدات، الأسترات، اللاكتون، الفيوران والإثيـرات وغيـرها فى جميع العينات. أما مركب الأثيايل بنزين وهو من الهيدركربونات الطـيارة تـواجد بصورة أساسية فى جميع عينات اللحم المطبوخ الطازج والمجمد كمكون رئيسى لنكهة اللحوم.
- تناقـصت عـدد مـركبات الـنكهة الطيارة فى اللحم المجمد المطبوخ لمعاملات الكنترول والفيبـروزيم والموربيست والبرونيفير بزيادة مدة التخزين بالتجميد حيث كان عددها ١١، ٣١، ١٥، ٣٢ علـى الترتيب وقد أختفت كثير من المركبات أثناء التجميد مثل البيرولات ، الفـيوران، الأنـدولات، المـركبات الأكسجينة فى كل العينات بينما ظهر مركب واحد من الفيورانونات فى معاملة البرونيفير.
- بعـد التخـزين بالتجميد كونت الأحماض أعلى نسبة من المركبات الطيارة فى لحم معاملة الكنترول ٤٢,٢٥% وكونت الهيدركربونات فى لحم معاملة الفبروزيم والبرونيفير ٤٩,٦٦% و ٥٨,٨٤% على الترتيب بينما كونت الألدهيدات ٦٥,٧٠% من كمية المركبات الطيارة فى لحم معاملة الموربيست.
- وعمـوما فإن تأثير إضافة بعض محفزات النمو على تكوين مركبات النكهة أدى الى إختفاء معظمهـا أو حـدوث زيادة أو نقص لبعض هذه المركبات فى اللحم المعامل خلال التخزين بالتجميد.
- أظهـرت بعـض الإختبارات الحسية بعض الإختلافات التى ترجع الى محفزات النمو حيث سجلت معاملة الموربيست أعلى نقاط فى الطراوة والعصيرية والنكهة يليها معاملة البرونيفير بينما معاملة الفيبروزيم كانت مشابهة تقريبا للكنترول.