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Development of canned meat production technique and its quality assessment

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ABSTRACT

This study was undertaken to produce canned meat following an effective and cost-effective technique for having safe and hygienic ready product to cook along with the determination of its preservation quality. Raw boneless meat (beef, chevon and broiler chicken) collected from local market were subjected to three treatments (addition of two different preservatives and no preservative) with three replications of each. Beef, chevon and chicken were considered meat type and Na-Nitrite (150g/kg) and Nacl (5g/kg) were the used preservatives. Fresh meat quality was compared in ANOVA of CRD and canned meat were in 3*3 factorial design using GLM of SPSS 17.0. Meat was canned using pressure canner at 240° F and 10 lb pressure for 90 minutes. No change in color, texture and flavor was found in canned meat up to 30 days of storage period. Both pH and protein level were influenced by canning where increasing trend was observed compared to fresh meat. In case of pH, chicken meat treated with Na-Nitrite had higher pH ($p<.001$) irrespective of meat and preservative type. In result, a scientific meat canning technique was developed through this study and considering the physico-chemical aspects Na-Nitrite could be a suitable preservative for meat canning.

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Introduction

In Bangladesh today's livestock sector is very promising. About 69% of total supplied meat in Bangladesh is being used for producing processed products and remaining 31% goes for household consumption and consumers prefer beef most in processed form than chicken (Kaiser et al., 2017). Propelled by increased income, urbanization and increasing amount of people cumulatively enforces the demand of diversified feature and quality attribute of this product. Meat is one of the necessary foods for humans, as it is considered as promising protein source in addition to fats and salts, meat is considered the best medium for the growth of various microorganisms which causing health and economic problems caused by toxins secreted by these microorganisms (Faustman and Cassens, 1990; Heinz and Hautzinger, 2007). Besides, it is much more important for physical and mental development of human (Hossain and Hassan, 2013). Food safety is a major concern across the world and in recent years, the growing need for food safety has prompted study into the risks associated with consuming contaminated (by pesticides, heavy metals, and toxins) foods (Al-Azzawi and Al-Ani, 2014). As a result of these

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factors, it has become necessary to preserve the nutritional value and freshness of meat and meat products (Pressman et al., 2017). In the past, the first method of preserving meat was spontaneous fermentation. In addition to the fermentation method, salt has been widely used in food preservation in general and meat in particular, and salt is still one of the most common methods of food preservation where it helps to reduce the growth of microorganisms by providing environment that is not suitable for the growth of these microorganisms and reducing their water activity (Rahman, 2007). Nitrites and nitrates are known to be multifunctional food additives and powerful antioxidants as they are used in many foods and in the treatment of meat as preservatives (Long et al., 2014). Together with nitrides and nitrates, phosphates are used in meat products for a variety of purposes such as improving texture, pH stabilization and modifications, organoleptic properties (color, flavor, tenderness and juiciness) and extending shelf life (WHO, 2000).

Now people irrespective of gender are working outside of home and they have no time for cooking like our traditional system and most of them are dependent on processed food. But it is a matter of great regret that we have a very few numbers of branded beef processed product item which are available only in capital or big cities and no processing system of raw meat has yet been developed. So, development of meat value addition technique at industrial level has huge opportunity which will satisfy consumers demand and contribute to national economy. This will also satisfy the globally emphasized food safety issue too. Because in our country context maximum animals are slaughtered in non-scientific and unhygienic way which ultimately deteriorate the product quality. As a result, consumers suffer from several food borne illness. All the unethical practices during slaughtering and carcass processing is responsible for meat adulteration which can adversely affect peoples' liver, kidney, muscle and other parts of the body (Ahmed, 2018). So, it is perfect time to diversify the traditional production system and introduce value addition system of products and by-products. Several options like deboning, size reduction, seasoning, tenderization, smoking, battering, canning, marinating etc. are globally accepted to add value to meat of which meat canning technique is getting popularity day by day. Canning is an international popular food preservation technique which involves processing and sealing of food products in air tight container which improves the shelf life, preservation quality and saves the cooking time of consumers. Considering this point, the present study was designed to develop a globally accepted scientific raw meat processing technique to add value of it.

Materials and Methods

Place of study

The present research work was conducted in Meat Processing Laboratory of Bangladesh Livestock Research Institute, Savar, Dhaka, 1341 at 2018-2019 fiscal year.

Sample collection and preparation: Fresh boneless beef, chevon and live chicken (broiler) l were purchased from local market immediate after slaughter and brought at meat processing laboratory of BLRI. For the preparation and production of canned meat, raw meat was sliced with a knife (German, Stainless steel, 11290-170, 6.5˝) for filling the canning jar. Glass jar (Imported, Product dimension: Height-115mm, Diameter-85mm, Volume- 500ml, Length-85mm; Made in China) was used in this study.

pH: The pH of both beef and chevon was recorded at about 6 h postmortem (fresh meat). However, the chicken meat pH was recorded immediate after slaughtering. The pH of both fresh & canned meat was recorded with a digital pH meter ((Hanna; model no. HI2211-02) following the method of University of Nebraska-Lincoln: Fact Book 2005-2006.

Proximate composition: Both fresh and canned meat at 30 days aged samples were collected for proximate component analysis. However, the proximate composition of both fresh and canned meat was determined by the method described by AOAC, 2005.

Drip loss measurements: Drip loss of fresh beef, chevon and chicken were measured from a standardized muscle cylinder (weighing about 60 g) and it was suspended in an inflated plastic box (4° C) for 24 hours (30 h postmortem). The percentage of drip loss was measured as described by Joo et al., 2007.

Drip loss (%) = [(sample weight – sample weight after 24 h)/sample weight] × 100

Cooking loss measurements: Cooking losses of fresh beef, chevon and chicken were estimated 24 hours post mortem according to Yang et al., 2006 by the following formula:

Cooking loss (%) = [(A-B)/(A)] × 100

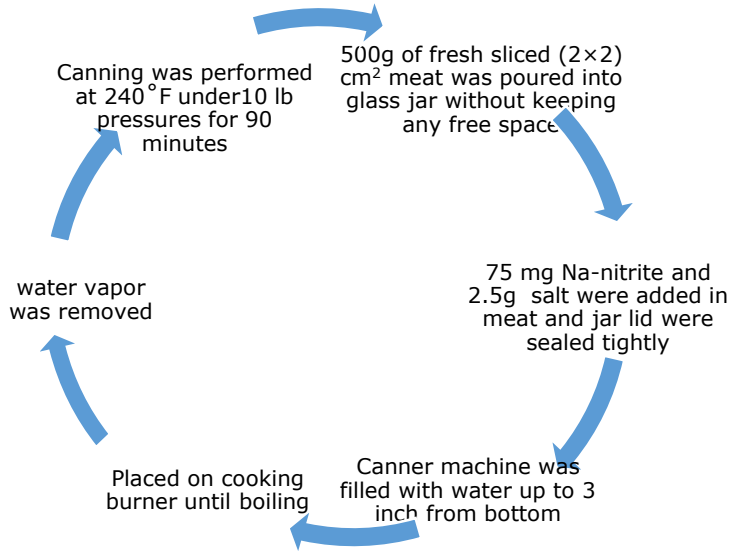
Microbiological test: The microbiological test viz, Total Viable Count (TVC), Total Coliform Count (TCC), Botulinum in canned meat (beef, chevon and chicken) were done at Food Safety Laboratory in BLRI.

Preparation of sample for microbial studies: Each of the canned meat samples (beef, chevon and chicken) were thoroughly and uniformly macerated in a mechanical blender using a sterile diluent (0.1% peptone water) as per recommendation of International Organization for Standardization. A quantity of 30g of the minced meat sample were taken aseptically transferred into a sterile container containing 90 ml of 0.1% peptone water. Homogenized suspensions were made in a sterile blender. Thus 1:10 dilution of the samples was obtained. Later using whirly mixture machine different serial dilutions ranging from 10-2 and 10-6 will be prepared according to the instruction of the standard method (ISO, 1995).

Enumeration of Total Viable Count (TVC): For the determination of TVC, 0.1 ml of each ten-fold dilution was transferred and spread on triplicate PCA using a sterile pipette for each dilution. The diluted samples were spread as quickly as possible on the surface of the plate with a sterile glass spreader. One sterile spreader was used for each plate. The plates were then kept in an incubator at 35°C for 24-48 hours. Following incubation, plates exhibiting 30-300 colonies were counted. Colonies were counted with the aid of a colony counter. The average number of colonies in a particular dilution was multiplied by the dilution factor to obtain the Total Viable Count. The TVC was calculated according to ISO, 1995.

Enumeration of Total Coliform Count (TCC): For the determination of TCC, 0.1 ml of each ten-fold dilution was transferred and spread on triplicate MA agar using a sterile pipette for each dilution. The diluted samples were spread as quickly as possible on the surface of the plate with a sterile glass spreader. The plates were kept in an incubator at 35°C for 24-48 hours. Following incubation, plates exhibiting 30-300 colonies were counted with the aid of a colony counter. The average numbers of colonies in a particular dilution were multiplied by the dilution factor to obtain the TCC. The TCC were calculated according to ISO, 1995.

Production of canned meat: Canned meat was produced by following Karen Fifield, 2016 with slight modification. The maximum residue limit (MRL) for sodium nitrite ($NaNO_2$) in meat products is generally 200 parts per million (ppm) or 200 mg/kg. Before starting the canning procedure meat of all the can and glass jar was sterilized properly at 120-121ºC for 60 minutes. Flowchart is given bellow:



After removing glass jars from pressure canner machine all the jars were checked properly for any leakage. Then the can/jars were cooled with water for 1 hr. Finally, the lids of all the jars were again sealed with shrink paper using an electric hot gun.

Final recovery rate calculation

After 30 days, the canned meat from the glass jar was poured into a sieve for 10-15 minutes to remove water completely. Then the extracted

water amount and meat wt. after water extraction was recorded for final recovery rate calculation.

Statistical analysis

Data on physical, chemical and recovery rate of both fresh raw meats were compared statistically in an ANOVA of a Completely Randomized Design and canned meat was in 3*3 factorial design using General Linier Model Procedures of SPSS 17.0.

Results and Discussion

Physical and Chemical Composition of Fresh Meat: The physical properties of fresh meat used for canning purpose under this research, is presented in Table 1. Results obtained from this study revealed that, both chicken meat and chevon had significantly ($p<0.001$) higher meat pH than that of beef. The respective pH value of chicken meat, chevon and beef were 6.00, 5.96 and 5.45. Meat quality depends at a large on its pH level and the ultimate pH of red meat within 5.4 - 5.6 and white meat 5.3-6.5 considered as high-quality meat (Węglarz, 2010). Though the meat used in this study meet this range so it could be said that they were good in quality. Drip loss and cooking loss is considered to be very important for palatability, juiciness, and thus the overall quality and acceptability of meat. High drip loss in fresh meat indicates poor quality meat. Cooking loss indicates the ability of meat to retain its water after heating. Both chicken (14.34%) and chevon (14.06%) had significantly ($p<0.001$) higher drip loss of meat juice than that of beef (10.37%). The pH values of the muscles, species and age significantly ($p<0.05$) affected cooking loss of meat found by Price and Schweigert (1976). In case of cook loss, chevon losses higher juice during cooking than meat of two others species. The age ($p<0.05$) and breed differences ($p<0.01$) significantly influence the cooking loss of lamb; Njisane and Muchenje (2013) found significantly ($p<0.05$) higher cooking loss values in older sheep than meat from younger sheep. The chemical properties of fresh meat used for canning purpose under this research, is presented in Table 2. The chemical composition of fresh meat did not vary significantly ($p>0.05$) among the species except the protein content of meat and the protein content was significantly ($p<0.01$) lower in chevon (17.4%) than that of beef (19.8%) and chicken meat (19.7%).

Table 1: Physical properties of fresh meat in different species used for canned meat preparation

Items	Meat in different species			SEM	p-value	Sig.
	Beef	Chevon	Chicken			
Meat pH	5.45± 0.03^{b}	5.96±0.07^{a}	6.00± 0.05^{a}	0.08	56.77	***
Drip loss (%)	10.37±0.48^{b}	14.06± 0.35^{a}	14.34±0.45 ^{a}	0.65	24.22	***
Cook loss (%)	19.14±0.54^{b}	21.75± 0.08^{a}	19.69± 0.06^{b}	0.43	19.04	**

N.B**.** SEM, Standard error of the mean; NS, not significant ($p>0.05$); *=$p<0.05$, **= $p<0.01$; ***=$p<0.001$, $^{a-b}$ means with different superscripts in the same row are significantly different.

Table 2: Chemical properties of fresh meat in different species used for canned meat preparation

Items (%)	Meat in different species			SEM	p-value	Sig.
	Beef	Chevon	Chicken			
Moisture	74.76±0.62	77.48±1.28	76.12±0.96	0.55	2.50	NS
DM	25.24±0.62	22.52±1.28	23.88±0.96	0.55	2.50	NS
CP	19.80±0.26^{a}	17.36±0.34^{b}	19.70±0.58^{a}	0.33	13.14	**
EE	2.07±0.35	1.92±0.05	1.71±0.29	0.15	0.40	NS
Ash	4.67±0.44	4.80±0.44	4.42±0.38	0.25	0.13	NS

N.B. DM, Dry matter; CP, Crude protein; EE, Ether extract; SEM, Standard error of the mean; NS, not significant ($p>0.05$); *=$p<0.05$, **= $p<0.01$; ***=$p<0.001$, $^{a-b}$ means with different superscripts in the same row are significantly different.

Quality assessment of canned Meat

The pH and proximate composition of canned meat was analyzed after 30 days of processing and data is presented in Table 3. Data shows that meat pH and nutritional value both were influenced by canning. The pH value of both red and white meat was increased after canning as

compared to pH of fresh meat. Irrespective of preservatives, chicken meat had significantly ($p<0.001$) higher pH value than that of beef and chevon. Irrespective of meat type, meat treated with Na-Nitrite had higher ($p<0.001$) pH value than that of control or meat treated with Nacl (common salt). Type of meat had an influential impact on the nutritional composition in canned meat. It was also observed that in canned meat, the protein level was increased by 5.44, 11.02 and 8.67% when used in beef, chevon and chicken as compared to their fresh product. But it can be said that canning has a good impact on nutritional values of meat. No physical abnormalities and odd flavor were checked physically. It was a very basic study to develop the canning process of meat and to study its shelf life. So, furthermore research need to be arranged to test the scenario of most important component like amino acid profile, fatty acid profile, cholesterol, per-oxidase value etc.

Table 3: Effect of meat type and preservatives on Physical and chemical composition of canned meat

Meat type and their interactions			Meat pH	DM (%)	CP (%)	EE (%)	Total minerals (ash)
Beef	Preservative s	Control	5.98	31.72	26.09	3.86	2.87
		Sodium nitrite	6.02	33.58	25.10	3.98	3.13
		Sodium chloride	5.99	28.61	24.52	3.80	3.26
Chevon	preservative s	Control	6.22	38.39	31.47	2.43	3.27
		Sodium nitrite	6.40	33.46	25.33	2.63	2.74
		Sodium chloride	6.28	34.32	29.21	2.80	3.31
Chicken	preservatives	Control	6.65	34.73	27.89	3.60	3.28
		Sodium nitrite	6.99	35.08	28.61	3.44	2.88
		Sodium chloride	7.10	34.68	28.62	3.42	2.04
Meat	Beef		6.00^{c}	31.36^{b}	25.36^{b}	3.88^{a}	3.08
	Chevon		6.30^{b}	35.39^{a}	28.67^{a}	2.62c	3.10
	Chicken		6.91^{a}	34.83^{a}	28.37^{a}	3.49^{b}	2.74
Preservatives	Control		6.28^{b}	33.66	28.48	3.30	3.14
	Sodium nitrite		6.47^{a}	33.93	26.03	3.35	2.92
	Sodium chloride		6.45^{a}	31.54	26.72	3.34	2.87
SEM			0.08	0.69	0.53	0.19	0.15
Sig. lev.	Meat (m)		***	*	*	***	NS
	Preservatives (p)		***	NS	NS	NS	NS
	m×p		***	NS	NS	NS	NS

N.B. DM, Dry matter; CP, Crude protein; EE, Ether extract; SEM, Standard error of the mean; NS, not significant ($p>0.05$); *=$p<0.05$, **= $p<0.01$; ***=$p<0.001$, $^{a-c}$ means with different superscripts in the same row are significantly different.

Microbiological Load

From microbiological test no botulism spore was found in canned meat using Na-Nitrite. This finding matches with the statement found by Sindelar and Milkowski (2012) who stated that nitrites possess an important bacteriostatic and bacteriocidal properties against several spoilage bacteria and food borne pathogens available in meat where EFSA (2003) priors C. botulinum most. But the TVC (Total viable count) and TCC (Total coliform count) value was a bit higher. Marwa et al., (2023) reported that the mean value of anerobic bacterial count in canned beef and chicken was $1.02\times10^{4}\pm1.23\times10^{4}$, $0.52\times10^{4}\pm0.70\times10^{4}$ Cfu/g. Nearly similar results were recorded by Ali et al., (2008) who reported that the mean value of anerobic bacterial count in canned beef was 74×103±0.48x103 Cfu/g. Higher incidence of anaerobic bacterial growth in canned meat can occur due to poor quality raw materials, microbial contamination before thermal treatment, inadequate thermal processing and improper storage conditions etc. These factors can contribute to the growth of anaerobic bacteria. Though it was a preliminary work that's why a series of research work need to be conducted to define the standard microbial load in canned product.

Beef Recovery Rate Calculation

Table 4 represents the effect of preservatives on losses and recovery of beef during canning process. During canning, the maximum loss (25.41%) was observed in control i.e. no

preservative group and highest final product recovery rate (63.42% meat) was in beef treated with Na-nitrite. Amount of loss of this group was only 4.69%. The recovery rate in beef treated with NaCl was comparatively lower (60.88%) than Na-Nitrite treated group but comparatively higher than control (53.91%) group. In case of

chevon maximum loss was found for control group but in case of chicken maximum loss was found for canned meat treated with NaCl.

Table 4: Loss or recovery rate of beef, chevon and chicken meat during canning process using preservatives or without preservatives

Type of meat	Preservatives	% Losses in canning	% water in can	% meat in can	Total fresh meat (g)
Beef	Control	25.42	20.67	53.91	500
	Sodium nitrite	4.69	31.88	63.43	500
	Sodium chloride	13.33	25.79	60.88	500
Chevon	Control	13.36	19.41	67.23	500
	Sodium nitrite	5.28	30.65	64.07	500
	Sodium chloride	8.70	23.67	67.63	500
Chicken	Control	9.42	4.41	86.17	500
	Sodium nitrite	10.29	18.91	70.80	500
	Sodium chloride	9.16	10.56	80.28	500

Table 5: Canned meat/kg production cost

Item name	Treatments		
	Control	Na-Nitrite	Salt
Boneless beef/kg	630.00/-	630.00/-	630.00/-
Sodium nitrite	-	3.00/-	-
Sodium chloride	-	-	0.25/-
Gas	5.00/-	5.00/-	5.00/-
Labor	12.00/-	12.00/-	12.00/-
Utensil & others	5.00/-	5.00/-	5.00/-
Total cost (Tk.)	652/-	655/-	652.25/-
Boneless chevon/kg	830.00/-	830.00/-	830.00/-
Sodium nitrite	-	3.00/-	-
Sodium chloride	-	-	0.25/-
Gas	5.00/-	5.00/-	5.00/-
Labor	12.00/-	12.00/-	12.00/-
Utensil & others	5.00/-	5.00/-	5.00/-
Total cost (Tk.)	852/-	855/-	852.25/-
Boneless chicken/kg	170.00/-	170.00/-	170.00/-
Sodium nitrite	-	3.00/-	-
Sodium chloride	-	-	0.25/-
Gas	5.00/-	5.00/-	5.00/-
Labor	12.00/-	12.00/-	12.00/-
Utensil & others	5.00/-	5.00/-	5.00/-
Total cost (Tk.)	192/-	195/-	192.25/-

Production Cost

Considering meat cost, chemical cost, labor, gas cost and others (utensil cost) cost it was estimated that the production cost of 1.00 kg canned beef was ranges from Tk. 652.00 to Tk. 655.00 and for canned chevon it was ranges from Tk. 852.00 to Tk. 855.00. In case of chicken canned meat, it was ranges from Tk. 192.00 t0 Tk. 195.00. Though it was done for research purpose so the value seems a bit higher but it could be lessened in commercial production through following more specific protocol with appropriate preservatives.

Conclusion

In conclusion, it could be said that canning has an impressive influence on meat processing system. So, it could be a good option to be introduced for meat value addition at industrial level of Bangladesh. Ultimately it will facilitate consumers to have hygienic quality food with minimum processing and cooking time, encourage farmers to rear more animal with profitable marketing system, create employment opportunity and boost national economy.

Authors contribution

Conceptualization, study design, methodology, laboratory activities, data curation, formal statistical analysis, writing, review and editing: BKR; laboratory activities, manuscript writing: JSK; formal statistical analysis, manuscript writing, review and editing: SAT; administration, project management, review and editing: NS. All authors have read and agreed to the published version of the
manuscript.

Data availability

With the authors' permission, all relevant data used in this study will be made public.

Conflict of interest

The authors disclose no conflicts of interest in publishing this research.

Consent for publication

All the authors agreed and decided to publish this article in the Bangladesh journal of Animal Science.

References

Ahmed R (2018). Ensure formalin-free foods to save future generations. *The News Today*. http://www.newstoday.com.bd/index.php?option=details

Al-Azzawi MN and Al-Ani LH (2014). Determination of heavy metals in imported canned fish that sold in Baghdad markets. *Iraqi Journal of Science*, 55(2B): 675-684.

Ali, EAWM, Othmun RM and Alhafeth TAK (2008). Microbial evaluation of canned meat. AL-Qadisiyah *The Journal of Veterinary and Medical Science*, 7(1): 10-13.

AOAC (2005). Official Methods of Analysis, Centennial Edition. Association of Official Analytical Chemist, Washington DC.

EFSA (European Food Safety Authority). Opinion of the Scientific Panel on Biological Hazards on a request from the Commission related to the effects of Nitrites/Nitrates on the Microbiological Safety of Meat Products. EFSA J. 2003; 14:1-34.

Faustman C and Cassens RG (1990). The biochemical basis for discoloration in fresh meat: A review. *Journal of Muscle Foods*, 1(3):217-243. https://doi.org/10.1111/j.1745-4573.1990.tb00366.x

Heinz G and Hautzinger P (2007). Meat processing technology for small-to medium-scale producers. RAP Publication, FAO, Bangkok.

Hossain MJ and Hassan MF (2013). Forecasting of milk, meat and egg production in Bangladesh. *Research Journal of Animal, Veterinary and Fishery Sciences*, 1(9):7–13.

ISO (1995). Recommendation of the meeting of the subcommittee, International Organization for Standardization on meat and meat products. ISO/TC-36/SC 6. The Netherlands. 10-18.

Joo ST, Kim BC and Kim CJ (2007). The relationship between color and water-holding capacity in post-rigor porcine longissimus muscle. *Journal of Muscle Foods*, 6(3): 211-226. https://doi.org/10.1111/j.17454573.1995.tb00568.x

Kaiser M, Kabir MH, Khan RI and Hashem MA (2017). Raw and processed meat in Ramna area of Dhaka city. Bangladesh. *International Journal of Applied Research*, 3(2):101-104.

Karen Fifield (2016). Preserved meat at home with a pressure canner. Michigan State University.

Long NBS, Gal R and Bunka F (2014). Use of phosphates in meat products. *African Journal of Biotecnology*, 10(86):19874-19882. https://doi.org/10.5897/AJBX11.023

Marwa AM, Mohamed MM and Kamal HA (2023). Chemical and Microbiological Spoilage of Canned Meat Products. *Alexandria Journal of*

Veterinary Sciences, 79(1): 73-80. https://doi.org/ 10.5455/ajvs.157089

Njisane YZ and Muchenje V (2013). Influence of Municipal Abattoir Conditions and Animal-related Factors on Avoidance-related Behavior, Bleeding Times at Slaughter and the Quality of Lamb Meat. *Asian Australas Journal of animal Science*, 26(10): 1496-1503. http://dx.doi.org/10.5713/ajas.2013.13137

Pressman P, Clemens R, Hayes W and Reddy C (2017). Food additive safety: A review of toxicologic and regulatory issues. *Toxicology Research and Application*, 1:1-22. http://dx.doi.org/10.1177/2397847317723572

Price JF and Schweigert BS (1976). Ciencia de la carne y de los productos ca´ rnicos. Acribia (Ed.), Zaragoza, Spain. pp.592.

Rahman MS (2007). Handbook of food preservation. *CRC press*. (Ed.) 2007; https://doi.org/10.1201/9781420017373

Sindelar JJ and Milkowski AL (2012). Human safety controversies surrounding nitrate and nitrite in the die. *Nitric Oxide*, 26(4):259–266. https://doi.org/10.1016/j.niox.2012.03.011

SPSS 2017. Statistical Package for Social Science. Copyright (e) SPSS Inc. USA. University of Nebraska- Lincoln: Fact Book 2005-2006

Węglarz A (2010). Meat quality defined based on pH and colour depending on cattle category and slaughter season. *Czech Journal of Animal Science*, 55(12):548–556. https://doi.org/10.17221/2520-CJAS

Yang HS, Moon SS, Jeong JY, Choi SG, Joo ST and Park GB (2006). Effect of sodium bicarbonate injection in pre-rigor porcine M. Longissimus lumborum on pork quality. *Asian-Australian Journal of Animal Science*, 19(6):898-904. http://dx.doi.org/10.5713/ajas.2006.898