Evaluating the Quality of the Edible Offal (Heart, Liver, Kidney) of Rabbits (Flemish Giant Breed) During Storage by Refrigeration Following the Evolution of the pH

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Abstract

The purpose of this paper was to determine the quality of the edible offal (heart, liver, and kidney) of rabbits (Flemish Giant breed) during storage by refrigeration following the evolution of the pH, after slaughter, during maturation, to autolysis and alteration, from 27 individuals (15 males and 12 females). The rabbits had an average body weight of 11.5 kg being at the age of reproductive maturity (11-12 months). The pH evolution of the edible offal (heart, liver, and kidney) of rabbits (refrigerated at 4^{o}C) was monitored during of 18 days after slaughter. The pH evolution had a fluctuant ascendant trend, quite similar for females and males, presenting insignificant differences by gender. At 24 h after slaughter, the mean values of pH of the main edible offal (from males and females) had the highest average values to the kidneys 6.48, followed by the heart 6.32 and by the liver 6.23. The alteration occurred much faster in kidneys and was starting with the 13th day of storage, the pH being close to 6.8-7.

Keywords: evolution, females, males, offal, rabbits.

1. Introduction

The analysed edible offal has an economic importance at the moment, as they are marketed separately from the carcass, packaged in vacuum, in chilled form. Their price is quite high, because they come from import (especially from Hungary and Spain), unfortunately autochthonous production does not feel its presence in stores.

Edible offal offers a range of foods which are nutritiously attractive, especially in developing countries. The edible offal is highly prized in South East Asia and Africa, whilst demand is variable and low in Australia and the USA, respectively [1, 2]. In slaughtered animals, edible offal contributes 33% of the edible material [2, 3].

In European countries and the Mediterranean area, people have consumed rabbit meat for a long time. Rabbit meat has lower cholesterol content and higher levels of protein with essential amino acids than meat from other animal species [4]. In addition, rabbit meat can be regarded as a functional food because of its potential for improvement in state of health and reduction of disease risk [4]. Rabbit meat provides consumers with rich nutritive and bioactive compounds such as PUFA, DHA, and selenium to improve physiological functions. In addition, the low n-6/n-3 ratio in rabbit meat helps control cardiovascular and other chronic diseases. In commercial rabbit breeding, acceptable meat quality standards are one of the most important limiting factors for the economic output of a farm unit [5]. Colour, intramuscular fat content, and pH value are all typical meat quality parameters [6].

The purpose of this paper was to determine the quality of the edible offal (heart, liver and kidney) of rabbits (Flemish Giant breed) during storage by refrigeration following the evolution of the pH, after slaughter, during maturation, to autolysis and alteration.

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2. Materials and methods

The biological material was composed from 27 rabbits from Flemish Giant breed (15 males and 12 females). The rabbits had an average body weight of 11.5 kg being at the age of reproductive maturity (11-12 months). They were fed without fodder and water restrictions. There have been sampled the edible offal (heart, liver, kidney), refrigerated at 2^{o}C and was monitored the pH evolution for 18 days after slaughter, during maturation, to autolysis and alteration, using the Hanna Electronics pH meter, 212 model.

Measurement was performed by calibrating the pH meter with two standard solutions of known pH. After balancing the device, the electrode is inserted in previously prepared meat broth (from edible offal) and the pH reading is achieved. Meat broth was prepared by adding 10 g of a finely chopped sample in 100 ml distilled water and then filtering the mixture. The results were statistically interpreted by classic methods (arithmetic mean (X), standard deviation (s), variance (S^2) and coefficient of variation (V%)).

3. Results and discussion

At 24 hours post slaughter, the mean pH of the main edible offal (from males and females rabbits) had the highest values at: kidney (6.48), followed by those from the heart (6.32), and from the liver (6.23), the alteration appearing after a few days (six - seven days). These values are much higher than those determined for the muscle groups from the same individuals [7], and for the kidney this high pH value (6.48) is probably due to the presence of uric acid in kidney.

The pH evolution at the level of the heart, showed a coefficient of variation that did not exceed a percentage of 6.40%, thus representing a very homogeneous population, both for males and for females (Table 1).

Table 1. The pH evolution for heart harvested from rabbits - females and males

Gender	Period	No	$\overline{X}$ ±S $\overline{X}$	S^2	V%	Minimum	Maximum
Males	24 h	7	6.312±0.035	0.016	2.004	6.110	6.510
	48 h	7	6.352±0.032	0.014	1.835	6.140	6.540
	3 days	7	6.442±0.053	0.031	2.734	6.210	6.830
	4 days	7	6.502±0.041	0.022	2.292	6.310	6.830
	5 days	7	6.502±0.041	0.022	2.292	6.310	6.830
	6 days	7	6.593±0.096	0.064	3.844	6.290	6.990
	7 days	7	6.743±0.053	0.031	2.616	6.500	7.030
	8 days	7	6.863±0.091	0.083	4.206	6.390	7.230
	9 days	7	6.878±0.124	0.122	5.081	6.400	7.330
	10 days	7	6.612±0.127	0.096	4.694	6.180	6.890
	11 days	7	6.746±0.107	0.091	4.481	6.410	7.120
	12 days	7	6.887±0.167	0.194	6.402	6.410	7.400
	13 days	7	7.043±0.120	0.100	4.495	6.670	7.450
	14 days	7	6.827±0.093	0.052	3.353	6.560	7.120
	15 days	7	6.875±0.097	0.056	3.450	6.560	7.140
	16 days	7	7.203±0.065	0.029	2.381	6.980	7.460
	18 days	7	7.286±0.048	0.016	1.754	7.120	7.430
Females	24 h	15	6.326±0.038	0.018	2.092	6.170	6.530
	48 h	15	6.486±0.051	0.031	2.701	6.280	6.910
	3 days	15	6.578±0.072	0.062	3.798	6.310	7.120
	4 days	15	6.609±0.078	0.074	4.108	6.220	7.160
	5 days	15	6.592±0.034	0.008	1.365	6.490	6.730
	6 days	15	6.609±0.121	0.103	4.845	6.290	7.120
	7 days	15	6.898±0.067	0.054	3.372	6.500	7.280
	8 days	15	7.005±0.107	0.139	5.313	6.390	7.460
	9 days	15	7.139±0.127	0.160	5.604	6.470	7.530
	10 days	15	6.550±0.107	0.046	3.258	6.440	6.870
	11 days	15	6.750±0.151	0.091	4.481	6.490	7.110
	12 days	15	6.758±0.086	0.029	0.433	6.590	6.910
	13 days	15	6.795±0.079	0.025	2.335	6.630	6.950
	14 days	15	6.808±0.105	0.044	3.071	6.680	7.120
	15 days	15	6.808±0.105	0.044	3.071	6.680	7.120
	16 days	15	7.063±0.081	0.026	2.296	6.890	7.220
	18 days	15	7.188±0.061	0.015	1.709	7.050	7.310

The pH evolution had a higher ascendency for females to day 9, after which there is a suddenly decrease on day 10, followed again by a relatively constant increase of it until day 16, then suddenly until day 18, more fluctuant for males.

The majority of researches performed on rabbit meat have analysed the pH at 24 hours only for *Longissimus dorsi* muscles and only a few studies have analyzed this parameter for muscles *Biceps femoris* [8, 9]. We did not find studies on pH evolution during storage for more days neither for these muscle groups. For edible offal we have not met any study for rabbits. A study from 2015, was made on edible offal from Swallow-Belly Mangalica pigs [10], one, on edible offal of cattle [11], from 2014, and one, from 2013, was done for edible offal from springbok, eland, red hartebeest and kudu [3], all presenting only the pH value at 24 h after slaughter. Daszkiewicz et al., 2012 [12], studying the effect of intensive and extensive production systems on carcass quality in New Zealand white rabbits observe that the mean values of pH at 24 h of meat from control and experimental rabbits were similar, oscillated around 5.78. The average values of pH24 determined in samples of *Longissimus dorsi* were lower than those reported by Maj et al. (2008) [13] (5.82-5.89) and Barròn et al. (2004) [14] (pH24 5.8-6.3), but higher than those noted by Pla et al. (1998) [15] (pH24 5.61-5.63) and D' Agata, 2009 [16] (pH24 5.71-5.83) and for *Biceps femoris* (pH24 5.92). According to Dal Bosco et al. (2002) [17], the pH of rabbit meat may be affected by various factors, including pre-slaughter handling (transportation, loading and unloading, stocking density), carcass cooling rate and housing conditions during fattening [13-17].

The pH evolution of the liver showed a coefficient of variation that did not exceed the threshold of 10%, thus representing a very homogeneous population, for males and for females (Table 2).

Table 2. The pH evolution for liver harvested from rabbits - females and males

Gender	Period	No.	$\overline{X}$ ±S $\overline{X}$	S^2	V%	Minimum	Maximum
Males	24 h	7	6.204±0.045	0.025	2.523	5.910	6.410
	48 h	7	6.283±0.062	0.046	3.409	5.990	6.790
	3 days	7	6.355±0.080	0.064	3.988	6.010	6.840
	4 days	7	6.392±0.078	0.072	4.202	5.830	6.910
	5 days	7	6.406±0.085	0.072	4.195	5.980	6.910
	6 days	7	6.293±0.061	0.033	2.899	6.020	6.650
	7 days	7	6.406±0.110	0.121	5.426	5.880	6.980
	8 days	7	6.333±0.094	0.079	4.440	5.840	6.830
	9 days	7	6.197±0.162	0.264	8.286	5.490	7.020
	10 days	7	6.272±0.184	0.204	7.201	5.510	6.740
	11 days	7	6.356±0.106	0.078	4.397	6.020	6.780
	12 days	7	6.212±0.148	0.131	5.829	5.640	6.610
	13 days	7	6.280±0.154	0.143	6.015	5.830	6.680
	14 days	7	6.815±0.096	0.056	3.468	6.560	7.200
	15 days	7	6.875±0.097	0.056	3.450	6.560	7.140
	16 days	7	6.903±0.106	0.068	3.773	6.390	7.120
	18 days	7	7.123±0.079	0.037	2.701	6.910	7.340
Females	24 h	15	6.261±0.056	0.038	3.110	5.910	6.530
	48 h	15	6.334±0.057	0.039	3.133	5.990	6.670
	3 days	15	6.303±0.055	0.036	3.016	6.010	6.630
	4 days	15	6.288±0.068	0.055	3.747	5.830	6.630
	5 days	15	6.351±0.083	0.063	3.938	5.980	6.680
	6 days	15	6.234±0.050	0.023	2.422	6.020	6.410
	7 days	15	6.312±0.092	0.101	5.034	5.880	6.960
	8 days	15	6.313±0.079	0.074	4.310	5.910	6.940
	9 days	15	6.163±0.136	0.222	7.651	5.490	7.080
	10 days	15	6.462±0.073	0.032	2.778	6.180	6.740
	11 days	15	6.473±0.096	0.056	3.646	6.110	6.850
	12 days	15	6.612±0.067	0.027	0.407	6.420	6.820
	13 days	15	6.727±0.043	0.011	1.550	6.620	6.890
	14 days	15	6.750±0.094	0.053	3.403	6.560	7.200
	15 days	15	6.750±0.094	0.053	3.403	6.560	7.200
	16 days	15	6.837±0.114	0.078	4.095	6.390	7.120
	18 days	15	7.278±0.023	0.003	0.779	7.190	7.340

The average values of the liver pH showed a slightly fluctuating increase, for females and males, until at day 9 when dropped, after which it takes place its accelerating growth, with significant fluctuations for both sexes (Table 2).

For the kidneys, the coefficient of variation did not exceed 5.06%, thus representing a very homogeneous population for both females and males (Table 3). The mean pH values observed for the kidneys were relatively similar for both females and males, showing minor fluctuations.

The data from the specialized literature regarding the mean value of the pH of edible offal (heart, liver and kidney) at 24 hours after slaughter was similar with that from this study (with exception of heart pH, which was lower than that from our study). Thus Tomovic et al, 2015 [10] found for edible offal from Swallow-Belly Mangalica pigs, at 24h after slaughter, the mean pH value of 6.47±0.05 for kidney (max 6.53), 6.07±0.10 for liver (max 6.21) and 5.85±0.15 for heart (max 6.12). Seong et al., 2014 [11], at 24h after slaughter, found for edible offal from Hanwoo Bovine relatively similar values: for kidney 6.48±0.18, for liver 6.23±0.12 and for heart 5.80±0.24. Magwedere et al, 2013 [13], found for edible offal from springbok, similar mean value of the pH at 24h after slaughter (6.54±0.15 for kidney, 6.30d±0.14 for liver, 6.08±0.39 for heart).

Table 3. The pH evolution for the kidneys harvested from rabbits - females and males

Gender	Period	No.	$\overline{X}$ ±S $\overline{X}$	S^2	V%	Minimum	Maximum
Males	24 h	7	6.475±0.047	0.029	2.611	6.190	6.690
	48 h	7	6.537±0.045	0.026	2.463	6.310	6.810
	3 days	7	6.595±0.060	0.040	3.018	6.370	7.010
	4 days	7	6.621±0.057	0.042	3.113	6.380	7.010
	5 days	7	6.654±0.069	0.038	2.947	6.320	6.890
	6 days	7	6.541±0.086	0.051	3.458	6.380	7.010
	7 days	7	6.834±0.074	0.061	3.614	6.230	7.110
	8 days	7	6.874±0.092	0.084	4.216	6.420	7.190
	9 days	7	6.854±0.122	0.120	5.053	6.510	7.350
	10 days	7	6.693±0.082	0.027	2.462	6.540	6.840
	11 days	7	6.652±0.057	0.016	1.929	6.580	6.880
	12 days	7	6.762±0.067	0.023	2.222	6.610	6.980
	13 days	7	6.885±0.026	0.003	0.764	6.810	6.930
	14 days	7	6.955±0.030	0.004	0.859	6.890	7.030
	15 days	7	7.030±0.068	0.018	1.930	6.930	7.230
	16 days	7	7.178±0.064	0.016	1.771	7.030	7.340
	18 days	7	7.205±0.108	0.047	2.999	6.910	7.390
Females	24 h	15	6.483±0.046	0.026	2.465	6.180	6.680
	48 h	15	6.663±0.049	0.029	2.563	6.300	6.840
	3 days	15	6.756±0.057	0.038	2.897	6.440	7.050
	4 days	15	6.782±0.072	0.062	3.667	6.270	7.150
	5 days	15	6.598±0.075	0.039	2.989	6.320	6.860
	6 days	15	6.719±0.103	0.074	4.047	6.380	7.050
	7 days	15	6.813±0.081	0.078	4.097	6.230	7.150
	8 days	15	6.878±0.078	0.073	3.935	6.420	7.250
	9 days	15	6.902±0.104	0.107	4.750	6.510	7.350
	10 days	15	6.745±0.032	0.004	0.942	6.710	6.840
	11 days	15	6.708±0.013	0.001	0.392	6.680	6.730
	12 days	15	6.863±0.037	0.005	0.079	6.790	6.940
	13 days	15	6.903±0.035	0.005	1.013	6.810	6.970
	14 days	15	6.958±0.094	0.035	2.695	6.820	7.230
	15 days	15	6.958±0.094	0.035	2.695	6.820	7.230
	16 days	15	7.058±0.029	0.003	0.829	6.990	7.120
	18 days	15	7.298±0.028	0.003	0.778	7.220	7.340

Investigating the contributing factors to post-mortem pH changes in springbok, eland, red hartebeest and kudu edible offal, Magwedere et al, 2013 [3], found final pH (at 24 h after slaughter) above 6.0, and suggest that alternative measures are required to inactivate certain endogenous pathogens in edible wild game offal. This study aimed to establish whether they edible offal meet the requirement for food safety (pH<6.0). Kidney fat had the highest mean ultimate pH (6.67) among all investigated edible by-products. A pH value below 6.0 is commonly used to destroy the most dangerous animal pathogens and ensure the safety of livestock products. Microorganisms have optimum, minimum and maximum pH for growth in different foods as a result of the interactions between the pH and other factors which either promote or inhibit microbial growth. In general, microbes do not grow, or else grow very slowly, at pH below 4.6, although there are exceptions. The pH of meat is important for good carcass quality and for inactivating viral and bacterial animal microbes [3].

Even under optimum conditions [18], the multiple potential stressors involved in the pre-slaughter process might affect the quality of commercial rabbit meat. At the industrial level, ultimate pH is the main parameter used to measure meat quality. Previous studies found that pre-slaughter transport stress raises meat pH in livestock. Other authors have also observed a higher ultimate pH (higher than 6.0) in rabbits subjected to long and short transports [19].

The higher ultimate pH is probably the effect of greater depletion of muscle glycogen reserves during the pre-slaughter experimental period, even for only a 40-min [20]. At high pH levels, the oxymyoglobin is rapidly turned into dark red-colored reduced myoglobin, and the muscle structure is less reflective because it is less compact [21].

It has been shown that longer journeys determine an increase in muscle ultimate pH, thus leading to higher water holding capacity and darker colour. A little difference in journey duration (3h versus 1h) can exert detectable variations in meat quality characteristics. The effect of longer lairage at abattoir seems to lead mainly to an increase in extra-myofibrillar meat water and cooking loss [21].

4. Conclusions

The pH evolution had a fluctuant ascendant trend, quite similar for females and males, presenting insignificant differences by gender. At 24 h after slaughter, the mean values of pH of the main offal had the highest average values to the kidneys 6.48 (similar for males and females), followed by the heart 6.32 (6.31 for males and 6.33 for females) and by the liver 6.23 (6.20 for males and 6.26 for females). The alteration occurred much faster in kidneys and was starting with the 13th day of storage, the pH being close to 6.8-7.

The quality and freshness of liver of rabbits are a little more preserved (nine days) during storage by refrigeration (following the evolution of the pH) unlike chicken liver (six – seven days). Given the high pH values for the heart and kidney of rabbits we recommend their sale in frozen form or their use for various heat-treated meat products (by boiling, baking, pasteurization or sterilization).

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