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A study on effect of pH on ageing pork quality under different storage conditions

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Abstract
It is very important to improve meat quality and its preservation for consumer acceptance at retail market. Tenderness of meat is a major quality attribute affecting consumer purchasing decision and one of the important factors that determines tenderness is pH of the meat. The objective of the current study was to determine the effect of ageing time and temperature combinations on pH of fresh pork obtained from adult animals. The pork was kept for ageing in two different packing conditions i.e., Aerobic and Vacuum at two different temperatures i.e., 4 °C and 7 °C. The sampling was done for assessment on 0, 6 and 12 days. We found that the ideal pH falling in the range of 5.7 to 6 was observed in vacuum packed samples both at 4 °C and 7 °C. From our study it can be concluded that vacuum packaging is a better option to maintain ideal pH of pork that ensures tenderness at both at 4 °C and 7 °C.

Keywords: pork, pH, tenderness, aerobic packing, vacuum packing

Introduction
Tenderness is considered as a crucial factor for determining meat quality, especially in developed countries. One of the widely practices technique in meat industry is Ageing, also referred to as "ripening" or "conditioning" and it improves meat tenderness and flavor (Sitz *et al*., 2006) [30]. The two common techniques of Ageing are "Dry Ageing" and "Wet Ageing". Whereas the former refers to a process in which unpackaged meat is stored in a refrigerated room with controlled temperature (0 °C–4 °C) and humidity (62%–87%) the latter refers to a relatively low-cost process in which the meat is packaged under vacuum in a water-impervious bag under refrigerated conditions (Smith *et al*., 2008; Jin and Yim *et al*., 2020) [31, 12].
Postmortem wet aging (in vacuum packaging) is a common meat industry practice to improve tenderness, palatability, and beef sub-primal cuts are aged/stored for an average of 20 days in retail establishments (Guelker *et al*., 2013) [9]. The cellular and biochemical mechanisms that govern the meat quality attributes undergo changes during postmortem aging. Ageing can also influence cellular mechanisms (such as reducing enzymes, oxygen scavenging enzymes, and mitochondria) responsible for meat color stability, resulting in lower color stability during subsequent retail display (King *et al*., 2012; English *et al*., 2016: Ponnampalam *et al*., 2016) [17, 7, 27]. Pommier *et al*., (1987) [26] showed that the amount of free cathepsin D (152 kDa aspartic protease) increased during ageing, which they attributed to a fall in pH and lysosomal rupture, but concluded that this did not affect tenderization. Richardson and Mead, (1999) reported that muscle pH and meat color are correlated, higher muscle pH is associated with darker meat whereas lower muscle pH values are associated with lighter meat. Therefore recording the dynamics of changes in pH is essential to assess the processing technology in meat. The objective of the current study was to effect of aging time and temperature combinations on most important fresh pork qualities of pH of under variable packaging conditions.

Material and Methods
Sampling
The slaughtered non-descript desi pigs with age above 1.5 years were selected for the study. Pork Latissimus Dorsi muscle samples were collected hygienically at local market under Malpura municipality immediately after slaughter from each carcass and placed in polyethylene bags and shifted to the laboratory under chilled condition for various analyses. After that samples cut in pieces weighed over digital balances model (SIMADUZU) with

maximum calibration of 220 grams and kept in high density LDPE pouches with 80-micron thickness. Later pouches were labeled for aerobic and vacuum at 4 °C and 7 °C with 0,6,12 days. Vacuum pouches were sealed with vacuum packing machine (DZQ-400) set at vacuum time at 30 seconds, aeration time of two seconds and sealing time set at 2.5 seconds. Later samples were stored in domestic refrigerator at 4° C and7°.

Ultimate pH

The pH of minced meat samples was determined as per method described by Trout *et al*., (1992) [33]. The homogenates were prepared by blending after 24 h of ageing of 10g sample with 90 ml distilled water using an Ultra Turrax tissue homogenizer (Model T25, Janke and Kenkel, 1 KA Labor Technik, Germany) for 1 min. The pH of the homogenates was recorded by immersing combined glass electrode of digital pH meter (HANNA instruments, Woonsocket RI USA, Romania).

Statistical Analysis: Data were analyzed using Statistical Software Packages (SPSS 16.0) following the procedure of Snedecor and Cochran (1994). Means between periods of storage, between groups and within groups were compared.

Results and Discussion

Table 1: pH of meat samples in different packing types at different temperatures

	Aerobic packing						Vacuum packing						SEM	*P* Value		
	4 °C			7 °C			4 °C			7 °C						
	0 d	6 d	12 d	0 d	6 d	12 d	0 d	6 d	12 d	0 d	6 d	12 d		P	T	D
pH	6.94	6.47	6.61	6.94	6.53	6.82	6.94	5.89	6.23	6.94	6.05	6.64	0.04	0.001	0.001	0.001

n = 10, P -Packing, T-Temperature, d- Days

The pH of muscle/meat is a measurement of acidity in a normal vital muscle resulting due to breakdown of glycogen to lactic acid, and it is approximately 7.2 in fresh meat (Choe, 2008) [6]. Ultimate pH is an important meat quality characteristic and the aim is to optimize pork quality whilst continuing to improve the cost of production for different market requirements. In our study, the average ultimate pH of pork on 0 day is 6.94, whereas ultimate pH of pork after 24 hours of ageing was recorded at 5.63 that might be due depletion of glycogen converted as lactic acid (Table 1). The pH increased significantly as with ageing period in both aerobic and vacuum packing. On 6th day, pH of aerobic ageing pork was significantly higher than that of vacuum packing. The pH of aerobic packing ageing pork was also significantly different on 6th day and 12th day under both 4 and 7 °C. Also, the pH of aerobic packing ageing pork was significantly different in both 4 and 7 °C. The pH of aerobic packing of meat under 4 and 7 °C at 6th day ageing was slightly lower than vacuum packing whereas 12th day is higher than the vacuum.Variation of pH was observed in both temperatures of vacuum packing increasing gradually with increasing ageing period and increasing temperature.

The pH of meat can range from 5.2 to 7.0 and the highest quality products tend to fall in the pH range of 5.7 to 6.0 (Bendall and Swatland, 1998). Therefore the ideal post-harvest handling of meat via processing should ensure this pH. But it is extensively reported that both the rate and extent of post-mortem pH fall will influence pork quality characteristics and pale, soft, exudative (PSE) pork commonly results from a rapid breakdown of glycogeninto lactic acid after slaughter (Bowker, 2000) [3]. Ultimate pH affects the color of pork products. Darker-colored chops tend to have a greater ultimate pH, whereas lighter-colored chops tend to have a lesser ultimate pH (Monin and Sellier, 1985) [23]. The ultimate pH is determined by the extent of the pH decline at 24 hours after slaughter. The ultimate pH results in meat proteins having decreased water-holding capacity and a lighter color (Joo, 1999) [13]. Conversely, a higher ultimate pH will give a less drip loss. In our study the pH of pork in vacuum packaging at 4 °C on day 6 is 5.89 hence falling in an ideal range.

Lower ultimate pH will lead to less saleable product, due to increased drip losses during the production processes of fresh meat. Drip loss in a consumer package will negatively affect the appearance and thereby the purchase intent. Ultimate pH also impacts eating quality characteristics such as juiciness, tenderness, and taste. Pork with a higher ultimate pH, which retains more water during storage, will also keep more juice after preparation of the meat (Hughes, 2014) [11]. More juice in the prepared meat will give a juicier, more succulent and tender eating experience. Longer times of feed withdrawal before transport for instance, will decrease the amount of glycogen present in the muscle at slaughter thereby resulting in a higher ultimate pH (Rosenvold, K., Lærke, H. N., Jensen, S. K., Karlsson, A. H., Lundström, K., & Andersen, H. J. (2002). Previous research has demonstrated small, but significant impacts of post-aging freezing on quality of pH (Kim *et al*., 2011b, 2018; Leygonie *et al*., 2011b; Kim and Kim, 2017) [16, 15, 19, 14]. Kim *et al*. (2018) [15] demonstrated that pork longissimus sections which were aged for 19 d, frozen, and then thawed maintained greater pH values than sections that were only frozen or frozen, thawed, and then aged (Kim *et al*., 2018) [15]. In a similar study examining the effects of aging and freezing/thawing sequence on beef biceps femoris and gluteus medias, freezing and thawing of muscles decreased the pH regardless of the sequence of freezing and thawing (Kim and Kim, 2017) [14]. Kim *et al*., (2011b) [16] observed that freezing for 9 weeks reduced pH values in sheep longissimus muscle compared to post-ageing freezing of streaks and wet ageing of streaks (Kim *et al*., 2011b) [16].

The use of gene marker technology is a powerful tool to increase ultimate pH (and other meat quality traits) in a pig population. The RN gene is an example of a major gene which influences ultimate pH (Otto, 2007) [24]. Two copies of the negative allele (22) cause an extremely low ultimate pH ("acid meat") and most of the breeding companies have erased the negative allele from the breeding herds (Lantz, T. 2020). Lawrie, (1998) reported that the normal muscle pH profile of most red meat animals shows a gradual decrease until an asymptotic minimum of about 5.4 to 5.5 has been reached, normally occurring over a 24 hrs period. The same initial pH (6.5) decreased to 5.65 at 6 hrs and 5.5 at 24 hrs in delayed chilling.

Conclusion

From our study it can be concluded that the vacuum

packaging of pork cuts at 4 °C and 7 °C for 6 days maintains desirable pH.

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