CHANGES IN FLAVOUR, COLOUR AND TEXTURE DURING STORAGE OF ACID-PRESERVED MEAT.

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SUMMARY

Treatments with lactic acid in concentrations up to 2% have been reported to increase meat shelf-life without considerably affecting its physicochemical characteristics. Although sensory evaluation has been carried out in acid-preserved meat, no studies have been done with respect to the production of flavour-related compounds during its storage, nor its colour and texture changes. The objective of the present work was to study some of the major volatile compounds related to the flavour of the meat treated with lactic and propionic acids, and any colour and texture changes during chill storage. Pork meat (L. dorsi) was treated with 1, 2 and 3% lactic and propionic acids. On average, acid concentration had a larger effect on volatile production than storage time or type of acid applied (lactic or propionic). Acid treatments reduced cohesion among meat fibres, producing meat slightly harder and less adhesive. Colour faded in all treatments during storage, shifting hue to yellow.

Introduction

Reducing the microbial load on the carcass surface would have as a consequence an increase in meat shelf-life. A number of treatments aimed to reduce microbial populations in the meat surface has been reported in literature, most of these are based on spraying the carcass surface with chemical compounds. Of these, treatments with organic acids have proved to be very efficient.

The sensory characteristics of meat may be affected by the treatments used to reduce meat contamination. Therefore, any potential treatment for the extension of shelf-life of raw meat should aim for a minimum alteration in these characteristics.

Materials and Methods

Post rigor L. dorsi muscles of 6-month sows were taken from post-rigor carcasses and stored at 6°C. Sterile samples of the meat were prepared by cooking the surface of the meat on a hot plate for 10 min in a laminar flow cabinet. The cooked layer was aseptically removed using sterile knives on a sterile surface. The underlying muscle was cut into approximately 5 cm3, and stored in glass jars where propionic or lactic acid was added at a given concentration, and the meat cubes were left immersed in the acid solution for 20 minutes, after which the acid solution was drained. The jars containing the meat samples were stored at 4-6°C.

Experimental Design: Completely randomized samples were allocated to a 2X3X5 complete factorial arrangement with three replicates, including the following factors and levels: acid (propionic and lactic), acid concentration (1, 2 and 3%), storage time (1, 3, 5, 7, 11 days). The response variables were: colour (Lightness, hue and chroma), texture: (Texture Profile Analysis: elasticity, cohesiveness, chewiness, gumminess, hardness), volatile compounds produced (2-methyl furan, 2-ethyl furan, toluene, hexanal, ethyl benzene, 2-heptanone, heptanal, 2-heptanal, 1-octen-3-ol, 2-pentyl furan, octanal, nonanal, decanal).

Analytical methods: Volatile compounds were removed from the headspace of the jars with a stream of dry nitrogen. They were collected on a Tenax trap, thermally desorbed and identified using a VG MD800 bench top mass spectrophotometer (Fisons Scientific, Manchester, U.K.) connected to a Hewlett Packard 5890 Series II gas chromatograph fitted with a headspace injector (Unijector, SGE). The meat volatiles were desorbed from the traps at 240°C for 2 min. During desorption a 400 mm region of the column was cooled in liquid nitrogen to cryotrap the volatiles. Following desorption, the sample was chromatographed from 30 to 240°C. The key volatiles from the meat were identified and quantified on the basis of their retention times and

characteristic ions, using a reference library, where the spectrum of an unknown is matched against that of a reference compound. Texture profile analysis was performed in the samples using a TA.XT2 texture analyzer. L, a and b colour coordinates were obtained with a Hunter Colorquest equipment, and transformed into L, hue and chroma. Microbial populations were determined using standard methods. The data were analyzed using a SASS package adapted to a personal computer.

Results and Conclusions

Volatile concentration: 2-methyl furan has a meaty aroma, it was found that storage time significantly affected its concentration. The control samples appeared to have the largest concentrations of this volatile, and the lactic acid treated samples showed higher concentrations than the propionic acid samples. With storage time, the concentration of 2-methyl furan for the propionic acid treated samples became larger and stabilized, whereas the lactic acid samples increased through out the study time. In control samples, the compound increased up to day 3 and then gradually decreased and stabilized. A lactic acid treatment affected this volatile more than a propionic acid treatment.

The concentration of 2-ethyl furan remained very low in the control throughout the storage time. The concentration of the volatile gradually increased with time in the acid treated samples, generally being higher in the lactic acid treated samples compared to the propionic acid treated samples.

Toluene is thought to originate from meat supporting the growth of Pseudomonads spp. or from the animal feedstuff. Concentration of this volatile was always largest in the control, which increased with time. Propionic and lactic acid treated samples showed similar concentrations of this volatile, although lactic acid treated samples did have slightly lower concentrations. There was a decrease in this volatile concentration as the acid concentration increased.

Ethyl benzene was significantly affected by the storage time. Concentrations of this volatile were smaller in the lactic acid treated samples than in the propionic acid samples, at every time of study. There was a decrease in volatile concentration as the concentration of lactic or propionic acids decreased. Concentration of the volatile in the control increased throughout storage. The lactic acid treated samples gave the greater variation in volatile concentration when compared to the propionic acid samples against the control.

2-Heptanone was significantly affected by storage time. The concentration of this volatile in all samples gradually increased over time, being slightly higher in the control. The main difference in volatile concentration was detected between 9 and 11 days of storage. As lactic and propionic acid increased, there was a decrease in concentration of 2-heptanone.

1-Octen-3-ol is derived from linoleate oxidation. The type of acid significantly affects its production. It was only present at very low amounts in the control. With storage time, the concentration of it increased, but at a lower proportion than the lactic acid treated samples. As propionic acid concentration increased there was an increase in 1-octen-3-ol production, the opposite was found for lactic acid treated samples. The concentration of 1-octen-3-ol in 1% propionic acid samples was similar to the one in control samples, the lactic acid treated samples having the most marked effect on the concentration of this compound.

With storage time the concentration of 2-pentyl furan increased in all samples, although its concentration in the control remained much smaller than in propionic and lactic acid treated samples, which had similar concentrations throughout the study time. It seemed that there was a pattern of increase in 2-pentyl furan concentration as propionic acid increased and a decrease with an increase in lactic acid.

Hexanal is one of the major secondary products formed during the oxidation of linoleic acid. This volatile was significantly affected by type of acid and storage time. The control samples showed the lowest concentration of hexanal, although it did increase with time. Concentrations in samples treated with propionic acid were lower than in lactic acid treated samples. With both acid treatments there was an increase in volatile concentration with increasing acid concentrations. The lactic acid treated samples gave greater variation in concentration when compared to the control.

Heptanal concentration was significantly affected by the type of acid and storage time. The concentration of this volatile increased over time, the control having the largest concentration at all times. Lactic and propionic acid treatments had a similar effect on heptanal production, although it was higher in lactic acid treated samples. There was a slight decrease in heptanal concentration as propionic acid was increased.

Octanal, nonanal and decanal have a high rate of formation during lipid oxidation and low flavour threshold; therefore they are major contributors to the loss of desirable flavours in meats. The concentration of octanal increased with storage time in the control. During the study time, concentration of octanal in control samples was always higher than in the acid treated samples. Lactic acid treated samples showed the highest

concentration. With both acids, the volatile concentration decreased as acid concentration increased. The type of acid significantly affected the production of nonanal. Concentration in the control was higher compared to other treatments, but it decreased with storage time. Nonanal concentration was higher in propionic acid samples than in lactic acid ones. As propionic and lactic acid concentration increased there was a decrease in nonanal. Three percent propionic acid and 1% lactic acid samples gave similar concentrations of this volatile. The concentration of octanal, nonanal and decanal increased gradually during storage, acid treatments produced lower concentrations of these 3 volatiles although propionic acid treatments increased during storage. Lactic acid treatments decreased the concentration of these three volatiles.

In general, lactic acid treated meat gave a greater variation in volatile concentration compared to the control. Statistically, however, the type of acid (lactic or propionic) did not seem to have an effect on the volatile concentration, although a slight effect was seen with hexanal ($P>0.07$), heptanal ($P>0.112$), 2-heptanal ($P>0.181$), 1-octen-3-ol ($P>0.144$) and nonanal ($P>0.087$). Most volatiles were significantly affected by the amount of acid added, with the exception of 2-methyl furan ($P>0.078$), heptanal ($P>0.012$) and 1-octen-3-ol ($P>0.122$). A similar situation was observed with respect to storage time, with the exception of toluene ($P>0.511$), 1-octen-3-ol ($P>0.237$), 2-pentyl furan ($P>0.321$), octanal (0.310) and nonanal ($P>0.378$). The carbonyl compounds have the greatest impact on flavour owing to their low flavour threshold in comparison with hydrocarbons, substituted furans, and alcohols. This explains the difference in the concentrations obtained, the highest overall concentrations being found for hexanal, octanal, nonanal and decanal compared to the two furans (2-methyl furan, 2-ethyl furan) and the alcohol (1-octen-3-ol). Aldehydes have been found to be the major contributors to the loss of desirable flavours in meats because of their high rate of formation during lipid oxidation and low flavour threshold. The formation of saturated aldehydes (hexanal, nonanal) were two of the greatest. The acid treatment, particularly lactic acid, appeared to induce lipid oxidation as throughout the study time the concentration of hexanal in the control remained lower than the acid treated samples. The contribution of alcohols to the undesirable flavour quality appeared lower than that of the aldehydes, possibly owing to the higher flavour threshold of the alcohols. 1-Octen-3-ol is derived from linoleate oxidation, this did not exceed its threshold until approximately 3 days of chill storage. The contribution of ketones to the undesirable flavour quality appeared even lower than alcohols, as 2-heptanone did not appear in larger concentrations until 9 days of storage at chill temperatures.

Texture: The amount of acid added had no effect in most texture variables, with the exception of a slight effect on cohesiveness ($P>0.136$) and adhesiveness ($P>0.163$). Conversely to previous factors studied, storage time had a considerable effect in all texture coordinates. All acid treatments, even those at 1%, tended to denature myofibrillar proteins, thus having a less cohesive material. This effect became more noticeable during the last days of storage. As proteins denature fibres became tougher, therefore the force required to compress them increased resulting in higher hardness values

Colour: The acid (lactic or propionic) had a strong effect on colour coordinates: lightness ($P>0.0001$), chroma ($P>0.001$) and hue ($P>0.001$). However, the amount of acid added had no effect on hue, but it had on lightness and chroma ($P>0.0001$). Colour coordinates varied considerably with storage time ($P>0.0001$). The acid treated meat appeared pale/grey visually, and propionic acid promoted visual colour fading to a larger extent than lactic acid. Propionic acid scored higher lightness values than lactic acid. As expected there was an increase in lightness as the concentration of propionic acid was increased from 1 to 3% at all days of storage. Lightness values for lactic acid-treated samples were lower than for propionic acid-treated. There was a small decrease in lightness as the concentration of lactic acid increased from 1 to 3%. Over time, storage time increased L values. The control has the lowest value of chroma, but it increases over time. Propionic acid-treated samples have generally larger chroma values than lactic acid ones. Values for chroma in lactic acid-treated samples appear to increase generally over time. With time, the control samples become less intense (hue decreased) no other pattern was visible with the acid treated samples. At 10 days of storage, samples treated with 3% lactic acid and 3% propionic acid had the highest hue values. In general, propionic acid appears to have a milder effect on colour than lactic acid.

Microbial population: Acid type (lactic or propionic had no effect on total plate count ($P>0.346$) and a minor effect on Pseudomonads counts ($P>0.072$). Both microbial populations were consistently lower in propionic acid-treated samples. The inhibitory effect of organic acids is related with the amount of undissociated acids; inside the cell they diffuse through the cell membrane and dissociate leading to a stop in vital processes of the cell. As propionic acid has a pKa 4.87 and lactic acid of pKa 3.86, propionate would be expected to be the more potent antimicrobial since a greater proportion would be dissociated. Although the balance between these factors depends upon the quantity of acid used and the buffering capacity of the food.