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# SHELF LIFE OF FRESH PIG MEAT IS IMPROVED BY APPLYING A HIGH CIRCULAR AND LOW CARBON FOOTPRINT FEED CONCEPT

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## I. INTRODUCTION

The pig industry has increased its interest in studying the role of nutrition in enhancing meat quality. During the grower and late finishing period, the incorporation of more by-products into pig diets supports both sustainability goals and production cost-effectiveness [1], but the potential adverse effects on meat quality parameters, such as oxidative stability and shelf life, should be considered. Although functional feed additives - including high levels of vitamin E, phytogenic compounds, and other antioxidants - positively influences these parameters [2], the precise biochemical mechanisms underlying their effects are not yet fully understood. Moreover, few information exists on whether circular feed ingredients from the food industry can contribute to improved outcomes regarding meat quality. To address these technical uncertainties, the present study was designed, aiming to establish whether improvements in pork meat quality could be achieved by using a combination of functional additives and high proportions of circular feed ingredients. In a subsequent phase, detailed biochemical and nutritional analyses will be employed to elucidate the specific metabolic pathways and interactions responsible for observed changes in fat composition, oxidative stability, and shelf life. By focusing on identification and mechanistic understanding, this research contributes to closing essential knowledge gaps in precision feeding strategies for sustainable pork production. The present study evaluated the effects of the pig diet (control and diet enriched with local agro-industry by-products) and the sex (entire male and female) on the shelf life of fresh pork loins stored in modified atmosphere packaging (MAP).

## II. MATERIALS AND METHODS

As part of a trial on the effects of feeding pigs a high circular and low carbon footprint feed concept, 48 pigs (23 male and 25 female) were randomly assigned to two treatments: Ten males and 13 females were fed a conventional cereal-based diet (“type 1”), while 13 males and 12 females received a circular ingredient-rich diet with functional additives (“type 2”), both formulated by Nijsen and provided from 25 kg up to slaughtering. Pigs were slaughtered the same day in a Dutch abattoir; left loins were vacuum-packed, refrigerated, and sent to IRTA (Spain), arriving 7 days postmortem. Each loin was cut into 8 slices of 1 cm thickness, which were placed in MAP trays (two slices/tray) with 70% oxygen and 30% carbon dioxide. A total of 192 trays (12 loins × 2 diets × 2 sexes × 4 times) were stored at 4 °C under 12 h LED light cycles to simulate commercial conditions. Two trained IRTA technicians evaluated them at 1, 6, 9, and 13 days post-packaging for colour stability (scale 5: stable to 1: unstable) and olfactory quality (5: no defects to 1: evident rancid/microbial activity). Lipid oxidation was measured by the thiobarbituric acid reactive species (TBARS) method by detecting malondialdehyde (MDA) in the last 3 times of shelf life. Total antioxidant capacity (TAC) was analysed with a commercial kit in all the 48 loin samples, just before packaging in MAP. The ANOVA of the data was carried out by using the mixed procedure including repeated measures (except for TAC) with SAS software (v9.4), considering sex, diet, time of shelf life, and their interaction (if significant) as fixed effects.

## III. RESULTS AND DISCUSSION

Results indicated an interaction in the colour stability trait, that shows a better visual appearance of loins from type 2 fed pigs at 13 days of shelf life (Table 1 and Figure 1). Additionally, the olfactory evaluation of loins from type 2 fed pigs revealed fewer defects and indicated an approximate one-day extension in shelf life. For both quality parameters, sex was not significant ($P>0.50$). Regarding the evaluation of lipid oxidation of loin samples, results showed an interaction between feed and time, indicating different dynamics of the loins from both feed types during the storage time. Particularly, the loins from type 1 fed pigs showed higher values of TBARS than those from type 2 fed pigs at days 6, 9 and 13 post-packaging, with higher difference at higher storage time. This could be related to a higher antioxidant potential of meat from type 1 fed pigs. Thus, the meat from type 2 fed pigs would be expected to better endure the oxidation processes during their shelf life. The evolution of lipid oxidation depends on multiple

factors, such as the fat type and content in meat, and the intrinsic traits of the animals like genetics [3]. In this study, the samples with over 0.7 mg/kg MDA showed high rancidity when evaluating their olfactory attributes, indicating relevant lipid oxidation processes. This tendency could be confirmed in further studies, assessing the oxidation of other meat cuts and in meat products, such as minced meat or patties. The total antioxidant capacity showed no differences between males and females, but the feed type was significant, showing the pork from type 2 fed pigs higher values compared those form type 1 (1045 ± 100 vs 977 ± 88 µM Trolox equivalents). These differences were detected despite the variability within each group being relatively high, indicating that TAC could be notably different when comparing individuals from the same group. The interaction between both effects was not detected, and result were in line with those of TBARS.

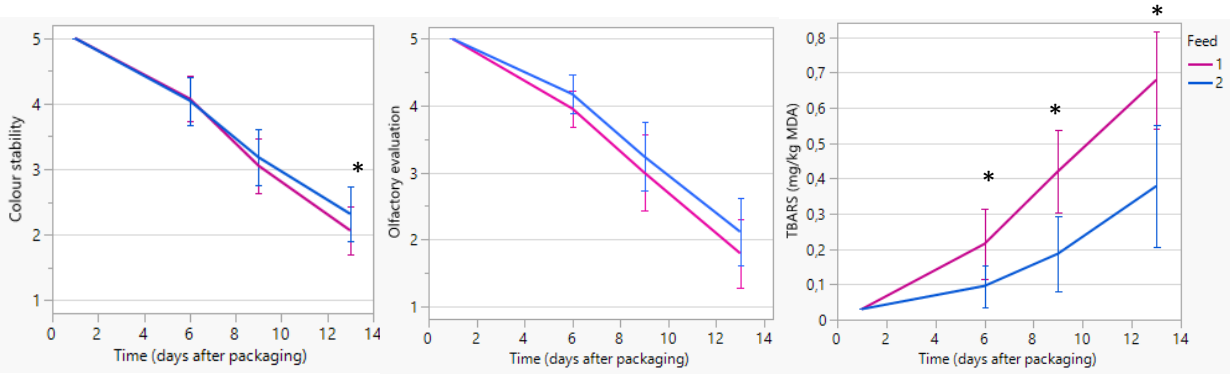



Figure 1. Evolution of colour stability, olfactory attributes and TBARS in loin samples, according to the feed types (*: indicates significant differences at a specific time of shelf life; P>0.50).

Table 1 – P-value from the ANOVA for colour stability, olfactory attributes and TBARS (mg malondialdehyde (MDA)/kg), according to sex, feed, time, and feed*time interaction, and for total antioxidant capacity (TAC; TE: Trolox equivalents), according to sex and feed types.

| | Colour stability | Olfactory evaluation | TBARS (mg/kg MDA) | TAC (µM TE) |
|---|---|---|---|---|
| Sex | 0.802 | 0.075 | 0.179 | 0.970 |
| Feed | 0.252 | 0.005 | 0.004 | 0.017 |
| Time | <0.0001 | <0.0001 | <0.0001 | - |
| Feed*Time | 0.030 | NS | 0.0005 | - |

## IV. CONCLUSION

The results obtained in this study showed that the feed concept based on high circular and low carbon footprint had a positive significant effect on important parameters related to meat stability during shelf life. Thus, this high circular and low carbon footprint feed concept could contribute to prevent food waste and sustainability of the meat chain.

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