

Effect of different packaging methods for preserving and maintenance of fresh reindeer meat

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Reindeer meat

Reindeer husbandry has long tradition and are rooted well in the Sami culture and northern part of Scandinavia. Reindeer meat constitute only a small part, 0.5% of the total production of red meat in Norway. It is assumed that there is a potential for increasing this market share if the availability and product ranges are increased. Reindeer meat is associated with native aspects. It is considered to be natural and healthy as low content of fat (2,5-3,5 % where unsaturated fat constitute approximately 50%)(Wiklund et al., 2001; Sampels, Pickova, Wiklund 2004), favourable fatty acid composition in addition to high degree of vitamins.

Packaging methods

MAP

Active packaging

One of the most rapid changes in the food industry today is the widespread use of plastic packaging materials. In the last third of the twentieth century, flexible and semi-rigid plastic containers have become increasingly common for the packaging of perishable foods such as processed meats, poultry, fish and vegetables,¹ often in combination with modified atmosphere packaging (MAP). Plastic materials may interact with contacting products, and allow mass transport of low molecular weight substances due to their morphology.² The permeability of packaging material to gases and volatiles represents a critical property

affecting the preservation of food products. The exclusion of oxygen is one of the most essential aspects, since oxygen participates in many reactions which affects the shelf life of foods.

Modified atmosphere packaging (MAP) is often used to prolong the microbiological shelf life of foods. The gas-mixture commonly consists of carbon dioxide (CO₂) and nitrogen (N₂). Many Gram-negative, aerobic rod-shaped organisms, such as *Pseudomonas spp* and Enterobacteriaceae are inhibited in their growth by CO₂. The growth of *Pseudomonas fragi* was strongly affected by the CO₂ concentration in the food matrix surrounding the organisms.⁸ Many Gram-positive organisms such as lactic acid bacteria and Brochothrix, are unaffected by the presence of CO₂.⁹ The deterioration of fresh packaged foods depends strongly on the storage temperature. Low temperatures increase the solubility of CO₂ and hamper the growth rate of spoilage organisms, in addition to reduce the permeability of the packaging materials.¹⁰ (8= Løvenadler, 9= rousset, 10= zagory

The antimicrobial effect of CO₂ in modified atmosphere packaging (MAP) of fish and meat has been known for several decades²⁻⁶. Only the CO₂ that is absorbed into the surface of the fish fillet has an inhibitory effect on the bacterial growth. Moreover, the rate of absorption and the amount of absorbed CO₂, and thereby also the shelf life extension, are affected by the partial pressure of CO₂ set by the level of CO₂ in the headspace at the time of packaging and the ratio between gas volume and product volume in the package (g/p ratio).⁷⁻¹¹ The optimal g/p ratio is therefore a considerable higher volume of gas than product in each package, which results in a quite low transport efficiency. In addition to secure high CO₂ absorption, an increased g/p ratio also prevents packaging collapse during storage¹². Additionally, storage temperature, type and content of fat in the product and pH level also affect the amount of absorbed CO₂^{13, 14}.

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Materials and Methods

Reindeer meat

Reindeer meat, rump steak??? (TYPE.....) were delivered by..... The rump steaks were vacuum packed, stored in cartons at°C and transported to Nofima Mat AS (Ås, Norway) within hours after slaughtering.

Packaging

Packaging methods

The packaging methods used in this experiment were 1) traditional MAP, 2) MAP with CO₂ emitter and 3) vacuum packaging. Packaging material for MAP and MAP+CO₂ emitter were 600 ml trays consisted of amorphous polyethylene terephthalate (A-PET)/Polyethylene (PE), sealed with a top web consisting of polyethylene terephthalate (PET)/ (PE) /ethylene-vinyl alcohol (EVOH)/ PE (ESB 65 HFP/AM, Wipak, Nastola, Finland) by using a tray sealing machine (Polimoon 511VG, Promens, Kristiansand, Norway) with 2 cycles of vacuum/gas filling, each consist of 90 % vacuum and 90 % replenishment of packaging gas ?? A pre-mixture of 60% CO₂ and 40% N₂ (Yara AS, Oslo, Norway) was used. The level of residual oxygen (O₂) was < 0.05% after packaging.

Samples stored in vacuum, bags consisting of (PA/PE ??) were used and a vacuum machine Were used .

The reindeer meat was cut in 2cm slices and approximately 280g meat was stored in each package. In all packages a liquid absorber was included, as for the samples packed with CO₂ emitter, the CO₂ emitter was a combined emitter and liquid absorber.

The oxygen transmission rate (OTR) was measured to be..... cm³/package-day (SD) for the APET/PE trays and ,cm³/package-day (SD.....) for vacuum bags measured at 4 °C and 100% humidity inside the package. ¹⁸

CO₂ emitter

The emitter ingredients were based on the emitter amount used in Hansen *et al.*¹⁵ and adjusted to the used gas/product ratio, liquid loss and pH of the reindeer meat in a pre-experiment. The emitters were prepared by adding NaHCO₃ and citric acid to a liquid absorber. The ratio between NaHCO₃ and citric acid was 0.84 per gram NaHCO₃. The CO₂ emitters were vacuum packaged and stored until time of packaging of the reindeer meat. The total weight of the CO₂ emitter (emitter and absorber material made by cellulose fibre) was registered shortly before packaging and sealing.

Storage conditions

The packages were stored at 4°C at Nofima Mat AS (Ås, Norway). The packages were stored until 21 days with sampling after 7, 13, 17 and 21 days of storage. Each treatment consisted of three replicates.

Analyses

Headspace gas analysis

The CO₂ and O₂ level in the headspace were monitored at each sampling time by a CheckMate 9900 O₂/CO₂ analyser (PBI Dansensor, Ringsted, Denmark).

Appearance of the packages

The appearance of the top web of the samples stored in the trays (and MAP) was evaluated by using a scale from 0 to 6 where 0 were defined as packages with extremely

under-pressure (concave), 3 was neutral and 6 were packages with extremely overpressure (convex).

Muscle pH

The pH in the fish was analysed using a Knick pH meter (Knick GmbH & Co, Berlin, Germany) and muscle electrode S/N 5290739 (Mettler Toledo, Urdorf, Switzerland). Each sample was analysed with triplicate measurements.

Liquid loss

The liquid loss from the samples was measured as the weight increase of the liquid absorber pads during storage. The weight of added NaHCO₃ and citric acid were taken into account when calculating the liquid loss for packages with CO₂ emitter. Results are given as % of initial muscle weight.

Colour measurements

The surface colour of reindeer meat was measured on top of the packages before opening. The tristimulus color coordinates were measured using Minolta Chroma Meter CR-300 (Minolta Camera Co., Osaka, Japan) with 8mm viewing port and illuminant D65. Measure values were calculated as CIE (1976) L* (lightness), a* (redness) and b* (yellowness) (Hunter and Harold, 1987). The measurements were performed at each storage time.

Odour and colour Ranking

During the experiment, a six-member panel evaluated the odour and colour of the reindeer meat at each sample time. All samples were exposed in white trays and in order to preserve

the odour each tray was covered by aluminium sheet. The samples were organized in three groups, each consisting of one parallel from all three packaging methods (group 1 = all parallel 1 etc). The samples within each group were ranked from best to worst. The panel analyzed the odour then the colour. The odour was evaluated 2 minutes and colour 10 minutes after opening. Each sample was coded with 3 digit numbers and the order of the samples was randomised for each assessor and the results were evaluated by using Friedman's test.

Cooking loss

Antioxidant capacity

Microbiological analyses

Microbiological analyses were performed on the reindeer meat at the time of packaging and at each sampling time as described in Hansen *et al.*¹⁶. Appropriate 10-folds dilutions were spread in duplicate on following agar plates:

- PCA (Plate Count Agar; Difco, Detroit, MI, USA) for total viable counts
- MRS agar (Difco) pH 5.7 for lactic acid bacteria (LAB)

All plates were incubated aerobically at 30°C for 3 days. The number of bacteria was expressed as colony forming units (CFU) per g.

Statistics

The general linear model included the main effects: weight of the emitter, g/p ratio, number of layers and size of the trays (8 treatments) and their effect on the responses: the % CO₂, appearance score, bacterial growth, liquid loss and pH, analysed using Minitab 15 (Minitab Inc., State College, PA). Additionally, one-way ANOVA was performed within each sampling time and between top and bottom layers for the different responses, and the different emitter variants were ranked by Tukey's studentized (HSD) test. The Pearson's correlation coefficient was calculated for pair-wise comparison of the CO₂ level and appearance score. Differences with $p < 0.05$ were considered to be statistically significant.

Based on the 32 samples measured after 14 days of storage (4 replicates per 8 treatments), a regression model was made, predicting the amount of CO₂. The x-variables in the regression were the weight of fish, the surface area of fish and the amount of added emitter material, gas to product volume ratio (g/p) and volume of the tray. The regression was performed using Partial Least Squares Regression (PLSR)²⁰, and validated with full cross-validation (Unscrambler 9.6, Camo ASA, Oslo, Norway).

RESULTS AND DISCUSSION

Gas composition and appearance

The CO₂ and O₂ level in the headspace were monitored at each sampling time. Monitoring gas composition in modified atmosphere storage experiments of meat is important in order to detect defect packages /leakage in addition to in the evaluation of pigment oxidation and microbial growth. Also, when a CO₂ emitter is used, it is important to monitor the CO₂ content in the packages in addition to the appearance of the packages to evaluate the capacity of the CO₂ emitter. The oxygen level in the MA-packages were low (< 0.05%) in all MA-packages during the storage time (Figure 1). The CO₂ content in the packages had as

expected different profile in MA packages compared to MA packages with CO₂ emitter. In traditional MA-packages the CO₂ content decreased from 57% at time of packaging to 46% after one day of storage and further reduction to 42.2% after 18 days of storage (FIGURE 2) . The initial reduction of CO₂ was probably due to CO₂ absorption by the meat(ref 14 og 15 I kylling artikkel) . For samples stored with CO₂ emitter there were a slight decrease in CO₂ content after 1 day of storage (to 56.3%) followed by an increase to 67.3% at the end of storage time. The reduction in CO₂ content after 1 day of storage was probably due to some absorption of CO₂ by the meat and a slight delay in CO₂ production as the production of CO₂ is dependent of addition of liquid from the food product.

The appearance of the packages (Figure 3) followed the measured CO₂ content as all MA-packages was evaluated as having vacuum effect and the top web was in contact with the meat, while samples packed with CO₂ emitter had slight degree of buckling after 7 days of storage. For the consumers it is preferred to have no buckling as this might be perceived as unpleasant. The capacity of the CO₂-emitter was probably too high and should be adjusted.

pH

The pH in reindeer meat increased from 5.4 to 5.6 during the storage time in all packaging methods. The pH range for the samples were in the same range as reported by Wicklund et al.(2003) According to One-way ANOVA performed at each sampling time no significant differences in pH values among the different packaging methods were detected despite different levels of CO₂ in headspaces (FIGURE 4). The difference in CO₂ absorption in the meat samples did not affect pH differently.

Liquid loss

The liquid loss from the samples was measured as the weight increase of the liquid absorber pads during storage and given as % weight increased per g meat. In order to maintain an

attractive product appearance and to avoid reduction of sensory quality such as juiciness, minimising liquid loss during storage is of importance. In addition the liquid loss at the bottom of a tray may also act as a medium for bacterial growth.

By using an absorbent pad all the liquid may be absorbed depending on the absorption capacity of the pad. However, by using a combined absorber and CO₂ emitter, the liquid will not be visible for the consumer as the liquid will be absorbed by the absorbent pad, i.e. the emitter and the emitter is additionally activated by the liquid.

The liquid loss has been reported to increase with increasing CO₂ concentration in MA packaging of fish (REF 23 og 17 I emitter-artikkel)

The liquid loss was measured to increase in all packaging methods during storage times, with lowest liquid loss in samples stored with CO₂ emitter. Significant higher liquid loss were detected in samples stored in vacuum and traditional MA-packaging (FIGURE 5). These results do not correspond to results reported on packing of fish by(REF 23 og 17 I emitter-artikkel) where increased CO₂ content resulted in increased liquid loss. Higher liquid loss in vacuum packed samples were as expected. FORKLAR MAP = vacuum??

According to one-way ANOVA performed at each sampling time the liquid loss for the vacuum packed samples was significantly higher than in samples stored with CO₂ emitter after 7 days of storage. After 13 days of storage no significant differences were obtained among the different packaging methods while after both 17 and 21 days of storage samples stored with CO₂ emitter had significant lower weight loss compared to both MAP and vacuum. One explanation for the differences between MAP and CO₂ emitter samples could be that in CO₂ emitter samples the available liquid is consumed, in addition to needed for CO₂ production. However, the method for measuring liquid loss from the product, by calculation of the increased weight of the absorber is possibly not the optimal method.

The occurrence of liquid loss during the first day or two is probably most important due to the initiation of the CO₂ production from the emitter, and the differences in liquid loss might have been less the first day after packaging than measured after 7 days.

Meat Colour

The colour of the reindeer meat was evaluated. Only small differences were detected between the packaging methods in all values (L, A and b). The L-value was almost unchanged during storage time for all samples. (FIGURE 6 However, according to One-way ANOVA significant lower L-value were detected in vacuum packed samples after 17 and 21 days compared to MAP and emitter

For samples stored in vacuum a-value increase from 12.9 at start of the storage time to 17.8 after 13 days of storage followed by a slight decrease (to 16.4). After 13 days of storage vacuum packed samples had significant higher a-value compared to both MAP and CO₂-emitter (according to One-way ANOVA), while after 21 days of storage samples packed in vacuum had only significant higher a-value than samples stored with CO₂ emitter. No significant differences were detected in the b-values.

The colour was also evaluated by a panel in a ranking test where the samples ranked according to best (=3) and worst (=1). Only small differences were obtained between the different treatments and after 21 days of storage apparently meat stored in vacuum was evaluated as worse than MAP and Emitter, however according to the Friedman's test based on mean values from 6 assessors and 3 groups (replicates) the differences were not significant (tests based in median values indicates that samples stored with emitter was ranked higher than vacuum packed samples)

Meat Odour

The odour of the meat was also evaluated by a 6 member panel in the same way as the colour.

No significant differences were detected until 21 days of storage where meat stored in vacuum were regarded as worst odour compared to MAP storage.

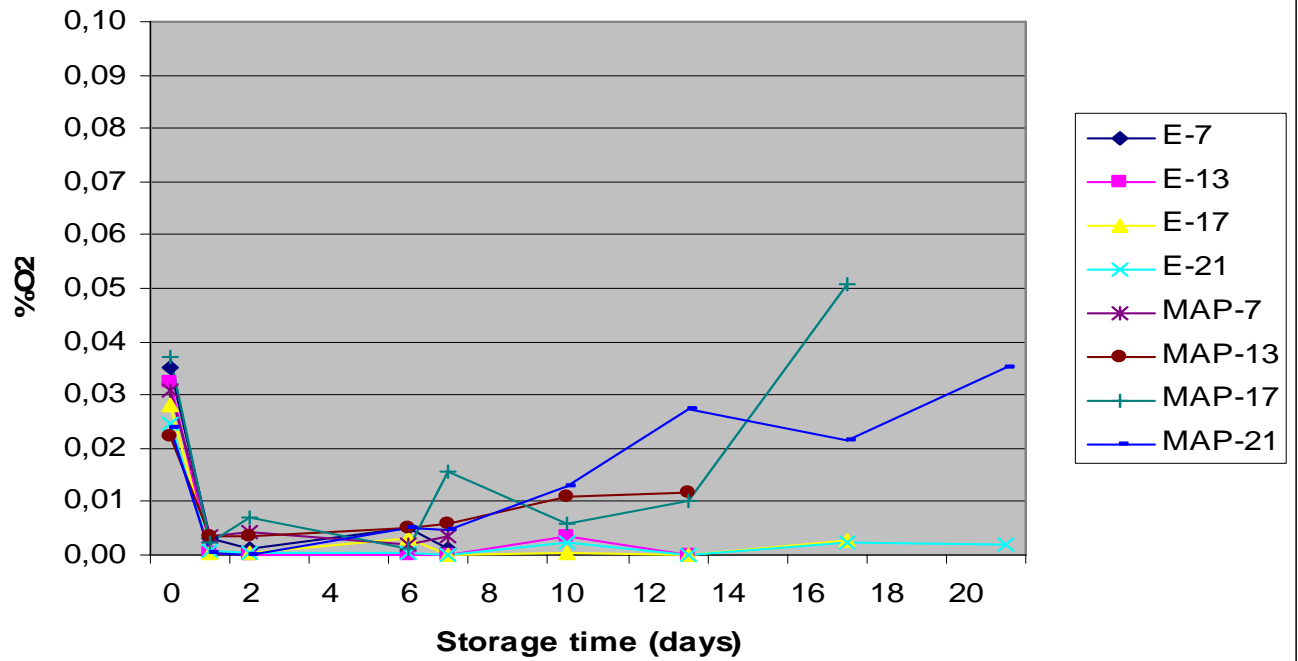
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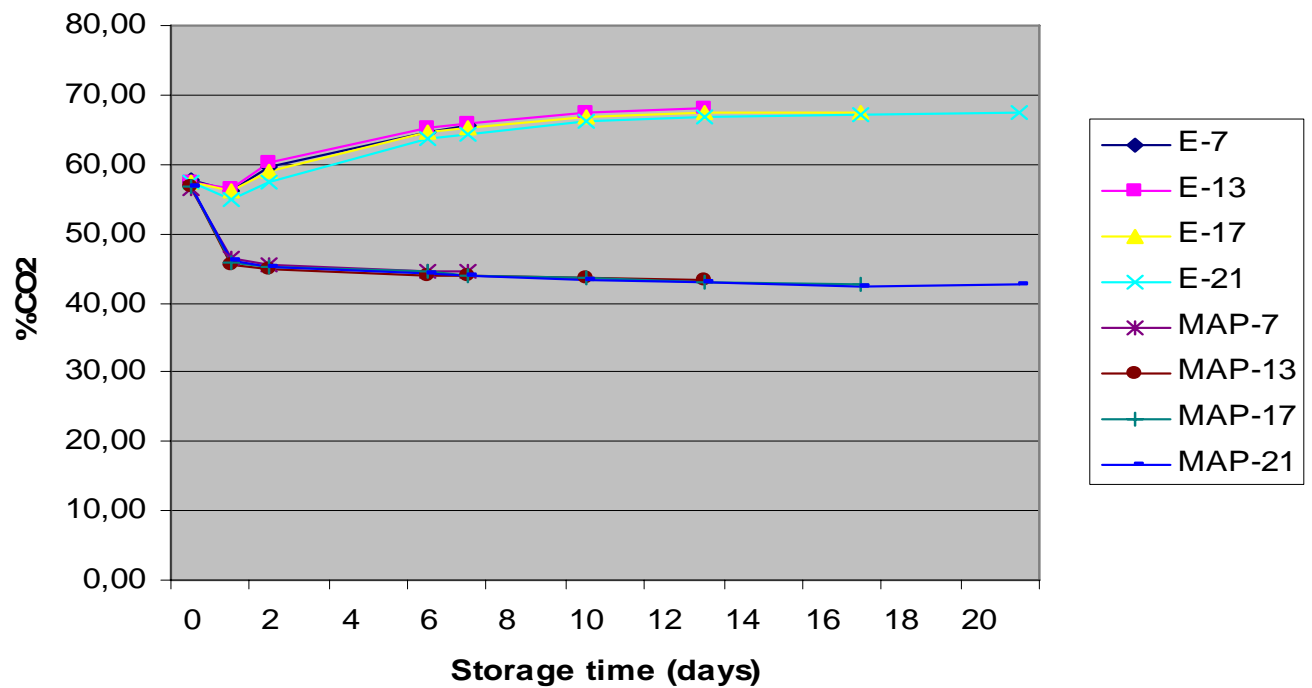
E. Wiklund, L. Johansson, G. Malmfors , 2003, *Food Quality and Preference* 14 (2003) 573–581. Sensory meat quality, ultimate pH values, blood parameters and carcass characteristics in reindeer (*Rangifer tarandus tarandus* L.) grazed on natural pastures or fed a commercial feed mixture

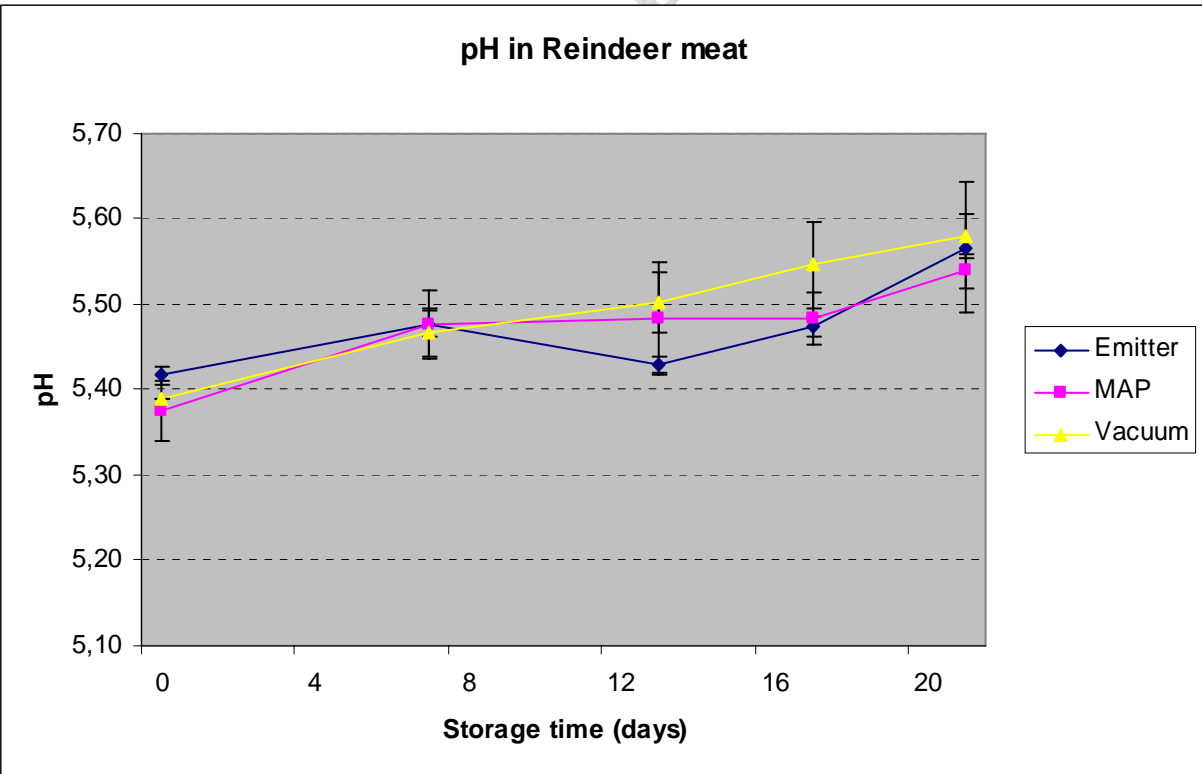
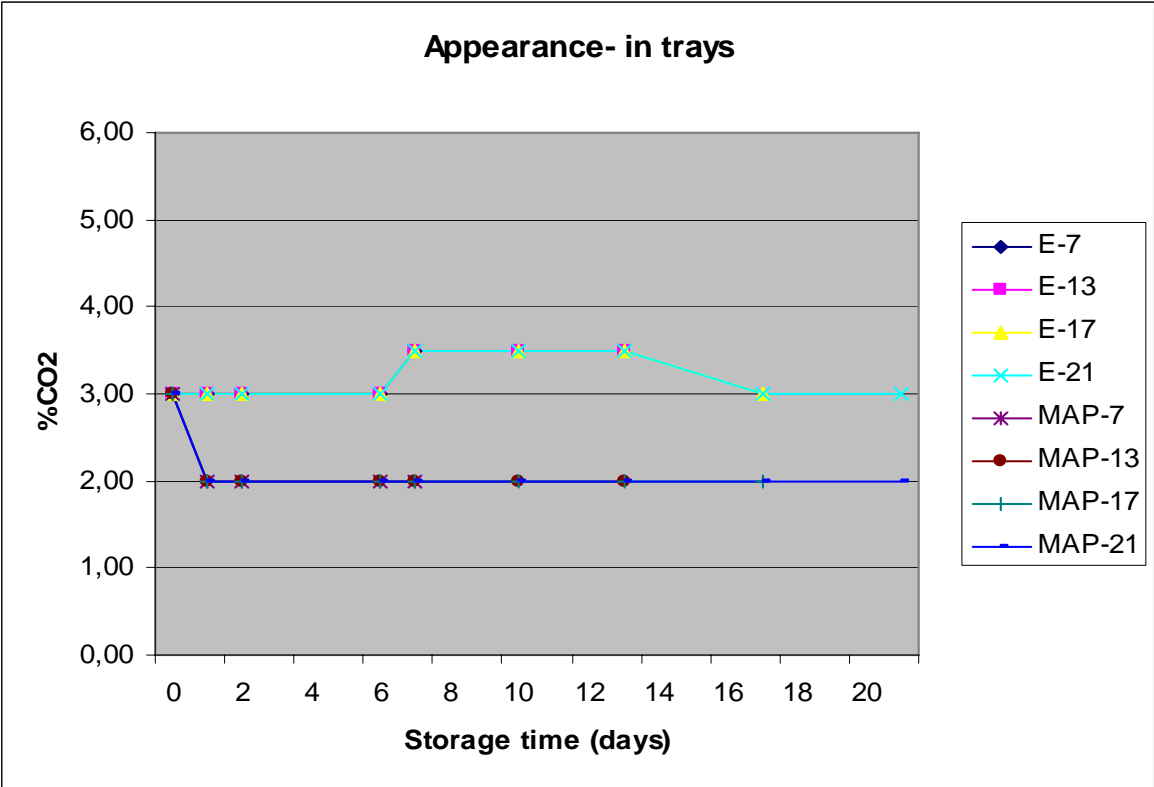
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O2-content in trays

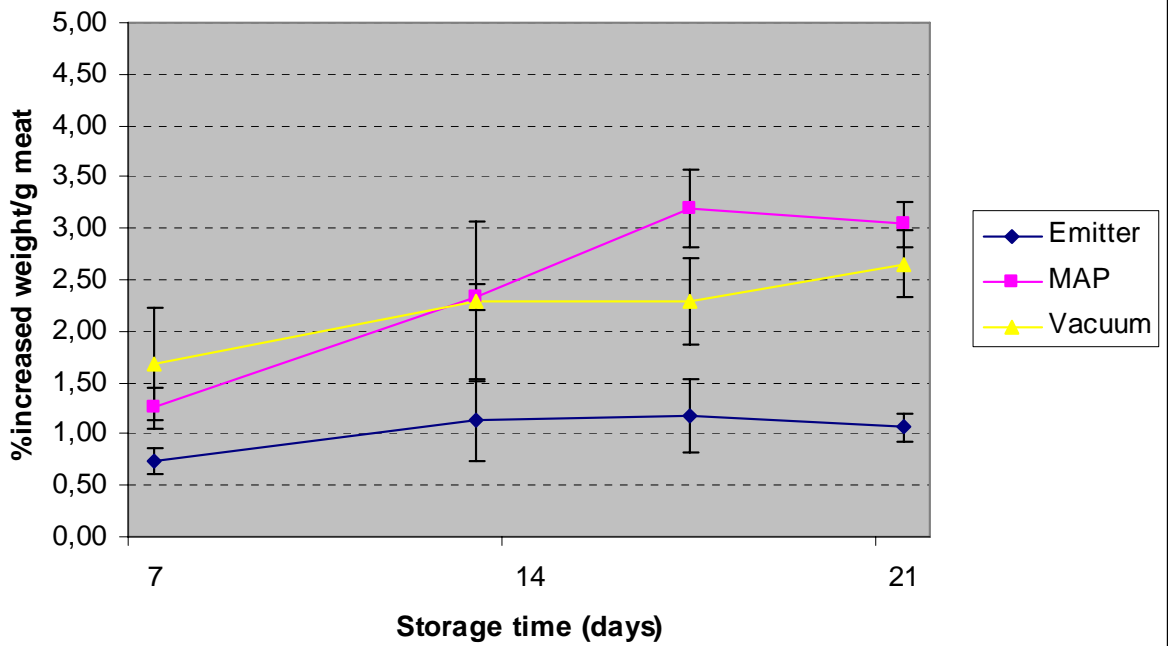


CO2-content in trays

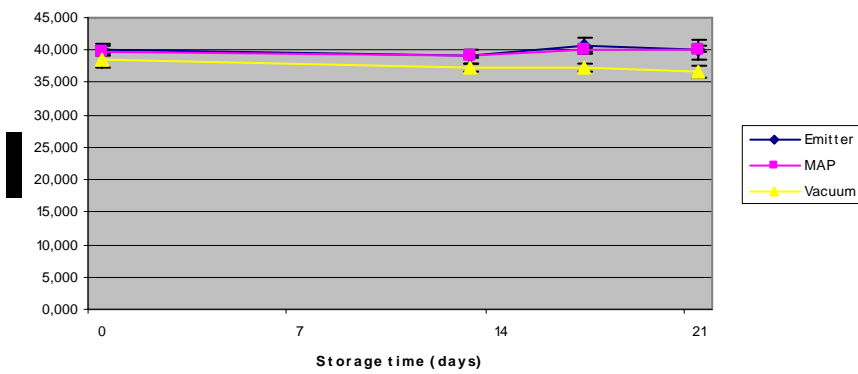




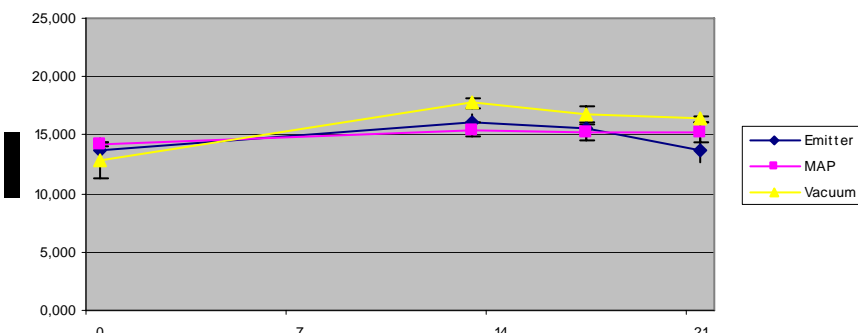
Driploss in Reindeer (measured as increased weight of absorber/g meat)

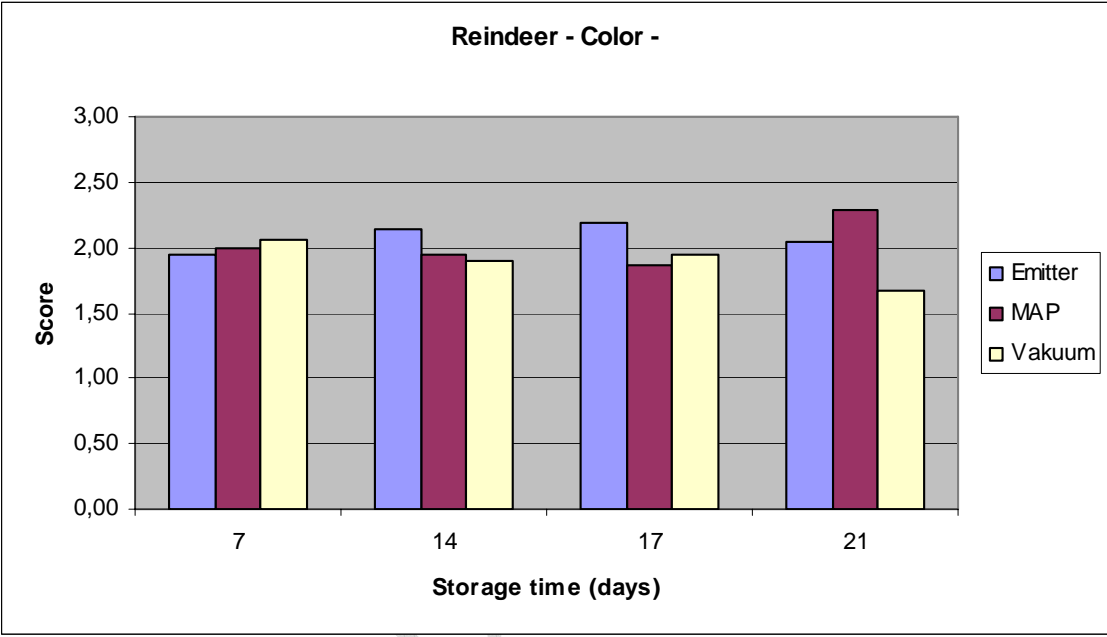


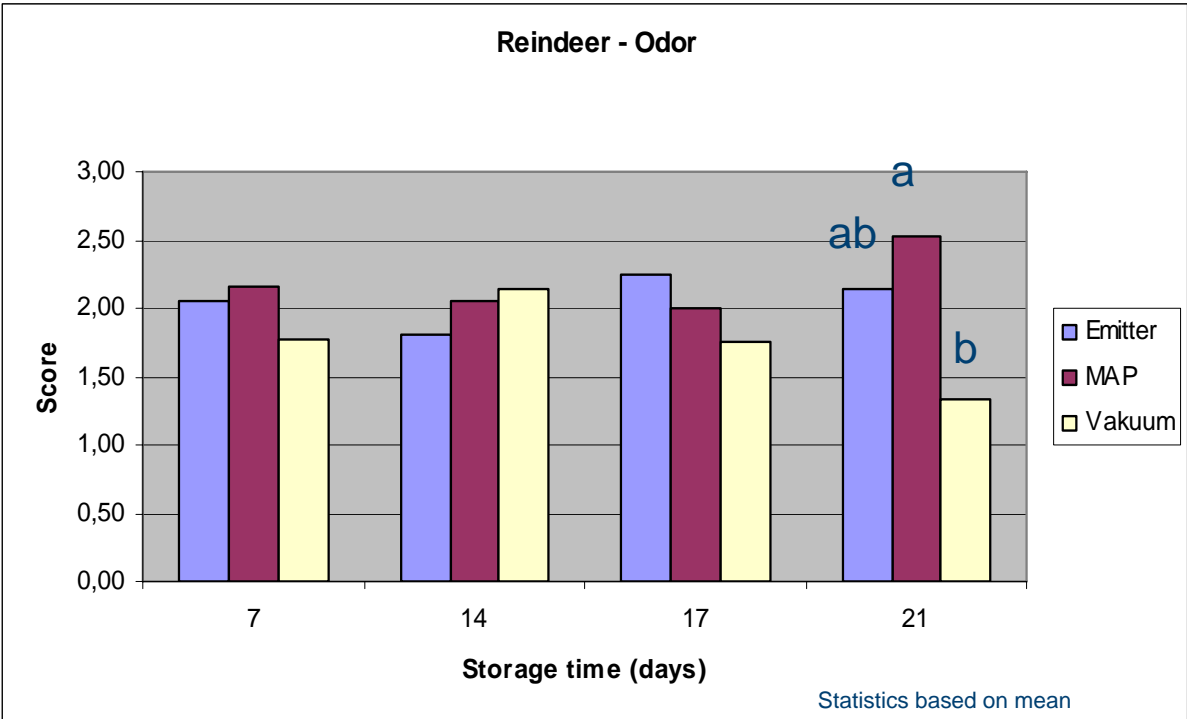
Minolta L-value ; Reindeer



Minolta a-value ; Reindeer







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