Physicochemical quality analyses of Camembert cheese packed in modified atmosphere using perforated film

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ABSTRACT

Camembert is a mould-ripened soft cheese that is highly perishable because of its high nutritionalvalue and moisture content. This study examined the effect of using two different films of different permeability on the physicochemical quality of the cheese samples. The samples were prepared at Cheese cellar, London, and analysed at the science laboratory of London South Bank University, London.The two films used were of the same food grade material i.e. polyethylene terephthalate (PET). One film had perforations (Mp), while the other is a non-perforated film (M). Without perforations, the permeability of the film for water, O_2, $CO_2$and N_2 is 3.9g/m^2 /24hrs at 38^{O}C, 3cm^3/m^2 /24hrs at 23^{O}C, 30cm^3/m^2 /24hrs at 23^{O}C and 3cm^3/m^2 /24hrs at 23^{O}C respectively.

The two set of samples were stored at 4^{o}C ± 0.5 and studied for a period of three weeks. The samples were randomly selected in duplicates on day 0 (of week 1), day 7 (of week 2), and day 14 (of week 3). Changes in the physicochemical properties of the food samples were studied.

The effect of the different films on intrinsic parameters such as the pH, water activity (a_w) and moisture content (Mc) of the food sample was measured.

For sample Mp, there was a steady increase in the pH, while sample M had an initial decrease in pH, followed by a rise in pH. Generally, increase in pH for sample Mp was higher than that of sample M. For both sample groups, there was a steady decrease ina_w, while there was an initial decrease in Mc followed by an increase.

Based primarily on physicochemical evaluation, the use ofthe perforated film (Mp) has a good potential for preserving the keeping quality of the food sample.

1. INTRODUCTION AND LITERATURE REVIEW

Camembert is an important mould-ripened soft cheese which is commonly consumed in many countries for its peculiar taste and nutritional value. An important determinant of the shelf-life of cheeses is their moisture content. It has been noted that cheeses havinghigh pH and moisture content, such as Camembert are very susceptible to microbialspoilage, by moulds, yeasts, and enteric bacteria. (Papaioannou et al, 2007).

Therefore, the extension of the shelf life of this soft cheese, and keeping it fresh for a longer period of time is a matter of importance.

Consumer demands for natural, healthy, preservatives-free products with extended shelf-life, have led food technologists and researchers to develop new packaging concepts. Among these new packaging concepts is the modified atmosphere packaging (MAP). MAP alters the natural gas composition surrounding the product in the package in order to delay deteriorative changes (Air products, 1995; Maria R. B., 2009). MAP technologies increase commercial life of cheeses because they combine the protection against oxidation and dehydration with the inhibition of undesirable microorganisms (Olivares *et al*, 2012)

MAP of different cheese varieties has been studied in the last decades (Rodriguez-Aguilera *et al*, 2011), but scarce information related to MAP of Camembert cheese is available.

The permeability and the transmission rate of the packaging film to O_2, CO_2, and water vapour are among the most essential factors which determine the gas composition in the package, which may

For packaged cheeses, the thermodynamic driving force for water transfer out of the cheese and out of the package depends also on the barrier to moisture that the package offers (Holm, Mortensen, &Risbo, 2006).

The cheese under study is a cylindrical, cream coloured, mould-ripened cheese. Traditionally, Camembert tends to be sold whole in thin, round, wooden containers, but it is also sold in tins, with a ring-pull tab for opening. The product is also commonly wrapped dry in a paper/foil wrapper. These systems of packaging may lead to excessive water loss from the product. On the other hand, using a barrier film that has very low permeability to water will not produce a desirable quality for these cheeses. The Camembert cheese under study does not last more than sevendays after it has been unwrapped, cut andrepacked bythe retailer in a MAP, using non-perforated film.

The shelf life of the Camembert cheese product used in this study could further reduced to three days after unwrapping and cutting it.

The shelf-life of this type of cheese could be extended by allowing water loss, but at a lower rate. Selecting a packaging film with the right permeability to water could be challenging, but

influence the product's deterioration rate (Mullan and McDowell 2003; Church 1994).Therefore, the MAP design for a product requires careful handpicking of the packaging film type and size of packaging for the product (Farber et al. 2003). The changes in water activity (a_w) and moisture content (Mc) that accompanies the maturation and storage of cheeses influences their microbiological and physicochemical properties (Saurel, Pajonk,&Andrieu, 2004). Therefore, the control of a_w and moisture content is very important for the preservation of quality and safety of cheeses.

identifying the correct packaging film for cheeses has been noted to be the key to extending the shelf-life of this type of cheeses (Simal, Sa´nchez, Bon, Femenia, &Rossello´ , 2001). The use of a packaging system with a tailor-made moisture barrier, which allows for water loss, but at a lower rate, is a way of extending the cheese's shelf-life (Pantalea˜o I. et al., 2006**).** MAP applications for a product are developed from different trials and test of different methods (Air product, 1995). The final choice on the packaging film to be used should be made based on vast evaluations and in collaboration with the packaging suppliers (Sandhya, 2010). Although, MAP with 30% CO_2 and 70% N_2) is recommended for soft cheeses, it is not used for mould-ripened soft cheeses (Air product, 1995). Also, perforated films are often used for fresh produce such as fruits and vegetables i.e. this is the first study evaluating the effect of MA and a perforated film on Camembert cheese.

The study examined the effect of using two films of same food grade material (PET), but of different permeability, and a modified atmosphere of 60% CO_2 and 40% N_2on the sensoryand physicochemical quality of Camembert cheese.

2. MATERIALS AND METHOD

The methodology used for the study is described below.

2.1**Food sample preparation**

The samples were collected from the delivery unit of *Cheese cellar*, London, and taken to the production unit (of the same food company), were each was unwrapped and cut into 8 wedges, using a clean wedge line cutter. Thewedges were placed in trays (each wedge weighing approximately 30g).

The packaging trays were then separated into 2 groups.

The Multivac's MAP machine which uses preformed tray and lidding film (PTLF) was used for the sample preparation. TheMultivac's MAPmachine was used to evacuate air from the package and to seal the trays with the 2 different films, after the addition of protective gases (CO_2, N_2)at pre-set levels. The gas mixture used for the study was 60% $CO_2$and 40% N_2.

The samples were then stored at $4^{o}C \pm 0.5$ in the storage room of the factory.Duplicate samples were randomly collected and analysed. The samples were held at ambient temperature during the evaluation of the physicochemical quality of the samples. A two weeks trial study was conducted, before the final three weeks study. The different samples were labelled using different code. Letter *M* was used for the camembert cheese packaged using non-perforated film, while letter *Mp* was used for the camembert cheese packaged using perforated film. Numeric subscripts such as 1, 2, and 3 were used to differentiate samples collected in different weeks (i.e.*1*for day o of week1,*2* for day 7 of week 2, and *3* for day 14 of week 3)

2.2 **Physicochemical analyses**

(a)*Package headspace gas composition:*

Systech's gaspace advance headspace gas analyser was used to analyse the package headspacegas composition. The percentage CO_2, N_2 and O_2in the two set of packages was monitored weekly.

The result, reported as mean value, was used to compare the permeability of the two films to the different gases.

(b) *pH measurement*

The pH value of each sample was recorded using a digital pH meter (Mettler Toledo FE20 Desktop pH Meter), equipped with a glass electrode that was inserted directly into the cheese sample for the measurement.

(c)*Water activity and Moisture content measurement*

The water activity value for the samples was determined usingThermoconstanter novasina TH200 water activity (aw) meter, while the moisture content value for the samples was determined using the AnD ML-50 Moisture Analyser.

The water activity values for each sample was determined at predetermined temperature for 5 min, while the moisture content values for each sample was determined by weight loss via heating at 105 ^{o}C for 10min

3. RESULTS AND DISCUSSION

3.1 Physicochemical analyses of the two set of samples

Changes in the physicochemical attributes (pH, water activity, moisture content) were monitored during storage of the two set of samples.

The headspace gas composition was also measured throughout the period of study. The results are shown below.

(a) pH properties

Preliminary study		
Week	Ma pH	Mpa pH
1	6.05	6.04
2	5.65	6.47
Final study		
Week	Mb pH	Mpb pH
1	5.92	5.83
2	5.65	6.71
3	6.07	6.87

Table 1.*Mean pH of the Samples.*
Ma = samples from preliminary study packed using non-perforated film. Mb= samples from final study packed using non-perforated

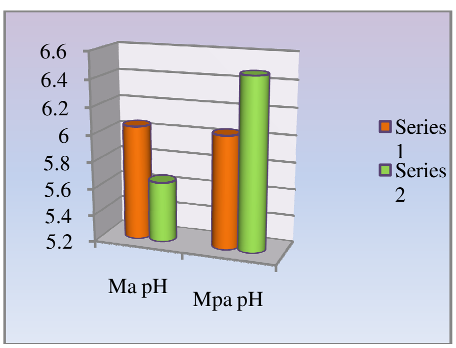


Fig . 1 *Mean pH of sample Ma and Mpa*

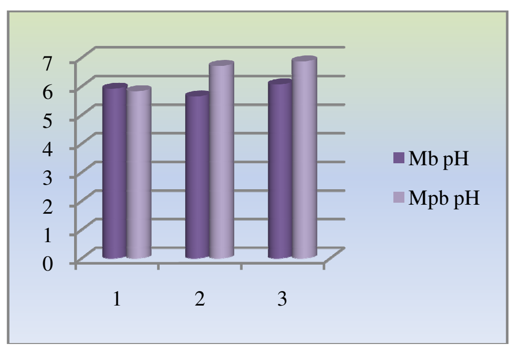


Fig . 2 *Mean pH of sample Mb and Mpb*

(b) Water activity (aw) measurements

Preliminary study		
Week	Ma aw	Mpa aw
1	*0.615*	*0.547*
2	*0.558*	*0.514*
Final study		
Week	Mb aw	Mpb aw
1	*0.716*	*0.676*
2	*0.665*	*0.613*
3	*0.468*	*0.454*

Table 2.*Mean water activity of the samples. Ma = samples from preliminary study packed using non-perforated film, Mb= samples from final study packed*

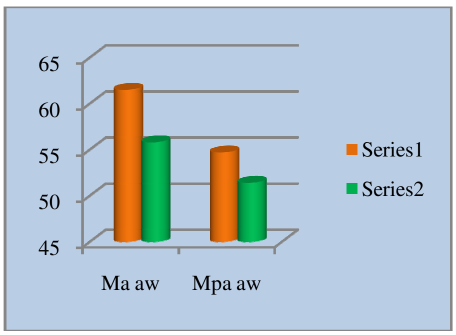


Fig. 3 *Mean water activity of sample Ma and Mpa*

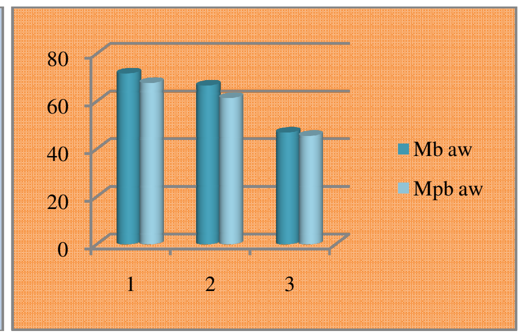


Fig. 4 *Mean water activity of sample Mb and Mpb*

(c) Moisture content(Mc) measurements

Preliminary study		
Week	Ma Mc	Mpa Mc
1	*59.0*	*57.0*
2	*58.0*	*48.8*
Final study		
Week	Mb Mc	Mpb Mc
1	*59.0*	*47.0*
2	*58.0*	*43.0*
3	*98.0*	*77.0*

Table 3. *Mean moisture content of the samples.*
Ma = samples from preliminary study packed using non-perforated film, Mb= samples from final study packed using non-perforated film, Mpa =

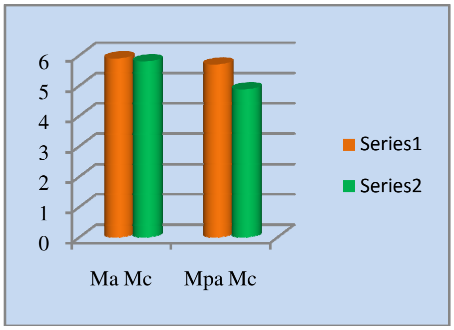


Fig. 5 *Mean Moisture content of sample Ma and Mpa*

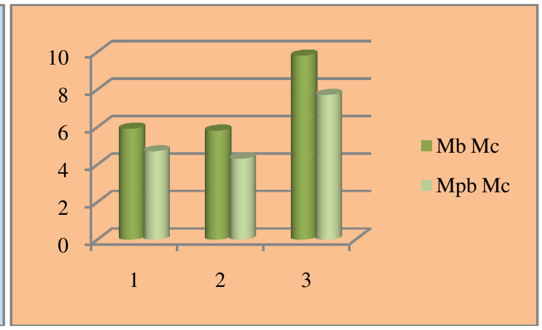
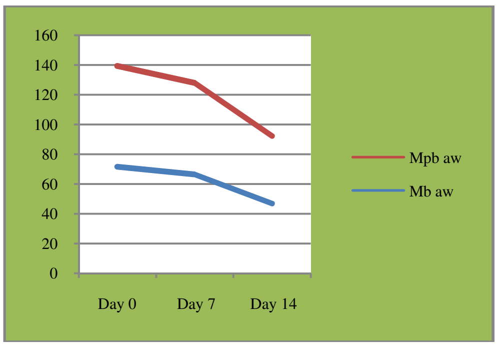


Fig. 6 *Mean Moisture content of sample Ma and Mpa*



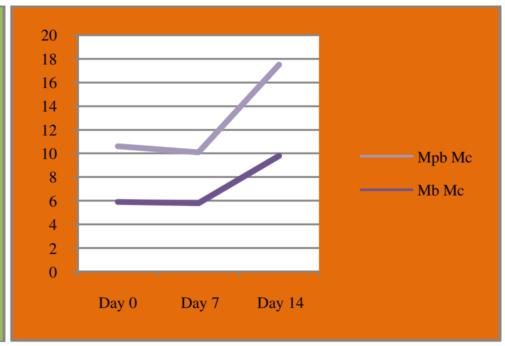


Fig. 7*Changes in water activity (a_w) for both samples M and Mp* Fig. 8 *Changes in moisture content (Mc) for both samples M and Mp*

(d) Mean headspace gas composition of modified atmosphere packaged (MAP) Camembert cheese using non-perforated (M) and perforated (Mp) film

First week	M1a Gas Composition	Mp1a Gas Composition
CO_2%	*62.4*	*1.3*
N_2%	*34.1*	*77.8*
O_2%	*3.59*	*20.9*
Second week	M2a Gas Composition	Mp2a Gas Composition
CO_2%	*66.1*	*0.85*
N_2%	*33.3*	*78*
O_2%	*0.63*	*21.2*

Table 4. *Mean headspace gas composition of sample M and Mp for 1st and 2nd*

First Week	M1b Gas Composition	Mp1b Gas Composition
CO_2%	*61.3*	*3.1*
N_2%	*34.8*	*76*
O_2%	*3.91*	*20.9*
Second Week	M2b Gas Composition	Mp2b Gas Composition
CO_2%	*63.3*	*0.25*
N_2%	*36.1*	*78.9*
O_2%	*0.672*	*20.9*
Third Week	M3b Gas Composition	Mp3b Gas Composition
CO_2%	*57*	*0.15*
N_2%	*41.5*	*77.6*
O_2%	*1.55*	*22.4*

Table 5. *Mean headspace gas composition of sample M and Mp for 1st, 2nd and*

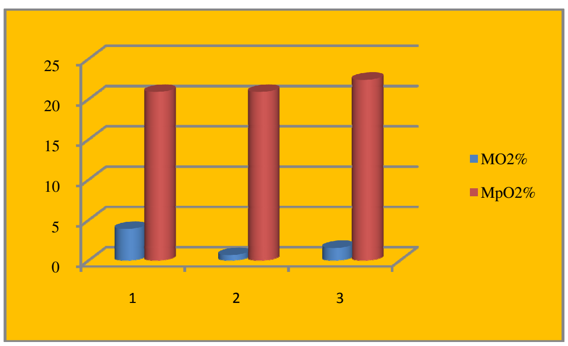


Fig. 9 *Mean percentage Oxygen of sample M and Mp for 1st, 2nd and 3rd week of final study.*

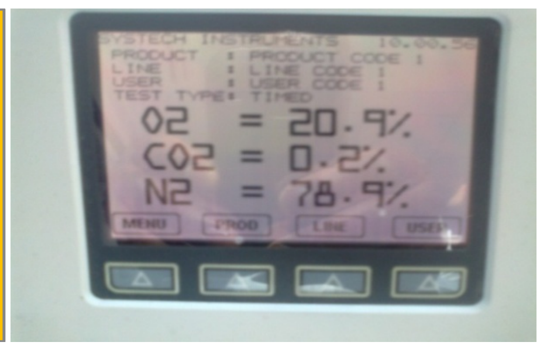


Fig. 10 *Showingthe typical reading of the gas analyser for the package sealed with perforated film, Mp.*

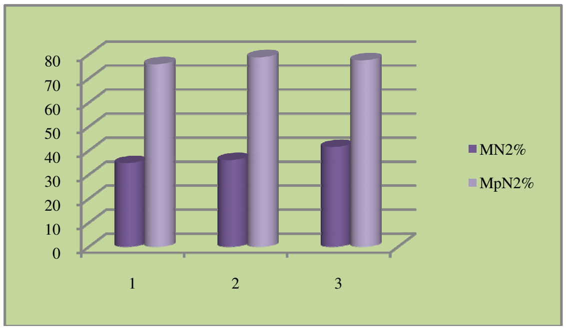


Fig. 11 *Mean percentage Nitrogen of sample M and Mp for 1st, 2nd and 3rd week of final study.*

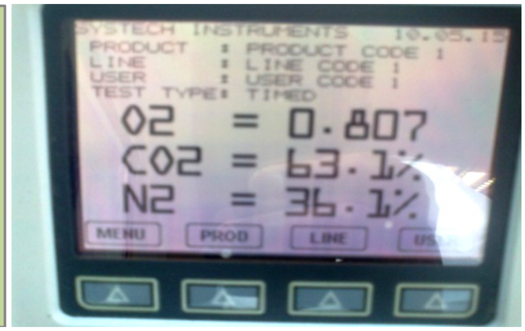


Fig. 12*Showing the typical reading of the gas analyser for the package sealed with non-perforated film, M.*

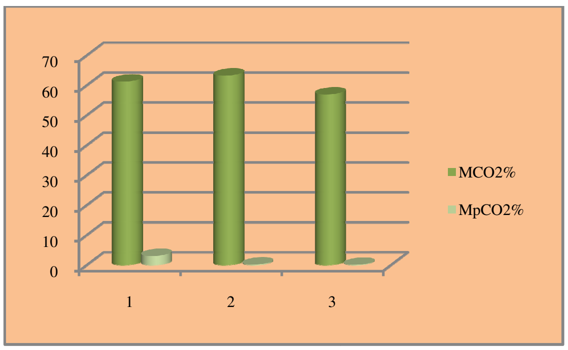


Fig. 13 *Mean percentage Carbondioxide of sample M and Mp for 1st, 2nd and 3rd week of final study.*

Fig. 14*Showing water droplets condensed on the inner surface of the perforated film of sample Mp2.*

(a)*Headspace gas composition:*

As expected, the headspace gas composition (CO_2, N_2 and O_2) for sample Mp was significantly different from the headspace gas composition for sample M, throughout the period of storage i.e. the perforated film was more permeable to the gases. The headspace gas composition for the package with perforated film was nearly that of the normal atmosphere by the third week of final study. *See table 4 and 5.* This difference in transmission rates is attributed to the perforations in the perforated film.

There was significant difference ($P < 0.05$) between the headspace gas composition of the packages sealed with non-perforated film and the packages sealed with perforated film. The package sealed with perforated film ((*Mp*) allowed high amount of O_2 and N_2, The package sealed with non-perforated film has low permeability. It therefore retained the high CO_2 concentration and maintained the low amount of residual O_2.Package Mp on the other hand allowed low amount of CO_2.*See fig. 9, 11, 13 and table 6, 7, and 8.*

(b) *Changes in pH*:

For the cheese samples in trays sealed with perforated film (Mp*)*, there was a steady increase in the pH (increase in alkalinity), while the cheese samples in trays sealed with non-perforated film (M) had an initial decrease in pH (increase in acidity), followed by a rise in pH.*See fig. 1 and 2.*Generally,the pH of sample *Mp* was higher than that of sample *M*, though the difference was not much. This steady increase in pH of sample Mp can be explained by considering the headspace CO_2 composition in the tray sealed with the perforated film. The % CO_2 in trays sealed with perforated film ranged from 0.15 to 3.1, while the %CO_2 in trays sealed with non-perforated film ranged from 57 to 66.1.

The high CO_2concentration in sample *M* was expected to result in a pH drop, which is thought to be associated with the formation of carbonic acid, acidic amino acids, and free fatty acid production during proteolysis and lipolysis, respectively (Dermiki et al. 2008). Farber (1991) also reported pH reduction in food samples, caused by CO_2 atmosphere.The increase in the pH of sample Mp may be attributedto the utilization of lactic acid by *Penicillium* and the release of ammonia as an end product of its proteolytic and deaminating activities(Fox et al, 1993)The pH changes could also be explained by water transmission rates of the two films. The rate of water transmission for the perforated film is presumed to be more than that of the non-perforated film. This could have affected the pH.*See fig. 14*

(c) *Changes in Water activity*(a_w):
Generally, there was a steady decrease in $a_w$for both samples, though not significant to prevent bacterial and fungal growth.The decrease in water activity (a_w)of both samples over the storage period, could be attributed to the proteolytic and lypolytic activities of the primary and secondary microflora of the cheese, which lead to production of several molecules e.g. amines, aldehydes, alcohols, sulphur compounds.Reduction in water activity has been attributed to proteolysis of casein (Schlesser et al, 1992). Also, the lowering of water activity during storagecould be attributed to surface evaporation of water from the samples, through the films(Schlesser et al, 1992). *See fig. 14*

(d) *Changes in Moisture content*(Mc) :
The trend of change in *Mc* was same for both samples, though sample Mp had lower *Mc* throughout the study. There was a slight decrease in the *Mc* of both samples ,between the first and second week of preliminary and final study. Sample Mp had greater decrease in *Mc*, due to the perforations.
Water droplets about to escape can be seen to condense on the inner side of the perforated film in *fig*. 14. This could have resulted in the relatively lower moisture content of sample Mp. On the 14th day of the third week of final study, the *Mc* of sample M had increased appreciably , as compared to sample Mp. This could have contributed to the runny state of the camembert cheese in the tray sealed with the non-perforated film.
This increase in*Mc*maybe due to solubilization of casein,an increase in pH, or both (Schlesser et al, 1992). Also, the mould responsible for ripening couldhave absorbed water for its metabolic activities.

3.2 **Statistical analysis**

The statistical analysis of the sets of data obtained was done using *SPSS* software (version 15). There was significant difference ($P < 0.05$) between the headspace gas composition of the packages sealed with non-perforated film and the packages sealed with perforated film at alpha level of 0.05 and confidence level of 0.95. The results of the statistical analyses as produced by the *SPSS* version 15 software are shown below.

Table 6. *Statistical analysis (Independent Samples Test)for % O_2*

	Barrier_film	N	Mean	Std. Deviation	Std. Error Mean
Gas_Mix_O_2%_Result	*Non_Perforated_Film*	*3*	*2.0440*	*1.67457*	*.96681*
	Perforated_Film	*3*	*21.4000*	*.86603*	*.50000*

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
									95% Confidence Interval of the Difference	
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*Lower*	*Upper*
Gas_Mix_O_2%_Result	*Equal variances assumed*	*1.766*	*.255*	*-17.783*	*4*	*.000*	*-19.35600*	*1.08845*	*-22.37803*	*-16.33397*
	Equal variances not assumed			*-17.783*	*2.998*	*.000*	*-19.35600*	*1.08845*	*-22.82098*	*-15.89102*

Table 7. *Statistical analysis (Independent Samples Test) for % CO_2*

	Barrier_film	N	Mean	Std. Deviation	Std. Error Mean
Gas_Mix_CO_2%_Result	*Non_Perforated_Film*	*3*	*60.5333*	*3.21921*	*1.85861*
	Perforated_Film	*3*	*1.1667*	*1.67506*	*.96710*

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
									Lower	*Upper*
Gas_Mix_CO_2%_Result	*Equal variances assumed*	*1.450*	*.295*	*28.335*	*4*	*.000*	*59.36667*	*2.09517*	*53.54955*	*65.18378*
	Equal variances not assumed			*28.335*	*3.009*	*.000*	*59.36667*	*2.09517*	*52.71021*	*66.02313*

Table 8. *Statistical analysis (Independent Samples Test)for % N_2*

	Barrier_film	N	Mean	Std. Deviation	Std. Error Mean
Gas_Mix_N₂%Result	*Non_Perforated_Film*	*3*	*37.4667*	*3.55293*	*2.05129*
	Perforated_Film	*3*	*77.5000*	*1.45258*	*.83865*

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
									95% Confidence Interval of the Difference	
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*Lower*	*Upper*
Gas_Mix_N₂%_Result	*Equal variances assumed*	*3.583*	*.131*	*-18.065*	*4*	*.000*	*-40.03333*	*2.21610*	*-46.18622*	*-33.88045*
	Equal variances not assumed			*-18.065*	*2.650*	*.001*	*-40.03333*	*2.21610*	*-47.64253*	*-32.42413*

df= degree of freedom, F= F value, N= number of sample mean used, Sig.= Significance, Std. deviation= Standard deviation, Std. Error Mean= Standard error of the mean, t= Independent t-test

4. CONCLUSIONS

The non-perforated film was able to act as a good barrier film in retaining the initial gas mixture, while the perforated film allowed high % O_2 (between 20.9 to 22.4%) and very low % CO_2 (between 0.15 - 3.1%). The non-perforated film allowed low O_2% (0.63 - 3.91%), which is desirable for food products (Air products, 1995) and high % CO_2 (57 - 66.1%).

Initially, it was hypothesized that the non-perforated film would preserve the physicochemicalqualities of the camembert cheese better than the perforated film . However, the final study revealed that the high % CO_2 may not be appropriate for mould-ripened cheese, such as Camembert. The high % CO_2 under the non-perforated film affected the mould used for ripening. At some point during the study few colonies typical of the *Penicillium camemberti* were observed, whereas high yeast and bacterial counts were noticed for the non-perforated film. The suppression of the mould growth may have given rise to successful competition by anaerobic or microaerophilic yeasts and bacteria.

Therefore, it could be concluded from this study that the use of the perforated film has a good potential for extending the shelf-life of the Camembert cheese.

The result of the study is consistent with the reasoning of some specialists on MAP that mould-ripened cheeses should not be preserved using modified atmosphere (Air products, 1995), because the CO_2 may affect the mould growth and hence the quality of the cheese.
The research revealed that low level CO_2 in the range of 0.2 -4% may be desirable for mould-ripened soft cheeses, such as Camembert.

To the best of our knowledge, this is the first study reporting on the use of MAP and perforated film for extension of the shelf-life of Camembert cheese. It must, however, be noted that these recommendations on MAP packaging conditions for Camembert cheese correspond to samples from one food company and thus their general application is yet to be verified.

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