Impact of packaging on the microbiological, physicochemical and sensory characteristics of a “pasta filata” cheese

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A B S T R A C T

The present study evaluated the effects of four packaging technologies (vacuum, 2 types of modified atmosphere packaging [MAP1 = 70% N₂/30% CO₂; MAP2 = 100% N₂] and paraffin) on the microbiological, chemical, physical and volatile organic composition, and the sensory characteristics of typical Sicilian stretched raw milk PDO (Protected Destination of Origin) Vastedda della Valle del Belice (VdB) cheese. The packaging applied did not affect the microbiological profiles of the cheeses. Of the chemical and physical parameters, only pH and water activity (aw) were statistically different among the trials. In particular, the cheeses wrapped in paraffin showed the highest pH value while those packaged using MAP showed the highest aw. The vacuum-packed VdB cheeses were characterised by the highest lightness (L*) value. The cheeses covered with paraffin reached the lowest scores at sensory evaluation, probably because they were characterised by the highest concentrations of the free fatty acids responsible for bitter flavours.

1. Introduction

PDO Vastedda della valle del Belice (VdB) is a stretched (pasta filata) cheese made with raw milk from Valle del Belice sheep without the addition of starter cultures, vacuum sealed, refrigerated and consumed within three months of production (Mucchetti et al., 2008). Packaging of this cheese is necessary to reduce the risk of post-processing contamination, and to ensure its safety and quality. For this purpose, vacuum packaging is commonly applied to VdB cheese in order to reduce oxidative damage (Favati, Galgano, & Pace, 2007). Modified atmosphere packaging (MAP) is gaining importance because it reduces the undesired changes occurring during long-term storage of cheese (Panteleão, Pintado, & Poças, 2007; Papaioannou, Choulia, Karatapanis, Kontominas, & Savvidis, 2007; Romani, Sacchetti, Pittia, Pinnavaia, & Dalla Rosa, 2002), improves the appearance of the final product and maintains freshness (Garabal, Rodriguez-Alonso, Franco, & Centeno, 2010).

The gas mixtures used for MAP applied to cheese include different percentages of carbon dioxide (CO₂), nitrogen (N₂), and oxygen (O₂) (Esmer, Balkir, Seckin, & Irkin, 2009; Gam mariello, Conte, Di Giulio, Attanasio, & Del Nobile, 2009; Garabal et al., 2010). Several studies have shown that MAP containing CO₂ is associated with better protection from the growth of undesirable microorganisms due to the reduction of the microorganism growth rate and also because it confers a direct antimicrobial effect by combatting membrane alterations and enzyme defects (Alves, De Luca, Grigoli, Van Dender, & De Assis, 1996; Daniels, Krishnamurthi, & Rizvi, 1985; Pintado & Malcata, 2000). However, other studies have observed that CO₂ could exert detrimental effects on the aroma and taste of various cheeses (Juric, Bertelsen, Mortensen, & Petersen, 2003; Olarte, Gonzales-Fando, & Sanz, 2001; Romani et al., 2002), and affect the microorganisms responsible foravour development in cheese. In contrast, N₂ acts as an inert filler gas, with no detrimental effects on cheese flavour and composition (Arvanitoyannis, Kargaki, & Hadjichristodoulou, 2011; Colchin et al., 2001).

A recent study carried out by the Authors regarding on vacuum-packed VdB cheese (Todaro et al., 2017) demonstrated its stability up to 180 days of storage. The overall satisfaction of sensory panelists was comparable to that registered for the cheeses at 3 months of storage. In order to improve the presentation packaging which most affects consumer purchase decisions, the aim of the present study was to evaluate the effects of different packaging technologies on the final microbiological, chemical, physical and sensory characteristics of VdB cheeses.
2. Material and methods

2.1. Cheese production, packaging and sample collection

The cheese production was carried out applying the guidelines provided by the Consortium for VdB Cheese Protection in a dairy factory permitted to produce PDO cheeses. The experimental plan included four cheese-making trials carried out in four consecutive weeks. A total of 192 VdB cheeses, 550 g each, were produced, 48 in each packaging category (2 cheeses × 6 storage time × 4 cheese-making processes). After production, all the cheeses were kept at room temperature for 24 h to allow drying and then underwent packaging as follows: 12 cheeses were vacuum-packed (VA); 12 cheeses were packaged using MAP with 70% N₂/30% CO₂ (MAP₁); 12 cheeses were packaged using MAP with 100% N₂ (MAP₂); and 12 cheeses were wrapped in paraffin (PA). The VA, MAP₁, and MAP₂ trials were immersed in liquid paraflin at 40 °C for 10 s and were then left to solidify at room temperature. All the cheeses were stored at 4 °C and were sampled after 15, 30, 60, 90, 120 and 180 d of storage.

2.2. Microbiological analysis

Two hundred and twenty-five ml of sodium citrate (2% w/v) solution were added to the 25 g cheese samples and were homogenised using a Stomacher (Type 400; Seward London, UK) for 6 min at 260 rpm. Decimal dilutions of cell suspensions were prepared in Ringer's solution (Sigma-Aldrich, Milan, Italy) and underwent analysis of the following microbial groups: total mesophilic count (TMC) on plate count agar (PCA) incubated aerobically at 30 °C for 72 h (ISO 4833-1, 2003b); coliforms on violet red bile agar (VRBA) incubated aerobically at 37 °C for 24 h (ISO 4832, 2006); Enterobacteriaceae on violet red bile glucose agar (VRBGA) incubated aerobically at 37 °C for 24 h (ISO 21528, 2004b); mesophilic and thermophilic rod-shaped lactic acid bacteria (LAB) on de Man-Rogosa-Sharpe (MRS) agar, acidified to pH 5.4 with lactic acid (5 mol*L⁻¹) and incubated anaerobically in hermetically sealed jar added to which AnaeroGen AN25 system (Oxoid, Milan, Italy) was added at 30 and 44 °C for 72 h, respectively, followed by Gram stain, catalase and oxidase tests; mesophilic and thermophilic coccus-shaped LAB on M17 agar incubated aerobically at 30 and 44 °C for 48 h, respectively, followed by Gram stain, catalase and oxidase tests; enterococci on rapid Enterococcus agar (REA) incubated aerobically at 44 °C for 48 h followed by catalase and esculin hydrolysis tests (Biorad Hercules, CA, USA); pseudomonads on Pseudomonas agar base (PAB) supplemented with 10 mg/ml cetrimide fucidin incubated aerobically at 25 °C for 48 h; Escherichia coli β-glucuronidase positive on tryptone bile glucuronide Agar (TBX) incubated at 44 °C for 24 h (ISO 16649-2, 2001); sulphite-reducing anaerobic (SRA) organisms incubated anaerobically on iron sulphite agar at 37 °C for 24 h (ISO 15213, 2003c) and coagulase positive staphylococci (CPS) on Baird Parker RPF Agar incubated at 37 °C for 24–48 h (ISO 6888-2, 1999).

Detection of Salmonella spp. and Listeria monocytogenes was carried out on 25 g of each sample by an enzyme linked fluorescent assay (ELFA) using an automatic VIDAS system (bioMerieux, Marcy-l’Etoile, France). The AFNOR BIO 12/23-05/07 method, including a pre-enrichment step in Buffered Peptone Water at 37 °C for 16–20 h, followed by another step carried out using VIDAS Immuno-Concentration Salmonella II (ICS2) applied for Salmonella spp. The AFNOR BIO 12/11-03/04 method was carried out using Half Fraser broth at 30 °C for 24–26 h and then Fraser Broth (FB) at 37 °C for 24–26 h for L. monocytogenes. Furthermore, one portion of the FB culture was used for the L. monocytogenes VIDAS test (LM02). All the culture media were purchased from Oxoid except where otherwise stated. The microbiological counts were carried out in duplicate for all the VdB cheeses produced.

2.3. Chemico-physical analysis

The cheese samples were analysed in duplicate for dry matter (DM), fat, protein (total nitrogen (TN) × 6.28) and ash content according to the International Dairy Federation (IDF) standards [4A (IDF, 1982), 2B (IDF, 1986), 25 (IDF, 1964b) and 27 (IDF, 1964a), respectively]. Salt content was determined using the Volhard method (AOAC, 2000). The pH was assessed electrometrically using the Documet Sartorius pH-meter (Data Weighing Systems, Inc., Elk Grove, IL, USA). Water activity (a_w) was determined according to ISO 21807 (2004a) using the HygroPalm water activity indicator (Rotronic, Basserdorf, Germany).

The measurements of peroxide value regarding VdB cheeses were determined according to IDF standard method 74A:1991 (IDF, 1991); the peroxide value of the cheese lipid was recorded as milli-equivalents of oxygen per kilogram of cheese lipid.

2.4. Surface colour

The colour of VdB cheeses was analysed on the top with a Minolta tristimulus Chromometer CR-300 (Minolta, Osaka, Japan) using CIELAB lightness (L*), redness measurement (a*) and yellowness measurement (b*) values (Hunter, 1975). The measurement of lightness (L* values, range 0–100) represents black to white, the redness measurement (a* values) describes green to red, and the yellowness measurement (b* values) represents blue to yellow. In addition to these attributes, the a* and b* values were also used to determine hue angle and chroma; the hue angle (a*/b*) gives the predominant wavelength responsible for the colour while chroma or saturation (√(a² + b²)) accounts for the vividness or the colour purity. The chromometer was standardised using a white standard plate. The results reported are the averages of five measurements on the same slice of freshly prepared cheese.

2.5. Analysis of the volatile organic component

VdB cheeses were analysed for their volatile organic compound (VOC) composition. The VOCs were determined using the headspace solid phase microextraction technique coupled with gas chromatography with mass spectrometric (GC/MS) detection. Cheese samples, frozen to −20 °C, were grated manually, and 10 g were transferred into a vial and mixed with 10 mL of water, 10 µL of internal standard solution (4.14 g/L 1-heptanol in 20% ethanol aqueous solution) and 1 g of sodium chloride. The vials, clear glass with screw caps with holes with PTFE/silicone septa 27,136 (Supelco, Bellefonte, PA), kept under magnetic stirring, were maintained at 60 °C for 25 min (Carlin and Versini, 2005) and the headspace volatiles were collected using DVB–Carboxen– polydimethylsiloxane (PDMS) fibres (Supelco, Bellefonte, PA) for 30 min at 60 °C. The solid phase microextraction (SPME) fibre was inserted directly into a Finnegan TraceMS for gas chromatography with mass spectrometry (Agilent 6890 Series GC system, Agilent 5973 Network Mass Selective Detector, Milan, Italy), equipped with a DB-WAX capillary column (Agilent Technologies, 50 m, 0.25 mm i.d., film thickness 0.25 µm, part no. 122–7032). The GC/MS analysis was carried out as reported by Corona (2010). In brief, the GC temperature was 40 °C for 2 min (during splitless injection), from 40 to 60 °C (at 4 °C/min), 60 °C for 2 min, from 60 to 190 °C (at 2 °C/min), from 190 to 230 °C (at 5 °C/min), 230 °C for 15 min (injector 250 °C, Fid 250 °C, transfer line 230 °C, carrier helium 1 mL/min; EM 70 eV). Mass spectra were recorded by electronic impact (EI) at 70 eV using ion source temperatures at 200 °C. The scanmode was used to...
detect all the compounds in the range of m/z 33–495 atomic mass units (amu).

Identification of the VOCs was carried out by injection of commercial standards and by comparing their mass spectra with the NIST/ EPI/NIH Mass Spectral Library database (Version 2.0d, build 2005) or on the basis of data available in the literature. Semiquantitative data (µg/kg of cheese) were obtained by measuring the relative peak area of each compound identified in relation to that of the added internal standard. Chemical and physical analyses were carried out in triplicate.

2.6. Sensory analysis

The sensory attributes of VdB cheeses were detected using a panel test (ISO 13299, 2003a) carried out by 6 trained panelists (3 males and 3 females, 25–50 years of age). Approximately 10 g of each cheese sample were placed in coded small white plastic plates and presented to the judges in randomised order. All samples were left at ambient temperature (approximately 20 °C) for 30 min before sampling.

The panelists were asked to evaluate fourteen descriptors regarding the aspect (colour and uniformity of structure), the smell (strength of odor, milk, butter and unpleasant smell), the taste (salty, sweet, acid, spicy and bitter) and the consistency (soft/hard, solubility and grittiness following mastication). After tasting, each panelist rated the overall acceptability of the product. Quality was scored using a line scale anchored on the left (visual analogue scale) with dislike/low quality and on the right with like/high quality. The hedonic scale results were converted as distance (cm) of the mark from the left end of the line.

2.7. Statistical analysis

The microbiological, chemical and physical parameters were analysed with repeated-measures linear analyses of variance (ANOVAs) (generalised linear model (GLM) procedure, SAS 9.1.2 software), which included the fixed effects packaging, storage and cheese-making processes; peroxide value, cheese colour parameters, sensorial descriptors and the VOCs were analysed with a two-factor ANOVA model which included fixed effects packaging and storage. Comparisons among the least-square-means were carried out using the t-test; the differences were considered significant at P < 0.05.

3. Results and discussion

3.1. Microbiological results

The viable cell counts of the microbial groups investigated in the VdB cheeses indicated that Pseudomonas spp., Enterobacteriaceae, sulphite-reducing anaerobic organisms, and coagulase-positive staphylococci were below the detection limits in all the cheese samples while Salmonella spp. and L. monocytogenes were not present (Results not shown). These results are in accordance with European Commission (EC) Regulation No 2073/2005 concerning the microbiological criteria for foodstuffs, both for food safety and process hygiene criteria.

Lactic acid bacteria were detected in all the cheeses and their levels are reported in Table 1. For the majority of Sicilian cheeses which do not utilise a starter culture, this autochthonous microorganisms, necessary to transform curd into cheese (Settanni & Moschetti, 2010), derive from raw milk (Guarcello et al., 2016), animal rennet (Cruciata et al., 2014), traditional wood equipment (Licitra et al., 2007), and the transformation environment (Scatassa, Cardamone et al., 2015), and enhance the stability and the sensory properties of the final products (Guarasi et al., 2017; Scatassa, Gaglio et al., 2015). Recent studies regarding VdB production carried out with the aim of an in-depth investigation of the role of wooden vats on the final characteristics of the final cheeses indicated the possibility of activating ad hoc biofilms with indigenous LAB selected as starter strains (Cruciata et al., 2018; Gaglio, Cruciat et al., 2016), highlighting the importance of the process conditions for this type of cheese. In general, the levels of LAB, except those of thermophilic rods, were significantly different among the cheeses (data not shown), reflecting the variability commonly observed among the production carried out in the same factory on different days (Fitzsimons, Cogan, Condon, & Bereford, 1999; Williams, Choi, & Banks, 2002). However, the packaging did not affect the growth of LAB, and these findings were in agreement with the majority of the studies carried out on this topic (Lioliou, Litopoulou-Tzanetakis, Tzanetakis, & Robinson, 2001; Masotti, Battelli, & De Noni, 2012), even though they were in contrast with the data reported by Favati et al. (2007) who observed a slight reduction in LAB with MAP (70/30 N2/CO2) in comparison to vacuum-packaging conditions.

Within the LAB community, enterococci were registered at almost two to three orders of magnitude lower than other LAB populations. Although enterococci are important for the typicality of ripened cheeses (Foulquie Moreno, Sarantinopoulos, Tsakalidou, & De Vuyst, 2006), their presence has to be evaluated accurately due to their virulence and antibiotic resistant character (Gaglio, Couto et al., 2016). The low levels detected in the VdB cheeses indicated good manufacturing practices and adequate sanitary conditions during production. Although the EC Regulation No 1441/2007 sets no limit on the presence of enterococci in foods (Commission Regulation, 2007), our conclusions were also supported by the finding that the Enterococcus species generally found in this type of cheese were Enterococcus faecium and Enterococcus faecalis (Gaglio, Francesca et al., 2014) which have not been reported as causes of nosocomial infections due to cheese consumption.

<table>
<thead>
<tr>
<th>n.</th>
<th>MAP1</th>
<th>MAP2</th>
<th>PA</th>
<th>VA</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAB mesophilic (cocci)</td>
<td>7.6</td>
<td>7.6</td>
<td>7.5</td>
<td>7.7</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td>LAB thermophilic (cocci)</td>
<td>7.5</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6</td>
<td>0.06</td>
<td>0.78</td>
</tr>
<tr>
<td>LAB mesophilic (rods)</td>
<td>7.4</td>
<td>7.3</td>
<td>7.3</td>
<td>7.5</td>
<td>0.09</td>
<td>0.52</td>
</tr>
<tr>
<td>LAB thermophilic (rods)</td>
<td>6.9</td>
<td>7.0</td>
<td>6.9</td>
<td>6.9</td>
<td>0.09</td>
<td>0.85</td>
</tr>
<tr>
<td>Enterococcus</td>
<td>4.9</td>
<td>5.0</td>
<td>4.9</td>
<td>5.0</td>
<td>0.08</td>
<td>0.82</td>
</tr>
<tr>
<td>Total mesophilic count</td>
<td>6.9</td>
<td>6.8</td>
<td>6.9</td>
<td>6.8</td>
<td>0.13</td>
<td>0.99</td>
</tr>
</tbody>
</table>

### Table 1

Least squares mean values (Log) of viable cell counts of VdB cheeses that had undergone different packaging procedures.

### 3.2. Chemico-physical results

The mean values of the chemical and physical parameters of the cheeses are reported in Table 2. Dry matter, fat, protein, ash and salt content did not differ among the trials whereas pH and aw showed significant differences (P < 0.05). The pH values of the cheeses packaged in paraffin were higher than those registered for the other cheeses while the aw parameter was significantly lower in the paraffin and vacuum trials than in MAP1. The high pH and the low aw found in the paraffin cheeses was probably due to the higher proteolysis activity than in the other trials. In fact, proteolysis plays a defining role in the development of textural changes in the cheese curd, due to the breakdown of the protein network, a decrease in aw, through water binding by liberated carboxyl and amino groups and an increase in pH (McSweeney & Sousa, 2000).

### Table 2

Least squares mean values of chemical and physical parameters of VdB cheeses.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MAP1</th>
<th>MAP2</th>
<th>PA</th>
<th>VA</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>L*</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td>b*</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>0.13</td>
<td>0.99</td>
</tr>
<tr>
<td>CIEL<em>a</em>b*</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>0.16</td>
<td>0.88</td>
</tr>
<tr>
<td>a*</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>b*</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>Lightness (L*)</td>
<td>6.9</td>
<td>6.8</td>
<td>6.9</td>
<td>6.8</td>
<td>0.13</td>
<td>0.99</td>
</tr>
<tr>
<td>Hue angle (°)</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>Yellowness (b*)</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>0.16</td>
<td>0.88</td>
</tr>
<tr>
<td>Redness (a*)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>Chroma (C*)</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>0.16</td>
<td>0.88</td>
</tr>
</tbody>
</table>

The effect of different packaging on colour parameters is reported in Table 2. Lightness (L*), yellow–blue index (b*) and Hue angle were statistically influenced by packaging; the cheese packaged in paraffin was characterised by lightness values statistically lower and Hue angle values higher than the VA cheeses, but showed a b* parameter statistically lower than the MAP1 cheese. The vacuum-packed VdB cheeses showed the maximum lightness; a similar finding was reported for

### 3.3. Surface colour

The effect of different packaging on colour parameters is reported in Table 2. Lightness (L*), yellow–blue index (b*) and Hue angle were statistically influenced by packaging; the cheese packaged in paraffin was characterised by lightness values statistically lower and Hue angle values higher than the VA cheeses, but showed a b* parameter statistically lower than the MAP1 cheese. The vacuum-packed VdB cheeses showed the maximum lightness; a similar finding was reported for

Robinson, 2001; Masotti, Battelli, & De Noni, 2012), even though they were in contrast with the data reported by Favati et al. (2007) who observed a slight reduction in LAB with MAP (70/30 N2/CO2) in comparison to vacuum-packaging conditions.

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different cheeses by Hong, Wendorff, and Bradley (1995) and by Robertson (1993) who found that bleaching could be reduced by vacuum packing, even though the international literature has reported conflicting data regarding the effect of packaging on cheese colour (Khoshgozaran, Azizi, & Bagheripoor-Fallah, 2012).

### 3.4. VOC composition

The VdB cheeses were found to emit sixteen volatile compounds (Table 3), including 7 organic acids, 3 alcohols, 2 aldehydes, and 2 ketones, 1 hydrocarbon, and 1 phenol. Free fatty acids (FFAs) represented the main volatiles identified in our samples, accounting for approximately 90% of the total volatile fraction in accordance with the results reported by Gaglio, Scatassa et al. (2014). According to Verzera et al. (2010), the most commonly represented volatile components in VdB cheese are medium-chain FFAs. The consistent presence of FFAs could be explained by the activity of the endogenous milk lipases resulting from handling practices, mainly due to the pregastric esterase of the lam body n paste used for curdling.

Packaging influenced several VOCs, in particular the organic acids which were found at low levels in vacuum-packed and in MAP cheeses. Short-chain fatty acids, in particular acetic and butanoic acids (repellent, sour, rancid), are the most important flavour notes of cheeses (Berard et al., 2007; De Noni & Battelli, 2008; Hassan, Abd El-Gawad, & Enab, 2013). Hence, the presence of bitter flavours in PA and MAP cheeses might determine a low satisfaction of these samples at sensory evaluation.

Alcohols, aldehydes, and esters are poorly represented, probably because VdB is a fresh cheese and the concentrations of these chemical compounds increase with ripening (Fernández-García, Gaya, Medina, & Núñez, 2004). Among them, cyclic compounds, such as benzaldehyde and 2-phenylethanol, were mostly represented. Benzaldehyde originates from the oxidation of cinnamic acid or phenylacetaldehyde, and generates a bitter almond note (Molimard & Spinnler, 1996); 2-phenylethanol, providing a floral rose-like note to many cheeses (Molimard & Spinnler, 1996), is known to be developed by L. lactis & Spinnler, 1996), is known to be developed by L. lactis and VdB cheeses are mainly fermented by this autochthonous starter LAB species (Gaglio, Francesca et al., 2014; Gaglio, Scatassa et al., 2014).

With regards to the packaging effect, the VA cheeses showed the lowest levels of isovalerylalcohol and benzaldehyde. This finding is due to the lower FFA generation of VA cheeses in comparison to the other trials. Medium-chain FFAs are important components of cheese flavour, not only because they provide the cheeses with the main notes, but also because they act as precursors of other important aromatic components, such as alcohols, aldehydes, and esters (McSweeney & Sousa, 2000). Regarding the MAP cheeses, those stored under carbon dioxide (MAP1) contained higher concentrations of aldehydes and fatty components, such as alcohols, aldehydes and esters (McSweeney & Sousa, 2000). Regarding the MAP cheeses, those stored under carbon dioxide (MAP1) contained higher concentrations of aldehydes and fatty components, such as alcohols, aldehydes and esters (McSweeney & Sousa, 2000). Regarding the MAP cheeses, those stored under carbon dioxide (MAP1) contained higher concentrations of aldehydes and fatty components, such as alcohols, aldehydes and esters (McSweeney & Sousa, 2000).

### 3.5. Sensory findings

Table 4 reports the sensory scores of the descriptors evaluated during taste sessions. “Overall satisfaction” was the only descriptor which differed significantly among the cheeses packaged using different systems. Vacuum-packed cheeses were the most appreciated by the tasters, probably due to the concentrations of the organic acids (Table 3) while the PA cheeses obtained the lowest appreciation by the judges. Sensory analysis is important when considering the packaging system. For this purpose, research and development projects may involve cost reduction, substitution of ingredients, process and formulation changes and packaging modifications without affecting the product characteristics and overall acceptance. However, in this study, sensorial analysis was not able to detect any flavour difference between the cheeses packaged using the different systems. Hence, on the basis of the sole “overall satisfaction” parameter, it would not seem appropriate to propose changing the current system of packaging for VdB cheese.

### 4. Conclusions

This study demonstrated that the four packaging technologies applied to the VdB cheeses did not differ in their influence on the microbiological aspects. Regarding the main chemical parameters, VdB cheeses packaged in paraffin presented the least appreciable final
Different letters indicate statistical differences at P values ≤ 0.05.

Acknowledgments

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References


Table 4

<table>
<thead>
<tr>
<th>MAP1</th>
<th>MAP2</th>
<th>PA</th>
<th>VA</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n.</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>44</td>
<td>47</td>
<td>46</td>
<td>48</td>
<td>1.8</td>
</tr>
<tr>
<td>Uniformity of structure</td>
<td>83</td>
<td>83</td>
<td>82</td>
<td>85</td>
<td>1.9</td>
</tr>
<tr>
<td>Strength of odor</td>
<td>57</td>
<td>55</td>
<td>57</td>
<td>55</td>
<td>2.5</td>
</tr>
<tr>
<td>Odor of butter</td>
<td>47</td>
<td>51</td>
<td>48</td>
<td>47</td>
<td>2.2</td>
</tr>
<tr>
<td>Odor of milk</td>
<td>42</td>
<td>39</td>
<td>43</td>
<td>42</td>
<td>2.6</td>
</tr>
<tr>
<td>Unpleasant odor</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Salty</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>18</td>
<td>1.7</td>
</tr>
<tr>
<td>Sweet</td>
<td>40</td>
<td>38</td>
<td>37</td>
<td>41</td>
<td>2.1</td>
</tr>
<tr>
<td>Acid</td>
<td>18</td>
<td>13</td>
<td>17</td>
<td>17</td>
<td>1.8</td>
</tr>
<tr>
<td>Bitter</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>1.0</td>
</tr>
<tr>
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<td>3</td>
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<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Soft/hard</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>16</td>
<td>2.2</td>
</tr>
<tr>
<td>Solubility</td>
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<td>78</td>
<td>78</td>
<td>81</td>
<td>2.4</td>
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<tr>
<td>Grittiness</td>
<td>11</td>
<td>9</td>
<td>15</td>
<td>11</td>
<td>2.3</td>
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<tr>
<td>Overall satisfaction</td>
<td>56 a</td>
<td>61 ab</td>
<td>57 a</td>
<td>65 b</td>
<td>3.1</td>
</tr>
</tbody>
</table>

characteristics in terms of pH and aw, probably due to higher proteolytic activity. Furthermore, paraffin influenced the content of the FFAs and cyclic compounds, determining the generation of the bitter notes responsible for the scarce satisfaction of the tasters. On the basis of these results, vacuum packaging is confirmed to be the most suitable packaging for VdB cheese.

textural properties of Croton de Chavignol cheese. Food Science and Technology Research, 15, 367–376.


