Carbon footprint of Grana Padano PDO cheese in a full life cycle perspective
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1. INTRODUCTION
The Grana Padano Protected Designation of Origin (PDO) cheese accounting for 24% approx. of total milk output in Italy – with 183,200 tons produced in 2015, is one of the most important cheese of the country [1].

The aim of the present study was to assess the carbon footprint of the Grana Padano PDO cheese with a “from cradle to grave” approach: from production to packaging disposal. The study was submitted for a critical review to an independent certification body in order to verify the compliance with the ISO/TS 14067 [2].

2. MATERIALS AND METHODS
The study involved two dairies (A and B) with 8 and 16 farms respectively. The functional unit (FU) was 1 kg of cheese aged for 12 months. Farm data were collected through farmer interviews, while the other data (from milk collection to end of life operations) were provided mainly by the dairies. Off-farm greenhouse gas (GHG) emissions were estimated following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Tier 1 and 2) [3] [4], the off-farm GHG emissions were done using the SimaPro 8.0 software [5] by the 100-year Global Warming Potential (GWP) [6]. The allocation between cheese and by-products (i.e. cream and whey) was done by mass of proteins and fats as proposed by the Product Category Rules (PCR) Yoghurt, Butter and Cheese published on the International EPD® System [7].

3. RESULTS
The results obtained were 16.02 and 15.84 kgCO₂e FU⁻¹ for A and B respectively (Table 1). The main contributor to the climate change was the production of raw milk (75.3% and 73.9% of the total impact respectively – Figure 1).

Table 1: CF of Grana Padano PDO cheese [kgCO₂e FU⁻¹]

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm</td>
<td>12.06</td>
<td>11.71</td>
</tr>
<tr>
<td>Milk collection</td>
<td>0.29</td>
<td>0.10</td>
</tr>
<tr>
<td>Milk processing</td>
<td>0.49</td>
<td>0.86</td>
</tr>
<tr>
<td>Packaging</td>
<td>0.13</td>
<td>0.19</td>
</tr>
<tr>
<td>Retailing</td>
<td>0.18</td>
<td>0.08</td>
</tr>
<tr>
<td>Use</td>
<td>2.83</td>
<td>2.81</td>
</tr>
<tr>
<td>End of life</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Total</td>
<td>16.02</td>
<td>15.84</td>
</tr>
</tbody>
</table>

The main flow affecting the results was CH₄ from enteric fermentation, its percentage contribution for dairy A and dairy B were 40.8% and 41.5% at farm level and 30.7% and 30.71% throughout the whole life cycle (Figure 2). The other steps of the process (from the raw milk collection through the product processing to the end of life operations) had a smaller impact that was estimated to be 24.7% and 26.1% respectively. The use phase (cooled storage and product waste) played the main role in the GHG emissions of the post-farm steps (17.6% and 17.8% respectively).

4. CONCLUSION
The results showed some critical steps in the life cycle, not surprising the farms activities play the most important role in GHG emissions. This means that focusing on farm phase, the most important GHG reductions could be reached; anyway, all the other steps have to be considered in order to develop a more sustainable production.

Through the critical review carried out with ISO/TS 14067 requirements, this study can be used by the dairy producers involved as a first step to implement an own policy on the climate change issue. In addition to GHG emissions, there are other significant impact categories not discussed in this document such as: eutrophication, photochemical oxidation and acidification [8].

REFERENCES