Ensiling total mixed rations - an innovative procedure

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Introduction

- What is TMR (Total mixed rations)?
- TMR silage
- Humid waste and coproducts in ruminant rations
  - Japan (Nishino et al., 2003; Wang & Nishino, 2008)
  - Iran (Abdollahzadeh et al., 2010)
  - Israel (Weinberg et al., 2011)
  - Finland (Seppälä et al., 2012)
  - China (Hu et al., 2015)
Introduction

- Why ensiling TMR?
  - Better use of humid coproducts
  - Sinergistic effects on the fermentation of forages
  - Improve labor force and machinery use
  - Optimize animal feeding
  - Greater stability in nutrient intake
TMR ensiling in Brazil

1. On-farm production (bunker silos)
   - Optimize use of wet coproducts
   - Concentrate activities and labor force
   - Better food standardization
     - Studies are needed!!!
2. Industrial production

- Focus on marketing

- Large Investments: mixers, packing structure, storage and transport. Nutritionist consulting is mandatory
TMR ensiling in Brazil

2. Industrial production

- Outsourcing feed production:
  - Reduce the need for labor force and investments
  - Standardized quality of the feed
  - Possibility of decrease in production costs
CPFOR trials
1. TMR shelf life: additives and ensiling

- Preservation strategies of TMR in aerobic environments
- Determine maximum period of its use without compromising quality
- TMR (18.7% CP; 72% TDN) was manually prepared – plastic buckets
- Data loggers: every 30 minutes – 10 days
- Tests were carried out in controlled-temperature room (25 ± 1ºC)
Table 1. Aerobic stability (shelf life) of TMR\(^1\) with preservatives or ensiled with *Lactobacillus buchneri*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control</th>
<th>N8</th>
<th>N12</th>
<th>PA5</th>
<th>PA10</th>
<th>PA15</th>
<th>LB</th>
<th>SEM</th>
<th>(P^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter content, %</td>
<td>59.6(^a)</td>
<td>58.9(^a)</td>
<td>58.6(^a)</td>
<td>43.4(^b)</td>
<td>44.0(^b)</td>
<td>43.9(^b)</td>
<td>56.8(^a)</td>
<td>0.42</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Initial pH</td>
<td>4.80</td>
<td>4.92</td>
<td>4.96</td>
<td>4.42</td>
<td>4.42</td>
<td>4.48</td>
<td>4.19</td>
<td>0.18</td>
<td>NS</td>
</tr>
<tr>
<td>Stability(^3) (hours)</td>
<td>42(^c)</td>
<td>46(^c)</td>
<td>44(^c)</td>
<td>77(^bc)</td>
<td>95(^b)</td>
<td>106(^b)</td>
<td>&gt;140(^a)</td>
<td>1.77</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Highest temperature ((^\circ)C)</td>
<td>49.9(^b)</td>
<td>50.2(^b)</td>
<td>49.5(^b)</td>
<td>43.9(^b)</td>
<td>42.1(^b)</td>
<td>41.5(^b)</td>
<td>24.5(^a)</td>
<td>1.12</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Accumulated temp. ((^\circ)C)</td>
<td>183.1(^b)</td>
<td>173.1(^b)</td>
<td>173.8(^b)</td>
<td>107.2(^b)</td>
<td>77.4(^b)</td>
<td>67.6(^b)</td>
<td>0(^a)</td>
<td>2.13</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>DM losses (%)</td>
<td>12.6</td>
<td>14.1</td>
<td>14.2</td>
<td>16.2</td>
<td>15.9</td>
<td>14.1</td>
<td>0.42</td>
<td>2.77</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(^1\)TMR composed by sugarcane bagasse, corn grain, high moisture corn gluten feed, soybean meal, molasses, urea, and minerals.

\(^2\)Control – no additives; N8 – natamycin, 8 g t\(^{-1}\) wet basis (WB); N12 – natamycin, 12 g t\(^{-1}\) WB; PA5 – buffered propionic acid (Profresh Plus TMR & Feed Stabilizer - Micron Bio-Systems Ltd – UK - BPA), 5 g t\(^{-1}\) WB; PA10 – BPA, 10 g t\(^{-1}\) WB; PA15 - BPA, 15 g t\(^{-1}\) WB; LB – TMR ensiled with *Lactobacillus buchneri* (1x10\(^5\) CFU g\(^{-1}\) WB).

\(^3\)Stability – hours to reach 2\(^\circ\)C above room temperature.

\(^4\)Non significant.
1. TMR shelf life: additives and ensiling

Rotten TMR treated with preservatives after 140 h of aerobic exposure

Conclusion 1: Ensiling maximizes stability of air-exposed TMR
2. Additives and storage time of ensiled TMR

- Quality parameters, microbiology and stability
- Microbial additives: Cost-benefit for recovery and stability
- TMR was formulated for dairy cows (25L milk/day) - 15.5% CP; 74% TDN
  - 15 or 60 days of fermentation
  - *Lactobacillus plantarum* or *L. buchneri* – $1 \times 10^5$ CFU g$^{-1}$ WB
  - Aerobic exposure by 9 days (216 h)
Table 2. Variables related to TMR\(^1\) ensiled with no additives (Control) or inoculated with *L. plantarum* (LP) or *L. buchneri* (LB), stored by 15 or 60 days

<table>
<thead>
<tr>
<th>Variables(^2)</th>
<th>Control</th>
<th>LB</th>
<th>LP</th>
<th>P</th>
<th>Effect(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>60</td>
<td>15</td>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>pH</td>
<td>4.70(^b)</td>
<td>4.51(^b)</td>
<td>4.67(^b)</td>
<td>4.39(^b)</td>
<td>4.68(^a)</td>
</tr>
<tr>
<td>DM (%)</td>
<td>41.4</td>
<td>41.6</td>
<td>41.5</td>
<td>41.6</td>
<td>41.4</td>
</tr>
<tr>
<td>IVDMD (%)</td>
<td>84.4</td>
<td>84.0</td>
<td>83.9</td>
<td>83.9</td>
<td>83.2</td>
</tr>
<tr>
<td>N-NH(_3) (%) (% TN)</td>
<td>15.9</td>
<td>16.6</td>
<td>15.9</td>
<td>16.5</td>
<td>16.0</td>
</tr>
<tr>
<td>Fermentative gas production (L t(^-1) DM)</td>
<td>385(^b)</td>
<td>1,265(^a)</td>
<td>342(^b)</td>
<td>1,294(^a)</td>
<td>353(^b)</td>
</tr>
<tr>
<td>Aerobic Stability (hours)</td>
<td>64(^{aAB})</td>
<td>&gt;216(^b)</td>
<td>68(^{aA})</td>
<td>&gt;216(^b)</td>
<td>50(^{aB})</td>
</tr>
<tr>
<td>Aerobic DML (%) (%)</td>
<td>18.4(^a)</td>
<td>1.0(^b)</td>
<td>18.1(^a)</td>
<td>1.1(^b)</td>
<td>23.3(^a)</td>
</tr>
</tbody>
</table>

\(^1\) TMR composed by maize silage, wilted ryegrass silage, grounded corn, soybean meal, corn gluten feed, urea, minerals, sodium bicarbonate.

\(^2\) IVDMD - *in vitro* dry matter digestibility; TN – total nitrogen; DML – dry matter losses.

\(^3\) S – effect of storage period; A – effect of additive.
Figure 1. Fermentation products of ensiled TMR (15 or 60 days of storage)
Conclusion 2: 15 days of fermentation is too short to ensure adequate TMR stability. Storage period should be considered by the industry.

Microbial additives present limited potential for improving the fermentation of TMR.

Figure 2. Daily pH evaluation of ensiled TMR (15 or 60 days of storage) after aerobic exposure
3. Effects of holes in the sealing

- Commercial TMR is usually packed in plastic units from 50 to 1100 kg
- Cylindrical bales wrapped with layers of plastic film seem to be cost effective
- Transportation and storage → holes
- Trial: effect of holes on quality, temperature and microbiology
  - TMR formulated for dairy cows (25L milk/day) - 15.5% CP; 74% TDN
  - 8 cylindrical bales (1000 kg each)
  - Data loggers in the center (2 units each bale) - 15 min
Bales were stored in an open place for 60 days.

10th day → 2 holes of 25 cm² in opposite sides of 4 bales.
Table 3. Variables related to TMR\(^1\) ensiled in round bale silos with or without holes in the plastic film

<table>
<thead>
<tr>
<th>Variables(^2)</th>
<th>Holes</th>
<th>No holes</th>
<th>Mean</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter recovery (%)</td>
<td>96.5</td>
<td>98.5</td>
<td>97.5</td>
<td>0.97</td>
<td>0.129</td>
</tr>
<tr>
<td>DM (%)</td>
<td>41.4</td>
<td>41.8</td>
<td>41.5</td>
<td>0.08</td>
<td>0.063</td>
</tr>
<tr>
<td>IVDMD (%)</td>
<td>84.6</td>
<td>84.5</td>
<td>84.5</td>
<td>0.36</td>
<td>0.968</td>
</tr>
<tr>
<td>N-NH(_3) (% TN)</td>
<td>17.6</td>
<td>17.5</td>
<td>17.5</td>
<td>0.10</td>
<td>0.489</td>
</tr>
<tr>
<td>Lactic acid bacteria (log CFU g(^{-1}))</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>0.23</td>
<td>0.8825</td>
</tr>
<tr>
<td>Yeasts (log CFU g(^{-1}))</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>0.26</td>
<td>0.9380</td>
</tr>
<tr>
<td>Molds (log CFU g(^{-1}))</td>
<td>2.5</td>
<td>1.8</td>
<td>2.1</td>
<td>0.86</td>
<td>0.3076</td>
</tr>
<tr>
<td>pH</td>
<td>4.41</td>
<td>4.23</td>
<td>4.32</td>
<td>0.03</td>
<td>0.016</td>
</tr>
<tr>
<td>Average border temperature (°C)</td>
<td>23.9</td>
<td>22.4</td>
<td>23.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Average center temperature (°C)</td>
<td>23.4</td>
<td>21.9</td>
<td>22.6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\)TMR composed by corn silage, wilted ryegrass silage, grounded corn, soybean meal, corn gluten feed, urea, minerals, sodium bicarbonate.

\(^2\) IVDMD - *in vitro* dry matter digestibility; TN – total nitrogen; DML – dry matter losses.
Figure 3. Room temperature and average temperature inside round bale TMR silos with or without holes in the plastic film.
Conclusion 3: Although air input must be extensively avoided, small holes in the plastic film of TMR round bales do not cause great impact on the overall quality of the material.
4. Consumer perception

- Farmers surveys:
  - 1. Perception of the potential market;
    2. Perception of the effective users of TMR silages
- First survey: online questionnaire (www.milkpoint.com.br)
- Second survey: 12 farms (Paraná, n=9; São Paulo, n=3)
Online questionnaire (n=175)

HAVE YOU HEARD SOMETHING ABOUT TMR PURCHASING?

- Never heard about it: 47%
- Heard something or not sure: 22%
- Yes: 31%
Online questionnaire (n=175)

Could this technology be useful at your farm?

- Yes: 51%
- No: 10%
- Maybe: 39%
Online questionnaire (n=147)

How many months of the year do you believe you could use it?

- Up to 3 months: 28%
- Between 3 and 6 months: 43%
- More than 6 months a year: 29%
Online questionnaire (n=147)

How much you are willing to pay for 1000 kg (wet basis) of 25L-balanced TMR?

- Up to 134 kg of milk: 36%
- Up to 268 kg of milk: 42%
- Up to 401 kg of milk: 15%
- More than 401 kg of milk: 7%
On-farm survey (n=12)
### On-farm survey (n=12)

Table 4. Mean, standard deviation (SD), maximum (Max.) and minimum (Min.) values of on-farm survey data

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Max.</th>
<th>Mín.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of the herd (lactation cows)</td>
<td></td>
<td></td>
<td>160</td>
<td>19</td>
</tr>
<tr>
<td>For what level of production (kg of milk per day) the TMR you have bought is balanced?</td>
<td>30</td>
<td>6.7</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>How many kg of TMR are offered per animal per day?</td>
<td>33.3</td>
<td>12.3</td>
<td>53</td>
<td>15</td>
</tr>
<tr>
<td>What is the average productivity of the cows (kg of milk/day) fed with TMR silage?</td>
<td>23.5</td>
<td>6.7</td>
<td>35</td>
<td>13</td>
</tr>
<tr>
<td>How many months of the year do your animals consume TMR silage?</td>
<td>10.0</td>
<td>3.8</td>
<td>12</td>
<td>03</td>
</tr>
</tbody>
</table>
On-farm survey (n=12)

- Advantages:
  1\textsuperscript{st} - Decrease of labor force
  2\textsuperscript{nd} - Convenience
  3\textsuperscript{rd} - Less investment in machinery and fuel
  4\textsuperscript{th} – Constant feed quality
  5\textsuperscript{th} – Absence of losses
  6\textsuperscript{th} – Focus on other activities
On-farm survey (n=12)

- Disadvantages:
  1\textsuperscript{st} – Lack of competition in the market
  2\textsuperscript{nd} – Freights and distances
On-farm survey (n=12)

Are you interested in keep buying ensiled TMR?
Conclusion

- Ensiling is the most viable technique for TMR commercialize
- The use of additives seems to slightly change quality and preservation of ensiled TMR
- Marketing of ensiled TMR in Brazil is still recent, but with a strong potential of increase in order to meet different profiles of producers.
Thank you for your attention

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