Milk production and carbon footprint in two samples of Italian dairy cattle and buffalo farms

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INTRODUCTION

After the signature of the Kyoto Protocol, Italian Government established to reduce atmospheric greenhouse gas (**GHG**) emissions by 6,5% of GHG of 1990 by 2020 (Law n. 120 of 1st July 2002). FAO (2010) reports that 2.4 kg CO_2eq are associated to 1 kg of Fat Protein Corrected Milk (**FPCM**). The amount of CO_2eq associated to the production of 1 kg of milk (carbon footprint-**CF**) in a dairy farm system of a developed country ranged from 0.6 to 2.2 (Pirlo, 2012).

In Italy there are about 365 thousands Mediterranean Buffaloes. This population increased considerably in recent years, as consequence of the strong worldwide demand of "Mozzarella di bufala campana – DOP (Protected Designation of Origin)", and there is little information about CF of buffalo milk.

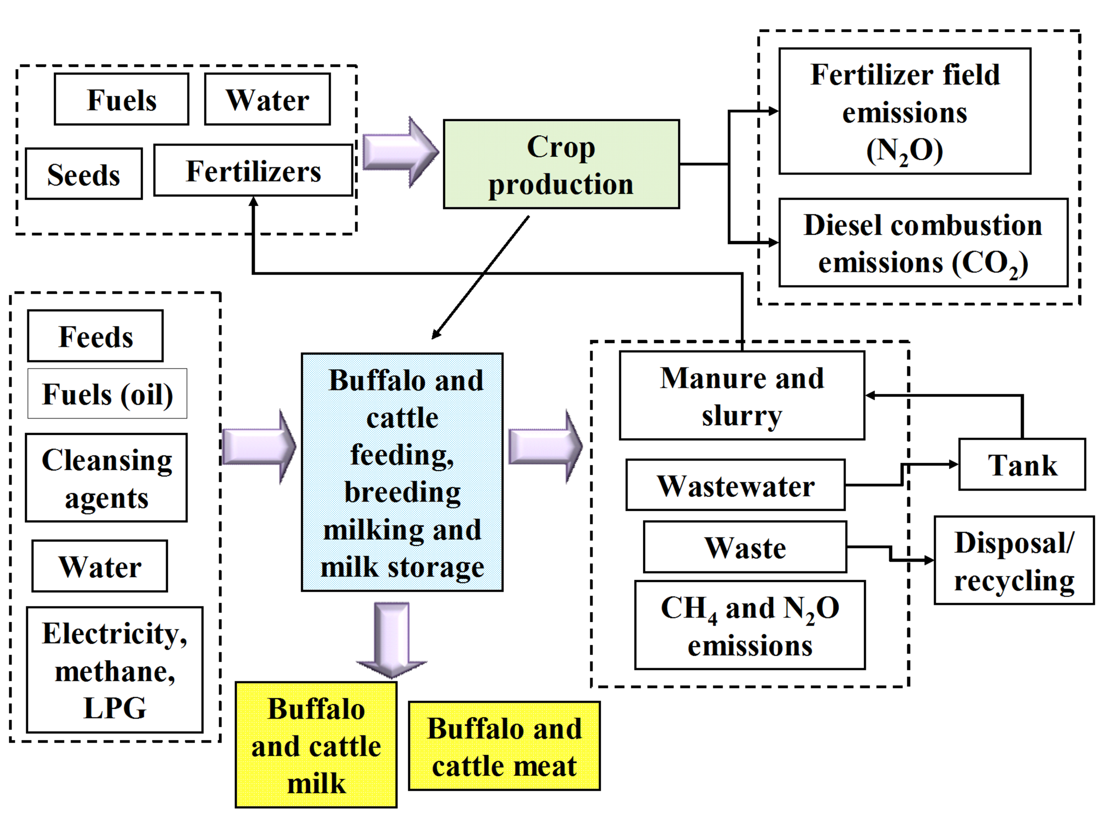
THE AIM OF THIS STUDY WAS TO ESTIMATE THE CARBON FOOTPRINT OF ONE KILO OF FAT AND PROTEIN CORRECTED MILK IN DAIRY CATTLE AND BUFFALO FARMS AND TO POINT OUT THE MAIN DRIVERS THAT INFLUENCE IT.

MATERIALS and METHODS

The **CF** of one kg of buffalo milk was estimated in 6 farms in the "Mozzarella di bufala campana-DOP" production area (Caserta, Italy) and a CF of bovine milk was estimated in a sample of 9 intensive dairy cattle farms in Northern Italy (Lombardia).

❑ ***The system boundaries***
farm gate

❑ ***The functional unit***
1 kg of Fat Protein Corrected milk (**FPCM**).



❑ ***Allocation***: milk production generates co-products (meat, crop commodities, fattening bulls or replacement heifers). To apportion that part, the allocation was made on the basis of co-products **economic value** (ISO, 2006).

❑ ***Impact categories***: the GHG emissions were expressed as global warming potential (**GWP**) in a 100-year time horizon defined as carbon dioxide equivalents (**CO_2eq**): 1 kg CO_2= **1** kg CO_2eq, 1 kg CH_4 = **25** kg CO_2eq and 1 kg N_2O = **298** kg CO_2eq.

❑ ***Greenhouse gas emission***: a simplified **LCA** method was used to estimate the CF: direct CH_4 (enteric fermentation and decomposition of organic matter in manure) and N_2O (denitrification and nitrification of organic N of manure and urine; N of chemical fertilizers) emissions were estimated according to ISPRA (2008) using a TIER 2 as level of approach, the others (direct and indirect CO_2) were estimated considering specific Italian condition.

❑ ***Statistical analysis***: linear regression was used to determine a relation between CF of buffalo and cattle milk and the variables which characterize the production system, by using the procedure PROC REG of SAS 9.1 (SAS Institute Inc., Cary, NC).

RESULTS and DISCUSSION

	Buffalo					Cattle				
	Min	Max	Mean	SD	CV	Min	Max	Mean	SD	CV
Total cultivated area (ha)	10	164	53.17	56.80	0.94	37	138.00	76.63	41.66	1.84
Buffaloes or cattle total (n)	220	465	360.83	103.50	3.49	187	467	320.44	96.85	3.31
% Growing buffaloes or cattle on total buffaloes or cattle (YAP)	43.01	65.34	53.26	8.49	6.27	42.77	57.91	50.99	4.43	11.52
% Cows on total buffaloes or cattle	34.66	56.99	46.74	8.49	5.51	42.08	57.22	49.00	4.43	11.07
Livestock Unit (LSU)	177	388	297	86.79	3.42	153.10	385.00	255.03	80.03	3.19
Stocking rate (SR)/ha	2.37	24.17	10.95	8.37	1.31	2.16	5.43	3.76	1.10	3.41
Lactating buffaloes or cows/LSU	41.10	54.38	47.27	5.69	8.31	34.00	48.00	41.78	5.07	8.24
Maize area (ha/head)	0.00	0.16	0.07	0.06	1.24	0.07	0.16	0.10	0.03	3.35
Grass and legumes area (ha/head)	0.00	0.35	0.07	0.14	0.50	0.006	0.25	0.084	0.077	1.09
Mineral N fertilizers (N-SNF Kg/ha)	3.64	348.81	241.39	126.49	1.91	77.36	162	120.49	30.42	3.96

Table 1. Characteristics of buffalo and dairy cattle farms.

	Buffalo					Cattle				
	Min	Max	Mean	SD	CV	Min	Max	Mean	SD	CV
Total milk production (t/yr)	190.6	413.5	307.3	95.2	3.23	854.9	2,142.4	1,470.9	459.8	3.20
Milk fat (%)	7.63	8.50	8.24	0.36	23.10	3.40	3.99	3.74	0.17	22.39
Milk protein (%)	4.31	4.90	4.57	0.19	23.55	3.30	3.85	3.41	0.18	19.34
Milk production (kg/cow/yr)	4.97	11.95	8.46	2.53	3.34	31.00	44.00	36.44	4.19	8.70
Total FPCM production (t/yr)	292.8	644.5	477.3	143.1	3.34	824.3	2,084.6	1,432.7	442.9	3.23
FPCM production (t/cow/yr)	2.18	5.14	3.56	1.11	3.22	9.16	12.84	10.81	1.24	8.70
FPCM production (t/LSU/yr)	1.13	2.61	1.66	0.52	3.22	4.58	7.90	5.67	0.96	5.90
Total meat output (t BW/yr)	5.90	31.50	20.98	10.69	1.96	23.45	82.00	44.83	18.23	2.46

Table 2. Milk characteristics of buffalo and dairy cattle farms.

Carbon footprint

	Buffalo					Cattle				
	Min	Max	Mean	SD	CV	Min	Max	Mean	SD	CV
Total CO_2 eq emissions (t/yr)	1,051	2,434	1,828	571	3.20	1,082	2,921	1,917	570	3.36
kg CO_2 eq/yr/kg FPCM	2.27	5.01	3.93	0.96	4.10	1.22	1.65	1.35	0.13	10.77
kg CO_2 eq/yr/kg FPCM (ea)	2.22	4.69	3.76	0.89	4.22	1.08	1.47	1.24	0.11	10.85
kg CO_2 eq/yr/kg BW output	2.05	6.26	4.00	1.39	2.89	2.42	5.11	3.49	0.94	3.71

Table 3. Carbon footprint (expressed as kg CO2 eq/yr) of buffalo and dairy cattle farms .

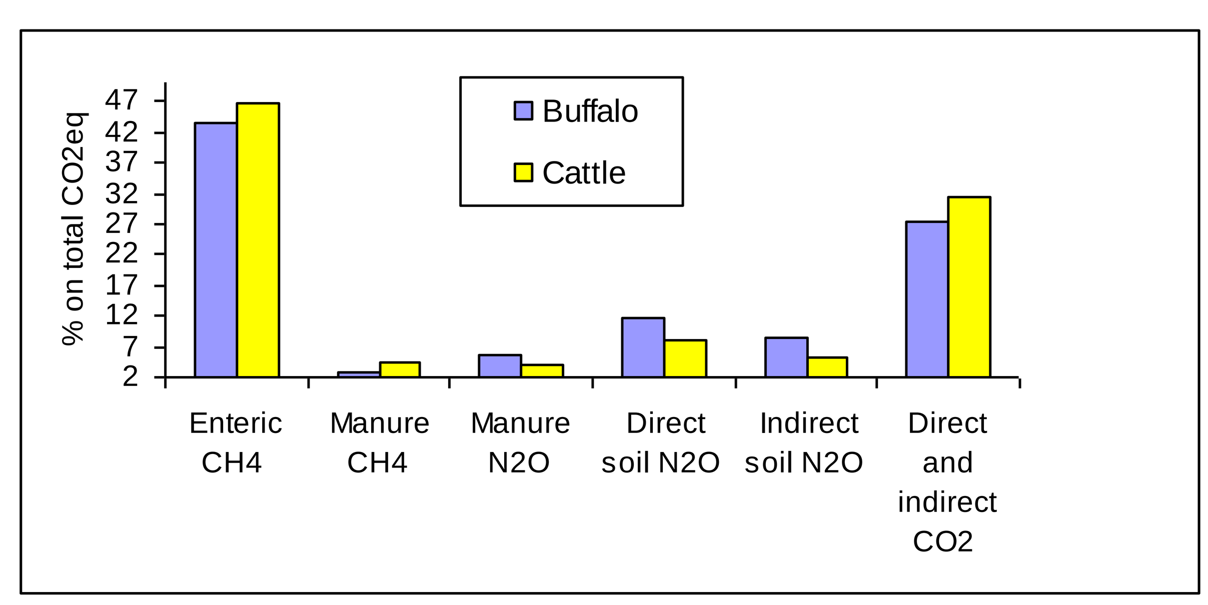


Figure 1. Contribution of CH_4, NO_2 and CO_2 to carbon footprint.

Table 4. Determination coefficient of linear regression between CF and some variables .

Variables	R^2	
	Buffalo	Cattle
FPCM/LSU	0.95	0.28
Farm size (FS)	0.039	0.04
Syntetic N-fertilizers/ha (N-SNF kg/ha)	0.12	0.02
Livestock unit (LSU)	0.11	0.02
Livestock rate (SR/ha)	0.003	0.02
Direct energy consumption (DEC/head)	0.10	0.09
Percentage of young animal (YAP)	0.11	0.28
YAP+DEC/head+FPCM/head	0.98	0.42

CONCLUSIONS

CF of buffalo milk is largely explained by productivity. This could imply that effective reduction of GHG emission can be obtained through breeding and feeding strategies aimed at improving milk production. In the sample of dairy cattle farms there is no single parameter that satisfactory explains CF. R^2 is 0.42 only if the parameters concerning production, herd composition and energy consumption are considered simultaneously. This could imply that increase of productivity is little effective for reducing GHG and that strategy to reduce GHG in dairy farms should consider several aspects of production system.

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