Mountain forage system management and dairy product quality

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Abstract
The intensification of farming practices is putting at risk the efficiency and sustainability of mountain forage systems and their social, cultural and environmental values. This paper highlights how mountain dairy farms should be of low-intensity in terms of external inputs and should base their feeding strategies on local forage resources. The possibilities of utilizing grazing in summer and of producing high quality nutritional feed stock for the winter period (by cutting local forages at an early stage of growth and conserving them as wrapped haylage) have beneficial effects on production costs, animal health and productivity and quality of dairy products. Furthermore, using high quality forages all year round can contribute to reduce the use of purchased off-farm feeds, to link dairy products to their '*terroir*' origin and to preserve the high natural and biodiversity value of mountain dairy farms.
Keywords: forage systems, milk quality, grassland environmental values

Introduction
Following models of farming system intensification was one of the factors affecting the decline of mountain dairy systems in several areas of EU putting at risk a range of social, cultural and environmental values (Beaufoy, 2017). In the European Alps 40% of all farm holdings were abandoned within the past 20 years and almost 70% of the farms still operating are run as a secondary source of income (Tabacco et al., 2011). At a farm and local landscape level, the tendency reported in many regions in recent years is to abandon semi-natural pastures and to concentrate stock on more productive lowland, with increased intensification on this land (Beaufoy, 2017). These systems are found mainly in marginal areas where physical factors, and in some cases social factors, have prevented intensification of land-use. Specialization in agricultural systems has resulted in decoupling of cropping and grassland systems and livestock production disrupting within-farm nutrient cycling leading to large nutrient imbalances and excessive nutrient accumulation (Sulc and Franzluebbers, 2014).
A wide range of semi-natural habitats (with high species diversity and unique species communities), as well as habitats that are less natural, but nevertheless are the main refuge for a significant number of farmland species (Keenleyside et al., 2014). Several of these habitats, which are amongst the most important for biodiversity in Europe, are included and maintained by dairy farms in mountain areas (Van Dorland et al., 2008). These dairy farms are required to be of low-intensity in terms of external inputs and should be based on feeding strategies predominantly based on semi-natural forage resources produced on-farm (Borreani et al., 2007; Revello-Chion et al., 2010), and supplemented to a lesser extent by purchased fodder and feeds. Furthermore, the local forage based diets are part of the basic link between dairy products and their original '*terroir*', a notion at the basis of the PDO labeling and image of the product quality from sensory, nutritional, or healthy point of view (Coppa et al., 2015; Giaccone at al., 2016). In this context, maintaining environmental and economic sustainability of such dairy farms is a key factor for an efficient use of grassland resources and provision of their ecosystem services.

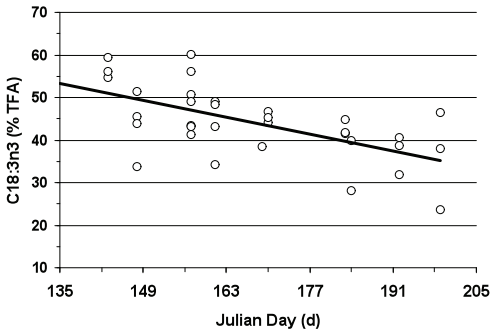
Linking quality traits to the production environment
The forages are known to confer specific organoleptic and nutritional qualities to the milk products (Martin et al., 2005; Giaccone at al., 2016) and to provide a value added to the product, that could

justify its higher price and offer the consumers a healthy image of the mountain environment. Feeding animals with fresh herbage instead of conserved forages and/or concentrates induces a general improvement of nutritional properties of animal products (healthier fatty acids (FA) composition, higher antioxidant concentration), a difference in sensory properties (yellower and softer products, with richer sensory profile) and a potential increase in product shelf life (Coppa et al., 2017), while linking more strictly the product to their origin of production. Unfortunately, in mountain dairy farms of Italy extensive grazing could be only performed in the summer period (3 to 4 months), whereas confinement feeding are practiced over a large part of the year (8 to 9 months).

Increasing content of healthy FA in dairy products

The healthy image of grassland-based dairy products is confirmed by several studies, that have revealed high contents of beneficial functional FA in those products derived from Alpine grazing systems (Coppa et al., 2013). Among the fatty acids, studies reported that the conjugated linoleic acid (CLA) has a wide range of healthy effects, like anticarcinogenic and antiatherosclerotic effects (Parodi, 2004). The most beneficial FA profile to human health and the higher amounts of terpenes are obtained during summer season, when cows grazed mountain pastures (Revello-Chion et al., 2010). However, a large portion of the milk and cheese are produced in winter and early spring periods, when cow diets are mainly based on hay (locally produced or purchased) and concentrates. The concentration of healthy FA in milk and dairy products is mainly due to polyunsaturated FA (PUFA) concentrations in the diet. The forages, despite their low lipid concentration, are an important source of PUFA for dairy cow. Sources of variation in the FA concentration of forage are plant species, leaf-to-stem ratio, stage of maturity, weather, and fertilizer regime (Revello-Chion et al., 2011). The α-linolenic acid (C18:3 n-3), the main precursor of the beneficial FAs to human health present in milk fat, decreased during the growing stages in herbage samples of semi-natural meadow in Italian Alps (Figure 1; Revello-Chion et al., 2011), implying the need of an early utilization even when forages are used to produce winter feeding stock (Coppa et al., 2015).

Figure 1. Evolution of C18:3n3 in fresh herbage during first growing cycle of grassland at 1400 m a.s.l. in Italian Alps. Julian day: 135 = May 15 (from Revello-Chion et al., 2011).



Improving nutritional quality of conserved forage

Field-cured hay is currently the main preservation system used to produce conserved forages, and is normally harvested at a late stage of maturity. Due to the high mechanical losses and frequently rain damage, the hays resulted to be poor in quality and, consequently the winter milk production needs to be supported with concentrates purchased from outside the production areas (Borreani et al., 2007). Wrapped bale haylage has proved to be a good alternative to move from haymaking to silage technology on small-to-medium farms in the lowlands, since it can easily be mechanized and can be harvested with the same equipment that is used for field-cured hay, with the only addition of a plastic wrapper. For those production chain in which a ban on silages does not exist, wrapped bales at low moisture content (haylage) could provide high nutritional quality forages during the whole year and contribute to reducing feeding costs (Tabacco et al., 2011; Borreani et al., 2013), without

altering cheese-making technological aspects (e.g. late blowing) (Borreani et al., 2007). Cutting the forage at an earlier stage of growth than normally made for haymaking, wilting it in the field to a 50% DM and preserving it in wrapped bales allow to obtain a forage that have 50% more protein and 20% less NDF than traditional hay (Figure 2), without substantial reduction in annual DM yield (Table 1).

Figure 2. Evolution of crude protein (A) and NDF (B) during first growing cycle of grassland at 1400 m a.s.l. in Italian Alps (full line, black symbols) and relation with DM content at harvesting for an early (circle) and a traditional (triangle) cutting times (dotted lines).

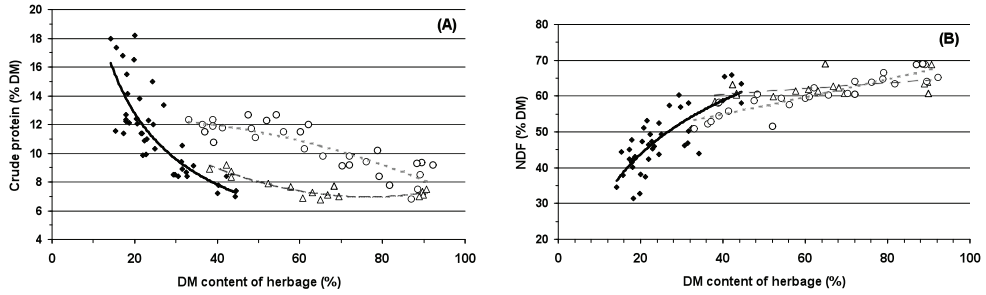


Table 1: Annual forage DM yield (t DM/ha), incidence on annual yield of first utilization of permanent grassland in relation of cutting time in Italian Alps (from Ciotti et al., 2000).

	Lowland (Samolaco, SO, 210 m asl)			Medium Alpine valley (Demonte, CN, 750 m asl)			Highland (Sauze d'Oulx, TO, 1500 m asl)		
Cutting time 1st growth	Annual DM yield	1st cut (%)	n. cuts	Annual DM yield	1st cut (%)	n. cuts	Annual DM yield	1st cut (%)	n. cuts
Early cut	11.8	26	4	9.0	52	3	4.6	61	2
Medium cut	13.1	34	4	9.1	54	3	5.2	77	2
Late cut	12.9	39	3	10.3	63	2.5	5.0	100	1

Table 2: Influence of nitrogen input on proportion of botanical families of permanent meadows in Valtellina (Italy) (Pers. Com. Fausto Gusmeroli – Ist. Fojanini, Sondrio).

	High input (200 kg N/ha)			Medium input (100 kg N/ha)			No-input		
Cut	*Poaceae*	*Fabaceae*	Other families	*Poaceae*	*Fabaceae*	Other families	*Poaceae*	*Fabaceae*	Other families
1st	71	3	26	52	13	35	39	13	48
2nd	70	4	26	44	16	40	28	20	52
3rd	53	5	42	35	13	52	20	18	62

Maintaining/increasing biodiversity of permanent grasslands

Low-intensity agricultural systems have consistently been shown to have higher biodiversity than more intensive systems, both in temperate regions and the tropics. Supporting such systems may therefore help stopping the decline of farmland biodiversity in terms of plants, mammals, bird and arthropod populations. At the field level, several management factors may affect biodiversity of grasslands interacting together in a large-scale temporal changes: use of organic and mineral fertilizers, grazing and cutting, drainage and ploughing, and the use of agrochemicals (Plantureux et al., 2005). When fertilizer are supplied at high level only a few fast growing plant species can compete for light (mainly *Poaceae*), eliminating less competitive plants and resulting in a decrease in the species richness (Table 2). From different studies, it appears that a significant reduction in plant diversity is generally observed even for fertilizer levels which are very low in comparison to the normal application rates in intensive grasslands. For nitrogen, a reduction of half of the total number of plant species can be observed for fertilizations greater than 50 kg N/ha per year (Plantureux et al., 2005).

Manage field margins and uncut strips for higher biodiversity

Semi-natural grasslands under extensive management typically have species rich communities, but their significance for agriculture has declined considerably, since most permanent grasslands have been turned into intensively managed grasslands (with several cuts per year and selected species) or crop fields (Lebeau et al., 2015), with a great reduction in related plant and animal biodiversity. Also the mowing process, especially with more frequent cutting at early stages of growth, is another important factor that has a direct and often substantial impact (in terms of mortality) on field invertebrates (Humbert et al., 2012), mammals and birds (Sargent et al., 2012) and reduction of plant biodiversity. In view of this, leaving uncut grass areas within meadows or uncut strips along field edges has been recommended as a mitigation measure to directly reduce mortality of beetles, orthopterans, spiders, lepidopteran caterpillars and other less mobile invertebrates (Humbert et al., 2012) and ground nesting birds and mammals. Furthermore uncut areas might also act as refuges to which invertebrates can move to and will provide foraging areas later in the season and maintain plant richness by allowing later-flowering plants to produce seeds.

Conclusions

Coupling summer grazing with the use of high nutritional forages during winter (obtained by cutting at an early stage of growth and conserving it as wrapped haylage) can contribute to a more efficient management of mountain grassland, a reduction in production costs and the possibility of a more strict link to the origin of production of mountain dairy products. Furthermore, some simple management aspects could contribute to maintain/increase the biodiversity value and the environmental importance of these high nature value farmlands.

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