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Tagasaste (Cytisus proliferus)

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Common names

Tagasaste, tree lucerne, white-flowered tree lucerne, escabon [English]; tagasaste [Spanish]; cytise [French]; Sprossende Zwergginster [German]

Species

Cytisus proliferus L. f. [Fabaceae]

Synonyms

- For *Cytisus proliferus* var. *palmensis*: *Chamaecytisus palmensis* (Christ) F. A. Bisby & K. W. Nicholls, *Chamaecytisus proliferus* subsp. *palmensis* (Christ) G. Kunkel, *Chamaecytisus proliferus* var. *palmensis* (Christ) A. Hansen & Sunding, *Cytisus palmensis* (Christ) Hutch.
- For *Cytisus proliferus* var. *proliferus*: *Chamaecytisus proliferus* (L. f.) Link, *Chamaecytisus proliferus* var. *proliferus* (L. f.) Link

Taxonomic information

7 morphological forms are endemic to the Canary Islands (Santos-Guerra et al., 1994):

- *Cytisus proliferus* L. f. var. *palmensis* Christ: Typical tagasaste
- *Cytisus proliferus* L. f. var. *calderae* (Acebes) ined.: White tagasaste
- *Cytisus proliferus* L. f. var. *proliferus*: White escobon of Tenerife
- *Cytisus proliferus* L. f. var. *hierrensis* Pit.: Escobon of El Hierro
- *Cytisus proliferus* L. f. var. *canariae* Christ: White escobon of Gran Canaria
- *Cytisus proliferus* L. f. var. *angustifolius* Kuntze: Narrow-leaved escobon
- *Cytisus proliferus* L. f. var. *meridionalis* (Acebes) ined.: Escobon of southern Gran Canaria

Other remarks:

- The plant is often found in the literature under the taxon *Chamaecytisus proliferus* (L. f.) Link, also written *Chamaecytisus prolifer* (L. f.) Link.
- The name variant *Cytisus prolifer* L. f. is common. The epithet *proliferus* is sometimes considered as a mistake, as *prolifer* is the correct masculine form. However, other authors consider that the epithet *proliferus* should be preferred due to its long history of usage (Santos-Guerra et al., 1994).

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Description

Tagasaste (*Cytisus proliferus* L. f.), also called tree lucerne, is a fast growing evergreen legume tree from the Mediterranean region. Tagasaste is a long lived perennial that can survive 60-80 years. It is recommended in sandy, hilly, gravelly soils in drought-prone areas where it provides good quality forage all year round. *Cytisus proliferus* var. *palmensis* is the true tagasaste: it is the only cutivated type and has been naturalized outside the Canary Islands. The other types, known locally as "escobones", are not cultivated. However, these types are grazed by goats and lopped by farmers (Francisco-Ortega et al., 1993).

Morphology

Tagasaste can reach 5-7 m with a crown diameter about the same size. Its root system is very extensive, and can grow as deep as 10 m and more. The branches are long, drooping, and leafy. Tagasaste has variable habit and may be erect or prostrate. Leaves are trifoliate. Leaflets are linear, grey-green in colour, silky pubescent on the lower face, about 7 cm long (but variable). The flowers are pea-like in shape, creamy white in colour, scented and borne in axillary clusters. Flowering occurs in winter and attracts bees when other sources of honey are scarce. Once pollinated, flowers turn into black-coloured, flattened, 5 cm long pods. Tagasaste pods contain 10 seeds. The seeds are small flattened, oval shaped, 5 mm x 3 mm wide, glossy black in colour (Ecocrop, 2016; Stokes, 2008; Cook et al., 2005; Newcomb, 1999; George et al., 2003).

Uses

Tagasaste is a much valued forage with good palatability and high protein content (Cook et al., 2005; Assefa, 1998; Newcomb, 1999). It can be grazed and cut for cut-and-carry systems. Prunings can be chopped and fed fresh as a wet leaf meal, or they can be dried and fed as hay (Esterhuizen et al., 2016; Cook et al., 2005).

Distribution

Tagasaste originated from the Canary Islands and became naturalized in most tropical highlands and mediterranean-type climate areas in the world with long, hot and dry summers like Australia, New-Zealand, Ethiopia, South Africa. However, it seems uncommon in the USA. Tagasaste can be found from sea level up to an altitude of 200-400 m in New Zealand where it can grow in marginal coastal sandy areas that were adequately fertilized (Newcomb, 1999). Tagasaste has moderate tolerance of frost: adults plants can survive frost down to -6°C but young seedlings are killed by frost and they should be planted (transferred) once cold periods are over. Tagasaste thrives in semi-arid areas where annual rainfall is in the range of 350-1600 mm, and it can survive down to 200 mm annual rainfall. Tagasaste thrives on acidic (pH ranging from 4.8 to 6.5) soils that are sandy, gravelly deep and well drained. Good drainage is mandatory where rainfall is important (Stokes, 2008; Newcomb, 1999). Alkaline and saline soils reduce tagasaste growth. Tagasaste is sensitive to waterlogging and wet heavy soils, it should then be planted in raised beds where waterlogging may occur.

Forage management

Establishment

Tagasaste is propagated by seeds. Seeds are hard coated and should be scarified or soaked in hot water prior to sowing. They should also be inoculated with the same rhizobium as for cowpea (*Vigna unguiculata*) where tagasaste is not commonly grown (George et al., 2003). Tagasaste can be directly sown or transplanted once seedlings are 10-15 cm high. If the seeds are directly sown, the seed bed must be well-prepared, weeded, and air pockets must be avoided. If the seeds are sown in heavy soils prone to waterlogging, they should be sown on raised beds. Tagasaste can be sown in rows at 2-4 m intervals between the plants and 4-8 m intervals between the rows. Planting can be done anytime but frost periods. In lower rainfall areas, end of winter should be preferred as the young plants may require some moisture. Young plants are very palatable to many domestic and wild animals, including rabbits and possums in Australia, and should be protected from them (George et al., 2003).

Yields

Annual forage yields are 5-10 tons DM/ha in Ethiopia and 13-18 tons DM/ha in New Zealand (Ecocrop, 2016).

Grazing

After a 10-24 (-36) months establishment period, tagasaste can be grazed by different classes of livestock such as cattle, sheep, goats and alpacas (Orwa et al., 2009; Cook et al., 2005; O'Donoghue, 2011). Animals can graze down to 20-30 cm height (i.e. 70-80% of the leaves). After the first grazing period, vigorous regrowth occurs. This should be pruned so that tagasaste plants do not grow beyond 1-2 m high and remain available to livestock (Esterhuizen et al., 2016; Cook et al., 2005; George et al., 2003). Animals tend to strip the bark and may kill the plant, so it may be necessary to strip graze tagasaste with the help of an electric fence (George et al., 2003).

Cut-and-carry systems

Tagasaste can be cut and distributed in cut-and-carry systems. It is then harvested with mechanical harvesters at 20-50 cm high during frost-free periods (because frost compromises regrowth). The fresh forage contains more dry matter (50-70%) than other forages and is easy to distribute to livestock. However, tagasaste should be cut before flowering stage, as flowering dramatically reduces the nutritional value of the forage (George et al., 2003).

Environmental impact

Soil fertility improver

Tagasaste is an N-fixing legume which improves the nitrogen status of the soil, and benefits to neighbouring grasses. Its extensive root system taps nutrients and water deep in the soil (down to 10 m) and makes them available in the upper layers of the soil for neighbouring plants (George et al., 2003).

Soil reclamation

Tagasaste has been assessed for salinity control: it reduces the water runoff and seepage and thus assists in reducing the rising water table effect (Eastham et al., 1993). However, it is sensitive to salinity, and growth is reduced in saline conditions (O'Donoghue, 2011).

Windbreak, soil binder, erosion controller and revegetation

A windbreak specialist, tagasaste reduces the impact of wind erosion and its extensive deep-rooted system assists in binding the soil, thus reducing the impact of water runoff in steep slopes. Tagasaste is valuable for revegetation in eroded areas (George et al., 2003; O'Donoghue, 2011).

Fire break

Tagasaste is used in Western Australia as a firebreak to protect pine plantations (O'Donoghue, 2011).

Bees

Tagasaste starts flowering during winter: it is thus a much appreciated source of nectar for bees. It provides high quality pollen and nectar (George et al., 2003).

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Nutritional attributes

Tagasaste foliage, like that of other legumes, is rich in protein, though the protein range is important (14-33% DM) and depends on the subspecies, season and age of regrowth. The fibre content is moderate to high (NDF 34-55%, ADF 20-36%).

Potential constraints

Tagasaste contains antinutritional factors including polyphenols, tannins and alkaloids.

Tannins

Tannin content is variable and depends on the origin of the plant, the cultivar, the preservation process (raw, wilted or dried), the age of regrowth, etc. (Borens et al., 1990; Kumara Mahipala et al., 2009b; Assefa et al., 2012; Assefa et al., 2008b; Chinea et al., 1998). Tannin levels found in different experiments are summarized in the table below:

Country	Total tannins	Condensed tannins	Hydrolysable tannins	Results	Reference
New Zealand	No tannins found in the leaves	-	-	-	Borens et al., 1990
Australia	8.9 g/kg DM	-	-	-	Kumara Mahipala et al., 2009b
Canary Islands	-	0.1 to 0.45 g/kg DM	-		Chinea et al., 1998
Ethiopia	-	7 to 32 g/kg DM	16 to 197 g/kg DM	HT decreased with the cutting age of regrowth All but one accession had CT lower than 26 g/kg DM	Assefa et al., 2008b

In Ethiopia, hydrolysable and condensed tannins were measured on 65 accessions of leaves for different ages of regrowth and treatments (fresh, wilted or dried) (Assefa et al., 2008b). Despite its great variability, the condensed tannins content was below the threshold of 50 g/kg DM which is considered to have a negative effect on voluntary intake and nitrogen digestibility in ruminants (Barry et al., 1999). *in vitro* DM degradability was tested with or without polyethylene glycol, which is known to alleviate the tannins' effects. No differences were found, confirming that the level of tannins has no effect on degradability (Kumara Mahipala et al., 2009b). Moreover no bloat occurs when animals graze tagasaste (Cook et al., 2005).

Alkaloids

In the Canary Islands, alkaloids are present in the leaves of several morphological types, ranging from 0.6 to 11.3 g/kg DM (Muzquiz et al., 1996; Ventura et al., 2000). In Ethiopia, lower levels from 0.024 to 0.053 g/kg DM were found in leaves, although higher levels were observed in branches, barks and stems with 0.20, 0.24 and 0.14 g/kg DM, respectively (Assefa et al., 2008b). The alkaloid content also varied with the type and accession (Muzquiz et al., 1996; Ventura et al., 2000). Sparteine is the main alkaloid and represents about 90% of alkaloids in most of the analyzed types (Muzquiz et al., 1996; Ventura et al., 2000).

Ruminants

Tagasaste is a highly valued fodder bush that produce important yields on a regular basis. Animals accustomed to grazing it consume even the thick stems, so that the shrubs are eaten back to a compact base very quickly. Tagasaste is a good source of protein and the digestibility is high enough to be used as a supplement for low quality forages, or in some cases as sole diet when traditional forages or pasture scarcity occurs. It is relatively well consumed by the animals although unexplained differences occur between varieties and animal species. It is also a good source of minerals, particularly calcium and microelements, but it is poor in sodium, which requires to provide salt blocks to the animals. The alkaloid content can limit DM intake, and should be assessed in order to know what can be expected when tagasaste is fed to animals.

Intake

The edible part of tagasaste includes leaves and part of the stem, with a diameter up to 3 mm for sheep and 6 mm for cattle (Oldham et al., 1994b). In two comparisons of fodder tree species in Ethiopia, tagasaste was well accepted by sheep (5th and 6th rank) and goats (7th rank) when compared to 19 (Kaitho et al., 1997) or 40 other species (Kaitho et al., 1996).

The acceptability and average DM intake of 4 morphological types (35.9 to 44.5 g/kg BW$^{0.75}$) offered to goats was not related to the chemical composition (protein or fibre) but to the sparteine content, the most important alkaloid present in tagasaste (Muzquiz et al., 1996; Ventura et al., 2000). The total alkaloid content was negatively correlated with DM intake, but not with rumen digestibility (Ventura et al., 2000). The DM intake of leaves fed alone to castrated male goats was 44 g/kg BW$^{0.75}$ (Alvarez et al., 2007). When offered alone to lambs, the DM intake of leaves and young stems increases with the DM content, from 19.8 to 48.7 g/kg BW$^{0.75}$ for freshly cut (26.9% DM) and sun dried (90.1% DM) material, respectively (Becholie et al., 2005). Conversely, a decreasing intake from 24.3-22.8 to 7.9 g/kg BW$^{0.75}$ was found for fresh (41% DM), wilted (53% DM) or sun dried (93.5% DM) material, respectively. The same tendency was observed with 6- or 10-month regrowth (Assefa et al., 2012). However, when fed to steers or heifers, DMI of tagasaste leaves and young stems increased with DM content: 8.4-7.4 to 16.6 g/kg BW$^{0.75}$ with steers and 1.4 to 33.4 with heifers (Assefa et al., 2012). DM intake of tagasaste (50% leaves, 22% stems < 5 mm and 28% branches > 5 mm) offered alone or supplemented with minerals to young lambs (6 months, 34 kg) was

much higher than previous results with about 738 g/d or 56 g/kg $BW^{0.75}$ (McGowan et al., 1995). There is no explanation for such contradictory results. Alkaloid content may be one possible explanation since Ventura et al., 2000 showed their negative effect on goat DM intake.

Digestibility

Like other legume trees, tagasaste has no effect on protozoa level in the rumen, and consequently does not impair fibre digestibility (Odenyo et al., 1997). *In vitro* DM digestibility averages 68% (El Hassan et al., 2000; Kaitho et al., 1998a) and OM digestibility 65 to 76% (Chinea et al., 2008a; Assefa et al., 2012). OM digestibility may vary according to season, physiological stage (Chinea et al., 2008a), age of regrowth and treatment (fresh, wilted or dried) (Assefa et al., 2012). The DM digestibility of tagasaste measured *in vivo* when offered alone or supplemented with minerals to sheep is 57% (Kumara Mahipala et al., 2009a), 67% (McGowan et al., 1995) or 69 % (Borens et al., 1990) and 68% measured on goats (Alvarez et al., 2007). The effective DM degradability measured with the *in sacco* method with sheep, steers or bulls ranges from 56.3 to 72.5% (Sileshi et al., 1996; Kaitho et al., 1998e; El Hassan et al., 2000; Assefa et al., 2008a). These different values can be explained by the proportion of young branches, the stage or age of regrowth, and the animal effect.

On average, 88 to 94% of tagasaste protein is truly degradable (Kaitho et al., 1998c; Kaitho et al., 1998e). The in sacco degradability measured *in vivo* is 74.2% (Varvikko et al., 1993) and about 34% of protein is by-pass (Kaitho et al., 1998e). That makes tagasaste a good protein source for low digestible forages with a low protein content.

Dairy cattle

In Ethiopia, tagasaste forage (80% leaves and 20% stem) could partly replace concentrate in a diet based on low quality hay offered *ad libitum* and supplemented with 4.5 kg concentrate, fed to zebu dairy cows (415 kg) in mid lactation. Hay DM intake did not change at any tagasaste level (6.99-6.62 kg DM/d). With up to 33% tagasaste, milk yield and milk composition were not different, but beyond this level, both milk yield and milk protein content decreased (Varvikko et al., 1993).

Beef cattle

In Australia, when tagasaste was grazed by heifers for a long time until their first lactation, they gained weight (280 to 488 kg) and reared their calf with no adverse effect and until weaning calves growth was about 1 kg/d (Oldham et al., 1994b). When steers were allowed to graze pasture with planted tagasaste and supplemented or not with 3 kg/d of oat grain, supplementation had no effect on daily weight gain which averaged 0.9 kg/d (Wiese et al., 1994).

Goats

In Rwanda, when tagasaste was fed as a supplement (2 kg fresh matter/d) to low nutritive value setaria to local breed goats (5-6 months, 10 kg), setaria DM intake slightly decreased from 37.2 to 33.7 g/kg $BW^{0.75}$ and tagasaste DM intake was high: 32.3 g/kg $BW^{0.75}$ (Niang et al., 1996). In the Canary Islands, tagasaste included into a total mixed ration at 58% replaced the conventional diet for dairy goats (90 days in milk) without any adverse effect, and tended to increase the daily milk yield from 1.4 to 1.7 L/d (Alvarez et al., 2007).

Sheep

Tagasaste could be grazed *ad libitum* to increase the ovulation rate (up to 20%) in merinos ewes when grazed about 2-3 weeks before mating, but results were lower than with lupin seed (66%) (Wilkins, 1997). Used as hedgerows into a pasture grazed by ewes and their lambs without supplement except minerals, the daily weight gain of lambs averaged 228 g/d (Oldham et al., 1994a). Other results obtained in variable conditions with sheep are summarized in table 1.

Several results obtained in Ethiopia show that when tagasaste is offered as a supplement to low quality forage fed to local breed lambs (14-23 kg), it slightly decreases or tends to decrease forage DM intake when supplemented over 150 g DM/d, but increases DM intake, diet DM digestibility and improves daily weight gain to 35-50 g/d (see **Table 1** below). Tagasaste can replace a concentrate fed at 200 g/d with low quality hay to growing lambs without any negative effect on daily weight gain (38-44 g/d) or carcass parameters. Only diet DM digestibility decreases over 33% replacement (Assefa et al., 2008a).

Table 1: Use of tagasaste in sheep diets.

Country	Breed	Experiment	Rate of tagasaste	Main results	Reference
Australia	Crossbred	Ewes and their lambs grazing pasture with hedgerows of tagasaste	*ad libitum*	The average DWG of lambs was 228 g/d and ranged from 183 to 274 g/d for 4 months	Oldham et al., 1994a
	Merinos (50 kg)	Tagasaste replacing at various levels oat forage fed *ad libitum*	0, 18, 35, 52, 72 or 100%	Increasing levels of tagasaste increased DMD of the diet up to 54% level, but not significantly nutrients intake	Kumara Mahipala et al., 2009a
New Zealand	Crossbred (27,5 kg)	Tagasaste small branches with leaves offered alone	*ad libitum*	Lambs consumed 72% leaves; DMI was 36.6 g DM/kg BW; DWG 95 g/d	Borens et al.,1990
Ethiopia	Ethiopian Menz (23 kg)	Sheep fed oat hay (5% CP) alone or supplemented with tagasaste leaves	250/d	Supplementation slightly decreased oat hay DMI (650 to 609 g/d), and lambs did not eat the entire supplement (149 g/d). Tagasaste supplement increased DWG from 15 to 25 g/d	Umunna et al., 1995b
	Ethiopian Menz (20 kg)	Sheep fed tef straw (< 5% CP) with (+175 g/d) or without tagasaste and with (+47 g/d) or without maize grain or wheat bran	175 g/d	Tagasaste supplementation slightly increased tef DMI, (509 *vs.* 576 g DM/d) and increased the DMD of the diet from 51.1 to 60%. Tagasaste increased nitrogen retention. Energy supplementation (maize or wheat) had no effect	Nsahlai et al., 1998
	Ethiopian highland (20 kg)	Sheep fed tef straw (3% CP) *ad libitum* with of without increasing levels of tagasaste	15, 30, 45 or 60% of the diet	Increasing levels of tagasaste tended or decreased tef DMI particularly at 60% (52,6 to 46,7 g/kg $BW^{0,75}$). It also increased DWG from 6,5 to 35,1 g/d compared to -24g/d without supplement	Kaitho et al., 1998d
	Local breed (14 kg)	Sheep fed local grass hay of low nutritive value (< 5% CP) with or without increasing levels of tagasaste	0, 57, 114, 178, 230 g/d	Increasing levels of tagasaste tended to decrease hay DMI at the highest level (383 *vs.* 430 g DM/d) but increased DWG to 45-52 g/d at the three higher levels compared to no supplementation (11.4 g/d)	Becholie et al., 2005
	Local breed (18 kg)	Sheep fed local grass hay of low nutritive value (< 5% CP) with or without increasing levels of tagasaste	0, 68, 128, 188, 238 g/d	Increasing levels of tagasaste tended to decrease hay DMI at the three highest levels (460 *vs.* 540 g DM/d) and increased DMD of the diet from 58.5 to 71% at the 188g/d level	Becholie et al., 2005
	Ethiopian	Tagasaste small branches with	0, 33, 67 or	DMI of hay decreased (538 to 507 g DM/d) with 67 and 100% level of	Assefa et

Menz (19 kg)	leaves replacing part or total concentrate offered at 200g/d as a supplement to poor quality hay (< 6% CP) for 90 days	100% in concentrate	tagasaste. DMD of the diet decreased (54,6 to 51,2%) with 100% tagasaste but DWG was not different (38-44 g/d) whatever the tagasaste level, although it tended to decrease with increasing levels of tagasaste and no difference on carcass parameters was observed	al., 2008a

CP: crude protein; DMD: dry matter digestibility; DMI: dry matter intake; DWG: daily weight gain

Poultry

Although no scientific publications are available on the nutritional value of tagasaste for poultry (as of 2016), there are some reports of its use for family poultry production. Given the moderate level of antinutritional factors, tagasaste leaves probably have a nutritional value close to that of other similar legumes, and their potential is mentioned by some authors (McGowan et al., 1992). Tagasaste seeds seem to be appreciated by poultry, although no performance has been reported (Simons, 2009).

Rabbits

International literature on the use of tagasaste in rabbit feeding is very scarce. In India, tagasaste foliage is used in winter to feed rabbits, in association with oats, carrots and *Phalaris aquatica* grass (Sakthivel et al., 2015). In New Zealand, young plantations of *Cytisus proliferus* must be protected against rabbits and hares because young plants are frequently browsed by these lagomorphs (Townsend et al., 1987). Tagasaste can therefore be considered as a potential forage for rabbits, but more investigations are necessary to determine optimum conditions of use. For example the consequence of the presence of alkaloids such as sparteine must be determined because this substance was shown to have detrimental effects on spontaneous forage intake in sheep (Ventura et al., 2000).

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Tables of chemical composition and nutritional value

- Tagasaste (Cytisus proliferus), aerial part, fresh

Avg: average or predicted value; SD: standard deviation; Min: minimum value; Max: maximum value; Nb: number of values (samples) used

Tagasaste (Cytisus proliferus), aerial part, fresh

Main analysis	Unit	Avg	SD	Min	Max	Nb
Crude protein	% DM	22.2	5.9	14.4	32.9	11
Crude fibre	% DM	14.8	6.2	11.2	22.0	3
NDF	% DM	44.5	8.1	34.1	55.0	7
ADF	% DM	26.4	5.7	20.4	36.1	6
Lignin	% DM	8.3	1.0	6.9	9.8	6
Ether extract	% DM	5.1	0.9	4.0	5.6	3
Ash	% DM	6.5	2.5	3.8	11.4	10
Gross energy	MJ/kg DM	19.4				*

Minerals	Unit	Avg	SD	Min	Max	Nb
Calcium	g/kg DM	4.7		3.7	5.7	2
Phosphorus	g/kg DM	1.8		1.7	1.9	2
Potassium	g/kg DM	13.4				1
Sodium	g/kg DM	0.5				1
Magnesium	g/kg DM	1.9				1
Manganese	mg/kg DM	54				1
Zinc	mg/kg DM	57				1
Copper	mg/kg DM	6				1
Iron	mg/kg DM	181				1

Secondary metabolites	Unit	Avg	SD	Min	Max	Nb
Tannins (eq. tannic acid)	g/kg DM	53.1				1
Tannins, condensed (eq. catechin)	g/kg DM	4.5		1.0	8.0	2

Ruminant nutritive values	Unit	Avg	SD	Min	Max	Nb
OM digestibility, ruminants	%	65.4				1
Energy digestibility, ruminants	%	62.5				*
DE ruminants	MJ/kg DM	12.1				*
ME ruminants	MJ/kg DM	9.7				*
a (N)	%	35.2	7.8	26.7	45.7	4
b (N)	%	63.4	9.0	53.8	75.4	4
c (N)	h-1	0.040	0.004	0.036	0.044	4
Nitrogen degradability (effective, k=4%)	%	67				*
Nitrogen degradability (effective, k=6%)	%	61	7	51	66	4 *

The asterisk * indicates that the average value was obtained by an equation.

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Tagasaste (Cytisus proliferus)

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