

Optim'Al: an online optimization tool for protein self-sufficiency of dairy cows' rations



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Challenge

With climate change being a growing concern, using locally-produced feeds to improve the self-sufficiency of livestock diets helps to limit greenhouse gas emissions caused by transportation, and promotes more circular and resilient agro-systems. However, achieving self-sufficiency comes at a cost: imported feeds, particularly protein feeds, can be more affordable than local ones.

Optim'Al is a web application that calculates dairy cows rations optimized for protein self-sufficiency and provides farmers with information on the impact of the diet on dairy performance, income, and feed margin.

How does Optim'Al work?

Optim'Al relies on linear programming to formulate diets. Like other formulation software, it can calculate the diet using traditional least-cost optimization. However, the main feature of Optim'Al is the ability to optimize the protein self-sufficiency of the diet, by giving feeds different dependence values based on their origin.

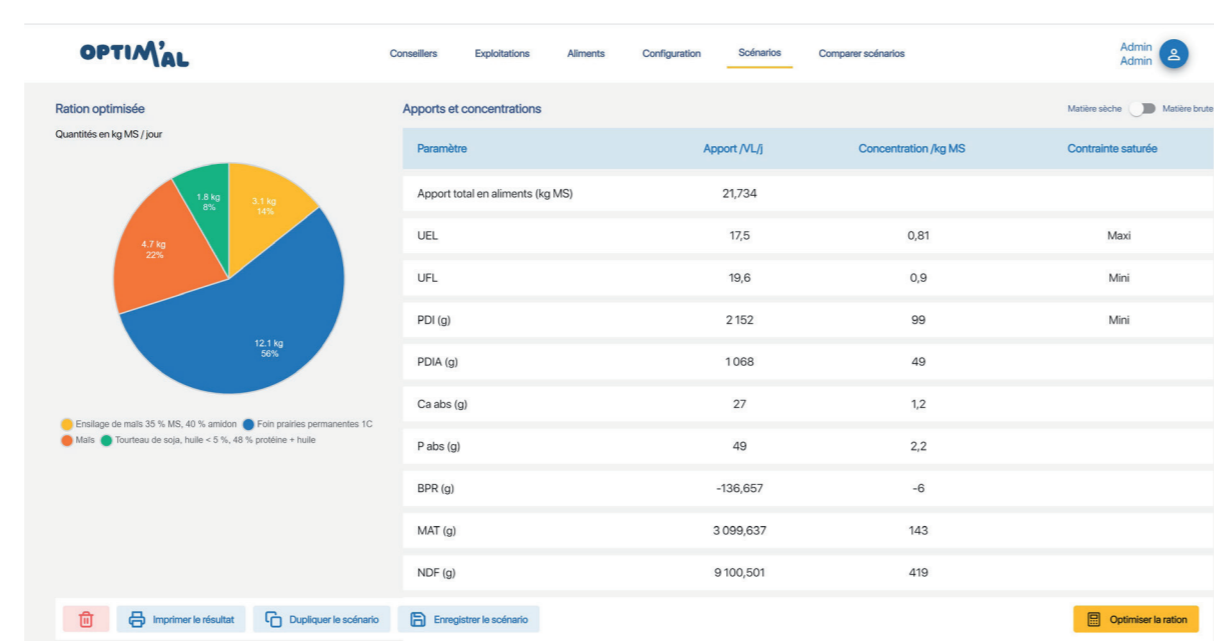


Those values are taken into account in the objective function of the optimization process, resulting in a diet with a minimum dependency on imported feed ingredients.

Optim'Al uses the INRA 2018 feeding system for ruminants. In this system, feed nutritive values depend on the ration and animal responses are not linear. The calculations are iterated until the Optim'Al converges to an optimized diet solution.

In addition to diet composition, Optim'Al provides the following:

- **Shadow prices** for each feed component of the ration.
- **Technical results**, including the expected milk yield, milk protein yield, milk fat yield, net energy for milk (UFL), and protein values (PDI and rumen protein balance).
- **Environnemental results**: fecal and urinary nitrogen losses of digestive or metabolic origin.
- **Economic results**: ration cost, milk income, feed margin.
- **Self-sufficiency results**: for protein, dry matter, and cost.
- Marginal costs and economic contributions for constraints.



Optim'Al users' accounts store the parameters of the farms they work with, a portfolio of customized feeds with their own prices and nutritive values, and their optimization results.

Benefits

Optim'Al makes it possible to feed dairy cows with rations less dependent on imported feed resources while still cost-efficient and able to maintain animal performance.

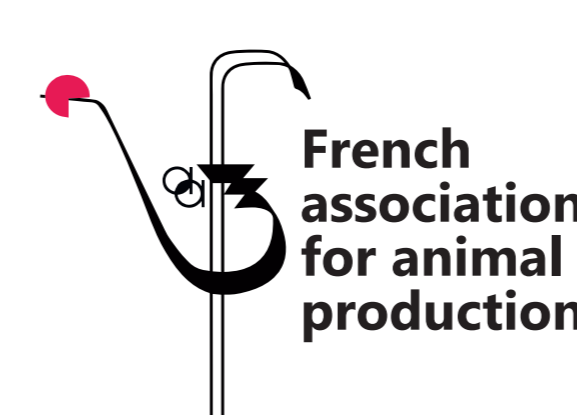
Least-cost vs self-sufficiency

In the following example, Optim'Al calculates the ration for a cow producing 30 kg milk/day, optimizing it either for cost, by creating the least expensive diet, or for protein self-sufficiency, by creating the diet with the least dependency on imported feed resources.

Ration for a cow producing 30 kg milk/d		Optimization for cost		Optimization for protein self-sufficiency	
	Price €/t DM	kg DM/cow/day	Shadow price range €/t DM	kg DM/cow/day	Shadow price range €/t DM
Maize silage, 35% DM	103 €	8.0 kg		8.0 kg	
Alfalfa silage, early bud	112 €	6.5 kg		4.1 kg	
Grassland silage, early cut	148 €	3.0 kg		3.0 kg	
Grassland hay	108 €	1.0 kg		1.0 kg	
Maize grain	180 €	0 kg		3.8 kg	180-242 €
Barley grain	157 €	2.7 kg	163-183 €	0 kg	
Soybean meal 48%	496 €	2.6 kg	364-498 €	0 kg	
Brewers grains, dried	337 €	0 kg		4.9 kg	191-464 €
Technical results	Expected milk yield	30 kg/cow		30.2 kg/cow	
	Milk protein yield	33 g/kg		33 g/kg	
	Milk fat yield	41.2 g/kg		41.0 g/kg	
	Dry Matter Intake	23.8 kg /day		24.8 kg/day	
	UFL (Forage Unit for Milk)	0.86		0.84	
	PDI (prot. digest. in the small intestine)	0.98 g/kg		0.97 g/kg	
	BalProRu (Rumen Protein Balance)	35 g/kg		2 g/kg	
Economic results	Ration cost €/1000 L	129.53 €		141.57 €	
	Milk income €/cow/d	13.32 €		13.39 €	
	Ration cost €/cow/d	3.89 €		4.27 €	
	Feed margin	9.43 €		9.12 €	
Self-sufficiency	For protein	68%		100%	
	For dry matter	89%		100%	

In this example, the self-sufficient diet replaces soybean meal with locally produced brewers grains, completely eliminating the farm's dependency on imported protein while maintaining milk production, quality, and income.

As commonly observed when dairy productivity is combined with protein self-sufficiency, the ration cost increases. However, this increase is less than 10%, as Optim'Al mitigates this effect thanks to optimization.



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