DIVERSIFOOD

Embedding crop diversity and networking for local high quality food systems

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Lupins in Switzerland

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1. Major and minor crops in Switzerland

1.1 Agriculture and major crops in Switzerland

Switzerland has a size of 41’285 square kilometres of which 36 % are farmland. As a large proportion of the farmland lies on the slopes of the Swiss Alps and Swiss Jurassic mountains, grassland and dairy production play a dominant role in Swiss agriculture. The agricultural area (seasonal pastures in the higher mountains excluded) is about 1 million hectares, 58 % of which is permanent grassland, only 38 % are arable, mainly concentrated in the Swiss plateau region between the Jura Mountains and the Alps (Agristat 2017).

Labour and machinery are expensive in Switzerland and much above EU levels, leading to high prices for agricultural crops and a high proportion of import. However, direct state payments and demand for high-protein, Swiss varieties allow for bread wheat production on 80’000 ha, rendering 315 000 to 400 000 tons per year, which is about 70 to 85% of the country’s demand. Due to the strong role of dairy production and animal husbandry, much of the arable land is cultivated for growing feed: grass-clover mixtures, maize for silage or grains, and feed cereals (mainly barley and triticale). Table 1 gives an overview over the area covered by the main arable crops.

About 14 % of the farmland are cultivated organically. Management differences between organic and conventional farming are smaller in the mountain areas than they are in the lowland, but price differences are significant. Consequently, many mountain farms have been converted to organic, leading to an even higher proportion of grassland within the organic sector.

Table 1: Overview over arable land and area under organic regime in Switzerland (simplified figures from BFS 2017a,b and Willer 2017)

	Hectares	% of whole country	Organic (ha)	% of total
Switzerland size	4 100 000	100,00		
Switzerland farm land	1 500 000	35,40		
Pastures in the Alps and Jurassic mountains	430 000	10,50		
Utilized agricultural area (without mountain pastures)	1 050 000	25,40	140 000	13,5
Permanent (natural) green land (lowland)	600 000	15,00	110'000	18,0
Arable land	400 000	9,6	28'000	7,1

Within the organic sector with its arable acreage of 28'000 ha (in 2016), the four main crops covering areas over 1'000 ha are grass-clover mixtures, bread wheat, spelt, and maize for silage. Vegetables are grown on 2'000 ha. Crops covering areas between 500 and 1'000 hectares are barley, maize for grains, wine and potatoes. Fruits, peas and triticale cover 450, 400 and 400 ha, respectively. Less important crops covering an acreage between 200 and 300 ha are rye, soybeans, sunflowers, and rapeseed. This overview over the main crops only reflects the acreage but not the financial output. In terms of financial production, vegetables, potatoes, fruits and wine play the most important role.

Table 2: Main crops and less important crops according to acreage in Switzerland, under conventional and organic regime 2015, 2016 (simplified figures according to: Schweizer Bauernverband 2017, Willer 2017, Clerc et al. 2015).

Category	**Crop**	**Acreage (ha)**	**Organic (ha)**
Feed	Ley (grass-clover mixtures)	126 000	12 000
	Maize for silage	46 000	1'600
	Barley (for feed)	28 000	1 000
	Maize for grains	15 000	600
	Triticale	8 000	400
	Wheat (for feed)	6 000	170
	Peas	4 400	400
	Faba beans	560	180[1]

Bread cereals	Bread wheat (winter and summer)	76 000	4 000
	Spelt and other bread cereals (Emmer, Einkorn…)	6 000	1 300
	Rye	2 000	300
Special	Fruits	31 000	450
	Rapeseed	23 000	200
	Wine	16 000	800
	Potatoes	11 000	600
	Vegetables	11 000	2 200
	Sunflower	4 600	280
	Soybean for human consumption	1 800	300

[1]: in 2014

1.2 Minor crops in Switzerland

For many farms in Switzerland, direct marketing of products is an important part of their economic strategy, and finding market niches helps to realize this. This is especially true in organic farming, the regime under which most of the minor crops are grown. Biofarm Genossenschaft, a committed trade organisation, tries to encourage farmers to grow minor crops for human consumption and is engaged in advice and trade of e.g. Swiss grown millet, oat flakes, rapeseed, sunflower oil etc. This helps to diversify the agrarian landscape and to reduce imports. – Table 3 gives an overview over the acreage of minor crops in Switzerland.

Table 3: Acreage and production amount of minor crops (conventional and organic) in Switzerland (2015) (according to Schweizer Bauernverband 2017, Erdin 2017, and Swissgranum 2017).

Crop	Acreage (ha)	Production (t)	Organic (ha)	Production (t)
Linseed	121	297	60	n.i.
Millet	63	172	30	n.i.
Emmer, Einkorn	67	500[1]	23	n.i.
Faba beans	556	2 000[1]	n.i.	n.i.
Lupins	105	311	13	n.i.
Lentils	70	n.i.	n.i.	n.i.

[1] Estimation by Swissgranum for 2017; n.i.= no information

2. The lupin story

2.1 Origin and history of lupins

The big, flat White Lupin (*Lupinus albus*) seeds have been eaten in the Mediterranean area since the time of the Egyptian pharaohs. Traditionally, they are eaten as whole kernels, washed, cooked and conserved in salt brine, similarly to olives, as a snack to accompany beer (ital. Lupini, span.

Altramuces, port. Tremoco, egypt. Termiz). Through the procedure of soaking and washing lupins in brine over several days and subsequent cooking, the bitter and poisonous alkaloids in the seeds are removed.

	
Fig.1: Lupini sottovuoto (Source: www.agraria.org)	Fig.2: Altramuces sold on the market (Quelle: commons.wikimedia.org)

In ancient Rome, authors already mentioned the fertilizing and soil improving effect of lupins. In the 18th century, King Frederick the Great of Prussia (Germany) tried to introduce lupins in Prussia in order to improve the poor, sandy soils, but the bitter green manure crops were never grown extensively north of the Alps. With the rise of modern plant breeding in the first third of the 20th century, German breeders started to screen thousands of single plants systematically for low alkaloid content. The success was a breakthrough and the beginning of Sweet Lupin breeding. It started with White Lupin, but later, also the more delicate wild plants Blue Lupin (*Lupinus angustifolius*) and Yellow Lupin (*Lupinus luteus*) were bred for low alkaloid content. Today, all three varieties are cultivated for feed and, to a lower proportion, for food and food ingredients such as protein isolates.

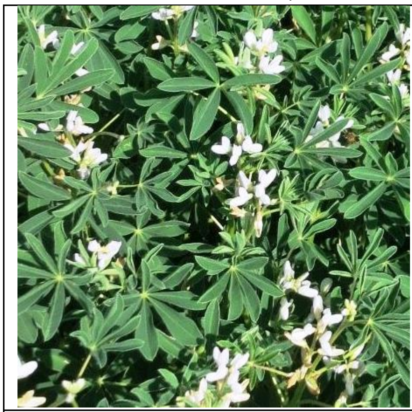		
Fig.3: White lupin (*Lupinus albus*)	Fig. 3: Blue lupin (*Lupins angustifolius*) (here,a white-flowering cultivar)	Fig.4: Yellow lupin (*Lupinus luteus*)

After the Second World War, when cultivation of pulses became more and more unprofitable for farmers and imports of soybeans increased, lupin breeding played only a marginal role in the breeding companies. At present, new awareness of the importance of pulses, and especially home grown pulses, rises in Europe and all over the world. Pulses can contribute to a healthy diet as well as to a diversified landscape and crop rotation. Many projects started in the last decade in order to revive and support pulse growing. The 68th UN General Assembly declared 2016 the International Year of Pulses in order to heighten public awareness of the nutritional and ecological benefits of pulses for food security and nutrition.

Sweet lupins can render high quality protein with an amino acid composition more valuable for animal or human nutrition than that of peas and faba beans. For this reason, and due to their lower need for warm spring temperatures, lupins are sometimes called the “soybeans of the North”, and related to the massive rise of Russian lupin production in recent years, one could even better call them the “soybeans of eastern Europe”. However, it is important in lupin breeding and cultivation that alkaloid levels are always controlled and kept at a minimum level.

Lupin growing experienced a great drawback when anthracnose, a disease caused by the fungal agent *Colletotrichum lupini*, appeared in the 1990s. This has led to a shift from white to blue lupin in Germany and Poland because blue lupin is less susceptible and renders better yields at the moment despite its lower overall yield potential. Yellow lupin, the most susceptible of the three Old World lupins, more les completely vanished from European fields except from some regions in Poland. Efforts in resistance breeding started, but until now, no truly resistant cultivars are on the market.

2.2 Lupins in Switzerland

To our knowledge, lupins have no tradition in Switzerland, neither have they been introduced to the country from the northern neighbour Germany, the western neighbour France nor from the southern neighbour Italy, where since Roman times lupins have been cultivated for human consumption.

In the late 1980s, several authors conducted trials with lupins and discussed the possibility of introducing them to Switzerland (Reinhard and Gehriger 1988, Perler 1991). Lupins turned out not to be able to compete with other crops under the given circumstances. When concern about the amounts of imported protein crops into Switzerland and about GMOs arose in the public awareness, lupins and soybeans were again tested in Switzerland within a European INTERREG trinational project (DE, FR, CH). Field trials with white lupin (Lupinus albus) and blue lupin (L. angustifolius) were performed and seed treatments against anthracnose, the presently most important fungal disease of lupins, were tested (Nawrath and Vetter 2001). One of the lupin pioneers in Switzerland was the organic farm bioböhler in Mellikon AG who produced a coffee substitute from white lupins in 1990 but had a devastating experience with anthracnose the following year. The farmer also run a lupin trial on his farm for his diploma thesis (Böhler 1998). After the experiences of the late 1908s, advisors no more recommended white lupin for cultivation in Switzerland. Another barrier for growing white lupins is the long ripening period in late summer when sometimes rainfalls stop the harvest season before ripening is finished.

Blue lupin, however, proved to have a much earlier ripening time and better resistance to anthracnose. FiBL produced a first technical leaflet on organic lupin growing in 2002
(Dierauer and Böhler 2002). Thus, blue lupin growing was recommended by advisors and feed mills, but without much success. Lupins were only grown on 50-100 ha in Switzerland in the past ten years (FAOSTAT 2017), and among the few farmers who know lupins it is a widespread opinion that lupins “don’t grow properly” and cannot compete with weeds.

After the organic grain legume acreage in Switzerland had decreased to nearly zero in the 1990s (Dierauer et al., 2017), awareness of this loss in diversity and knowledge arose in the first years of the 21st century. Like in many European countries, interest in and engagement for domestic protein feed grew again (Lehmann 2014) and public support for grain legumes was implemented (Bundesamt für Landwirtschaft, 2017). Research on grain legumes became also supported by private companies. Supported by the biggest retailer in Switzerland, Migros, and several feed mills, the FiBL extension service started the project "protein made in Switzerland" (FiBL, 2016) and set up on-farm field trials in 2008/09. It was the main goal of the trials to improve organic pea and faba bean production. Mixed cropping of peas and barley proved to be a successful strategy for organic production to overcome weed problems, but in the first years it was difficult to sell the harvest of the pea-barley mixture. This changed when two organic feed mills decided to invest in machinery for separation of the harvest mixtures. When they signalled that they were ready to buy harvest mixtures of grain legumes and cereals, the organic mixed cropping area started to grow again – up to over 500 ha in 2014 (Dierauer et al., 2017). Another factor for this success was the direct federal payment of 1000 Swiss francs per hectare not only for pure stands of grain legumes but also for mixed cropping, as long as the share of legumes in the mixture was higher than 30 percent (since 2014. Before, the minimum share had been 50 percent which very often could not be achieved).

In 2012, trials with mixtures of blue lupins and oats were added. Lupin growing was reconsidered given the fact that lupins were the third European domestic grain legume after peas and faba beans. Lupin is an interesting supplement to the range of grain legumes due to its high protein content and due to it being doubtlessly free from genetic engineering. The FiBL crop science department took up the lupin subject in 2014 and started a small-plot trial with lupins in order to test cultivars and cropping partners of blue and white lupins and to start anthracnose resistance pre-breeding of white lupin.

Through field days, newspaper articles and other dissemination activities, FiBL tried to make lupins known better in Switzerland.

At present (2015), only 105 ha of lupins are grown in Switzerland (BLW 2016). FiBL hopes to be able to promote lupin growing in Switzerland. Through field trials and media activities lupins are made better known, cultivars are tested and mixed cropping regimes are tried in order to suppress weeds.

3. Lupins and environment

3.1 Soil

The beneficial effect of lupins on soil fertility has been observed since the Roman times and was the main reason for the Prussian King Frederic the Great of Prussia to prescribe lupin growing in the 18th century in the northeastern parts of Germany. The ability of the lupin roots to fix nitrogen with the aid of the symbiotic bacteria Bradyrhizobium lupini and to mobilize phosphorous from deeper soil layers has often been described (Lucas et al. 2015, Dissanayaka 2016, Howieson et al. 1998). Through these traits, lupins are interesting crops for poor soils or low nitrogen input conditions. Organic farming always has to manage limited nitrogen supply, which makes legume growing essential. Diversity in legume crops helps to minimize pest and disease risks.

Lupins are sensitive to alkaline soils and can only be grown at a pH lower than 7. Free calcium in the soil interfers with the nitrogen fixing metabolism of the root nodule rhizobacteria and leads to chlorosis and iron deficiency. White lupin is more tolerant in this trait than blue lupin.

Despite their ability to ameliorate soils with their deep and active roots, lupins, especially blue lupins, cannot be grown on compacted soils, their roots being dependent on the oxidative process in the nodules.

3.2 Climate, Pests and Diseases

Being the protein crop with the best protein quality after soybeans, lupin can be sown much earlier in spring than soybean due to its higher cold tolerance, i.e. in March, and it can be grown up to an altitude of ca. 600m, whereas soybeans can only be grown in the warmer lowland regions. In France, a shift from spring-sown to autumn-sown white lupins can be observed currently (Moquet 2014), but in Switzerland, winter forms are not sown at present due to bad overwintering of the French cultivar Lumen in a field experiment in the winter 2012/2013 (Dierauer et al. 2013). However, spring-sown varieties have a good frost tolerance, and especially for white lupin, cold spring conditions help to stimulate generative development.

For white lupins having a vegetation period that is about six weeks longer than that of blue lupins, early maturity is a crucial trait because rainfall and moisture can lead to delayed harvest in autumn, enhancing the risk of crop destruction through anthracnose, which at present is the most important fungal disease in lupins. Another problem associated with the late maturity of white lupins is the risk of infestation with late, unwanted weeds, a problem that FiBL tries to address with mixed cropping trials for weed suppression.
Blue lupins can usually be harvested in late July or early August, which allows mixed cropping with cereals like oats or triticale if suitable cultivars are chosen.

Regarding the fact that the climate in Switzerland is currently changing faster than in other parts of Europe and that summer droughts have occurred regularly during the last decades (Bundesamt für Meteorologie, 2014), the ability of lupins to cope with dry conditions makes them a putatively interesting crop for the future.

Currently, anthracnose is the main problem in lupin growing, but as the cultivated area increases, other fungal diseases, viruses and pests like lice and lupin weevil (*Sitonia*) may arise.

3.3 Aesthetical and Ecological role for the landscape

Lupins have beautiful flowers enriching the green, maize-dominated aspect of the Swiss lowland landscapes. In the Swiss national agricultural policy 2014-2017, canton-based payments for crops that improve the aesthetical and ecological quality of the landscape have been introduced (Bundesamt für Landwirtschaft 2017b). In most cantons, such payments can be obtained for lupin growing. Many different insects can be observed in a flowering lupin field, especially bumblebees and other wild bee species, but also honey bees, several beetles and flies. Honey bees seem to profit more from lupin pollen than from nectar (Klein 2017).

Fig. 5: besides bumblebees, honey bees regularly visit lupin fields, loaded with pollen pellets.

4. Breeding and seed management

When modern sense lupin breeding started about one century ago, a narrow genetic bottleneck was created through the search for low alkaloid ("sweet") lupins. All breeding material was crossed with the same few "sweet" breeding lines and afterwards selected for soft white seed and low pod-shattering, enhanced yield and reduced flowering time and branching architecture. All these traits remaining important breeding goals, current breeding in white lupin is especially focused on anthracnose resistance (Wolko et al., 2011).

Breeding of white lupins is performed in Australia and has led to the release of cultivars with an improved anthracnose resistance there. In the Old World, white lupins are bred in France (Jouffrai-Drillaud), in Poland (Hodowla Roslin), in the Ukraine, in the Czech republic (Oseva), and in Germany (Saatzucht Triesdorf). Yellow lupin is bred in Poland (Hodowla Roslin) and some pre-breeding is done in Germany (Julius-Kühn-Institut). Blue lupin is bred in Poland (Hodowla Roslin), and in Germany (Saatzucht Steinach). The Chilean breeding company Semillas Baer also introduces its cultivars of blue and white lupin into the German registration system. Newly started, organically oriented breeding projects for white lupin exist in the Netherlands (Louis Bolk Institute) and Switzerland (FiBL).

Lupins being predominantly self-pollinating, breeding has normally been performed through pedigree selection of pure lines, but suffers from relatively high outcrossing rates of 8-10 % (Wolko 2011, Australian Government 2013, Green et al., 1980) which make isolation of flowering plants through insect and pollen proof material necessary. In seed production, good practice minimum distances between different cultivars are 100-200m (McNaughton 2017, Heinz 2016). This is important because cross-pollination may lead to increased alkaloid levels in the seed even if it takes place between two low-alkaloid cultivars.

One of the main constraints in lupin seed production is the fact that anthracnose is transmitted via seeds. An agar-based method for detection of seed infestation was established at the beginning of the century (Feiler and Nirenberg 1998), but the test takes three weeks and did not always render reliable results in practice. For white lupin, it is at present not possible to produce healthy seed organically as long as a fast, reliable seed testing method is lacking. Organic White lupin growers in Germany have to use conventional, untreated seed. (No white lupin is grown in Switzerland at present). For this reason, FiBL started to investigate in a qPCR-based method for seed analysis in 2016 (Szuszkievicz 2016), a work that is currently continued in the scope of a phd thesis.

5. Agronomy

Cultivation instructions for lupins can be read in many publications – printed or published in the internet (Böhler and Dierauer 2011, Gesellschaft zur Förderung der Lupine 2017, Schachler et al. 2016, Ökolandbau.de 2015, Spiegel et al. 2014, White et al. 2008). Therefore, these are not repeated here. As most instructions that can be used in Switzerland have been published in Germany, our main questions refer to differences between the two countries and can be posed as follows:

- Can lupins be grown on Swiss soils at pH 6,5 to pH 7 or are these too alkaloid?
- Which cultivars are suitable?
- Can lupins cope with the high Swiss rainfalls of 1000-1300 mm/year?
- How early can lupins be sown?
- Can mixed cropping help to defend lupins against weeds – and if yes: what partners can be recommended (species, cultivar) at what sowing densities?
- How does anthracnose develop under Swiss conditions?
- Do alkaloid levels stay below the thresholds of 0.02 % for human consumption or 0.05 % for feed under Swiss conditions?

These questions are subject of our lupin trials. As no extensive lupin trials have been run before in Switzerland, we will have to refer to our own results once we can rely on several years' experience. This will be done in the final report of the DIVERSIFOOD project.

Fig. 6: a ripe field trial with white lupins in 2015

Fig.7: harvesting the white lupins in 2015: how much weeds can be seen?

6. Quality aspects

In ancient and historical times, lupins were mainly grown for human consumption. The traditional, snack-like preparation of lupins as whole seeds illustrates their special taste and nutty consistence, which is quite different from the rather mealy consistence of other cooked pulses like peas, chickpeas, red beans, and lentils. This consistence is due to the high protein and relatively high oil content and virtual absence of starch in the seeds. Table 4 gives a comparison of the main nutrients of blue and white lupins with soybeans and the domestic pulses faba beans and field peas.

Table 4: nutrients of grain legumes compared to soybean meal. Reference values from feeding tables (Source for pea, faba bean, soybean, and blue lupin: Weber et al. 2016; for white lupin: Roth-Maier et al. 2004; for soybean meal: Bellof et al 2016) and field samples taken in Germany in 2015 (in brackets (Weber 2016)).
Units in g/kg original substance, related to a dry matter content of 88%.

	Dry matter	Crude protein	Crude fat	Crude fibre	Starch	Lysin	Methionin
Blue Lupin	880	295 (289)	48 (56)	143	49 (40)	14,7 (14,4)	1,8 (1,9)
White Lupin		328	77	114	74		
Soybean meal (post oil extraction)		449	13	59	69	27,3	5,9
Soybeans	880	356 (324)	181 (196)	55 (66)	52 (62)	21,8 (21,1)	4,8 (4,8)
Faba bean	880	260	14	86	390	16,3	1,8
Pea	880	200	13	57	430	15	1,9

An important quality trait of modern "sweet" lupin varieties is their low content of the bitter, toxic alkaloids. Cultivars containing less than 0,05% of alkaloids in the dry matter are called "low alkaloid" in breeders' terminology; cultivars containing less than 0,02 % are called "alkaloid free". These values are regarded as the thresholds under which lupin intake is harmless, and they are required for feed (0,05 %) and food (0,02 %). Since alkaloid levels may vary with year, cultivar and soil conditions, they have to be always controlled. Even the low threshold levels of alkaloids can be detected sensorically (Bundesinstitut für Risikobewertung 2017). Therefore, the preparation method of lupins is important in food factories as well as in private kitchens for the acceptance of the products.

Another critical issue of lupins is their allergenic potential. Especially persons allergic to peanuts or soybeans have to be careful when trying lupins. Therefore, lupin ingredients must always be declared in food.

Lupin protein is of high quality and rich in lysine and arginine, but, like all legumes, has a low level of sulphur containing amino acids such as methionine and cysteine. Thus, lupins become more valuable if combined with methionine rich foods like sesame seed, nuts, or cereals. Lupin oil is rich in unsaturated fatty acids, especially oleic acid and linoleic acid. Lupins are also rich in insoluble fibre, predominantly non-starch polysaccharides that have a less flatulent effect than those of other pulses. Recently, several studies have shown beneficial health effects of lupins in human nutrition (Bähr et al. 2014, Jahreis et al. 2016). Bread enriched in protein and fibre derived from lupin kernel flour resulted in significantly higher self-reported satiety of test persons, and in lower carbohydrate intake at the following meal. Systolic blood pressure and pulse pressure were significantly reduced in overweight test persons when lupin bread was consumed compared to white bread (Lee 2006). Further health related advantages are cited in Gesellschaft zur Förderung der Lupine 2017.

7. Uses of lupins

7.1 Green manure

One of the traditional uses of lupins is green manure. Due to their environmental properties, Lupins can help prepare uncultivated or disturbed soil for cultivation. For this purpose, bitter lupins are grown due to their greater vigour in growth. Mostly, they form one component of a rapidly establishing and deep rooting mixture. Thus, farmers growing sweet lupins should make sure that no bitter lupins are grown near their fields. In France, bitter lupin growing is forbidden (Harzic, 2017).

7.2 Feed for pigs, poultry, cattle, and fish

Lupin seeds are the second richest legumes in protein after soybeans and thus valuable for feed, but if compared to soybean meal (post oil extraction) which at present is regarded the ideal main protein ingredient of feed mixtures for all animal groups, there are some typical differences (Table 4).

In monogastric animal feeding (pigs and poultry) it is important to keep in mind the low level of sulphurous amino acids, especially methionine, because it is essential for them and cannot be synthesized by the organism. Thus it is recommended to supplement methionine in feed mixtures or, as in organic farming where no isolated amino acids are allowed, to supplement methionine through food mixtures containing extraction cakes from rapeseed, sunflower, linseed, sesame etc. (Verbund ökologische Praxisforschung 2014). As pigs and poultry are sensitive to alkaloids, it is also important to keep the lupin seeds below the threshold of 0.05 % alklaloid content. Given the modern blue lupin cultivars currently available on the European market, this is not a problem if certified seed is sown.

For cattle feeding, lupins can replace soybeans completely if the composition of the feed mixture is adequately adapted. The higher fat content compared to soybean meal has to be kept in mind. However, many organic actors try to encourage farmers to make a shift in cattle feeding from high energy and high protein diets towards diets consisting exclusively of roughage like grass, hay and silage.

In Switzerland, little experience with feeding lupins to lifestock exists. However, since the cultivation of peas, faba beans and lupins has increased during the past years in Germany due to the new EU Common Agricultural Policy (CAP), several new feeding recommendation booklets have been elaborated there (Weber et al. 2016, Bellof et al. 2016, Gesellschaft zur Förderung der Lupine 2017, Losand 2016).

Lupins are also suitable as fish food in aquaculture. In Germany, a project started in 2015 to investigate and improve lupins as fish food at the Alfred Wegener Institute (Helmholtz centre for polar and marine research) (Weiss and Fitzel, 2015). In Chile, a large proportion of the lupins grown there are used in aquaculture as feed for salmon (von Baer, 2014).

7.3 Food

In the vegetarian/vegan food sector, which currently evolves with double-digit growth rates, more and more lupin products can be found in wholefood/organic shops and in specialized webshops, whereas in the bigger retailers lupin products can hardly be found to date. To date, all lupin products that can be bought in Switzerland are imported, most of them from Germany. There exists no lupin processing in Switzerland yet, but some businesses are considering to try out lupin recipes. (Bio Partner, 2016)

All foodstuffs that can be made out of soybeans, like tofu, tempeh, “soy sauce”, vegan milk and meat substitutes, can also be produced from lupins. Due to the lower protein content compared to soybeans, the protein concentration process during tofu production generates a large amount of unwanted by-product (Okara, or lupin fibres, lupin seedcoats and lupin oil). In addition, the consistency of lupin tofu cannot compete with soy tofu to date, so isolated lupin protein is rather used for milk substitutes, as an excellent emulsifier, and as an ingredient in many protein rich functional foods especially for athlete nutrition.

In the organic sector, products containing the whole seeds rather than only the lupin proteins prevail. These are e.g. spicy bread spreads; lupin flower as an egg substitute for baking; couscous-like coarse lupin meal for "vegetarian Bolognese sauce", tabbouleh or vegetable fillings; lupin noodles; meat substitutes; shredded, roasted lupin seeds as a caffeine free coffee substitute.

Many lupin products are not only soybean free but also gluten free, offering an alternative to persons suffering from respective allergies or intolerances.

7.4 Image and Consumer acceptance

To date, lupins are nearly unknown in Switzerland, but during the last years, some articles about lupins appeared carrying a positive image of the crop. Sympathetic traits are the ecosystem services and beautiful flowers of lupins, the absence of genetic engineering in all lupins traded on the market, and the positive health aspects of their analytical constituents. The same is true for Germany where lupins are better known but not Exceptions like Felix Olschewski's blog "Urgeschmack" exist but form a minority (Olschewski 2014).

7.5 An interview with a Swiss lupin stakeholder

Interview with Christian Rytz from the feed mill Mühle Rytz, in Biberen (canton Bern). A family business with a long tradition, not only a mill for feed and human consumption, but also a cereal wholesaler with a strong organic branch active in the Swiss organic market since 1981. It is run by family members in the 9th generation. The interview took place per e-mail in late autumn 2016.

CA: Mister Rytz, at FiBL we work with lupins, and with our project we want to make lupins known in Switzerland and to test practicable cultivation regimes for lupins in organic farming (first for blue lupin).
CR: This is important.
CA: We also want to improve anthracnose resistance in white lupins.
CR: That would be brilliant!
CA: In 2015 and 2016, some articles about lupins and even a small film were published in Swiss media, we organized field days and information booths. Now I would bei intersted to know whether this year more farmers offered lupins to you?
CR: No.
CA: Did you buy Swiss-grown lupins in 2016 and if yes, how much? And if yes, was it from pure stand or mixed cropping?
CR: I only bought the harvest from a lupin field trial, from mixed cropping with oats.
CA: was the lupin quality of this batch satisfying?
CR: yes, the lupins were good and, contrary to our experience from faba bean/oat mixtures, also the oats. Oats from mixed cropping are often greyisch and light and don't really meet our quality

requirements. The problem is that the oats reach maturity earlier than the legumes.
CA: In which feed mixture would you preferably use lupins?
CR: lupins are suitable as a premium protein source for all feedstuffs, be it poultry, cattle or pigs. In our opinion, the price is the problem. It doesn't allow the farmers to obtain a satisfactory contribution margin. Lupins are in direct competition with importet protein crops. There is no tariff protection.
CA: Would you buy more lupins in future so that we can recommend this to the farmers?
CR: We can buy lupins. However, as long as there are only small amounts we pay the (lower) pea price for them and use them mixed with peas. Should the amounts rise, we could integrate them separately into our formulations. But this would need at least 50t per year. Then we could also pay more for the lupins than for the peas due to the high protein content.
CA: So here we have the typical start-up difficulties and the farmers should join up to bring about the amount of 50 t... – Mr. Rytz, thank you for the interview.

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