R4D INITIATIVES

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Profitability of Manufactured Feed Pellets for Small-Scale Crop-Livestock Farmers in Tunisia

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Background

Tunisia imports most of its annual needs for animal feed (corn, soybean meal, barley, etc.) as raw materials. This importation leads to a significant outflow of foreign currency, thus weakening the livestock sector and making it more dependent on international prices in an increasingly volatile geopolitical sphere, especially in the Middle East and North Africa (MENA) region. This also results in unreliable animal feed supply chains controlled or managed by the public institutions (Bureau of Livestock and Pastures: *Office de l'Elevage et des Pâturages*, Bureau of Cereals: *Office des Céréales*, Union of Agriculture and Fisheries: *Union Tunisienne pour l'Agriculture et la Pêche*), and the private sector (mainly represented by the importing companies and the processing plants). This has significant consequences for livestock keepers, who are already challenged by climate change and low availability of biomass for grazing, in addition to the increase in other costs of livestock keeping.

In this context of continuous increase in cost and market disruptions in the supply of raw materials for concentrate manufacturing, and particularly during the scarcity seasons (autumn and beginning of winter), it is imperative to look for appropriate and inexpensive

Farmer producing pellets
Photo: Udo Rudiger, ICARDA—2021

solutions. Among these, the valorization of local resources (agro-industrial by-products, crop residues, shrubs, etc.) and their application in animal feed production has become more extensive (Bhat, 2021). These resources are added directly, preserved (drying, silage), or added as mixtures with other feeding resources (e.g., cereal grains, protein supplements, vitamins, minerals) in the form of feed blocks or increasingly pellets. The use of pelleting machines has recently been promoted by several research for development projects and other local initiatives. Preliminary results seem to prove its technical and economic efficiency for the feedlot system.

During the past few growing seasons, within several R4D initiatives and projects (the SWC@Scale[1] as part of the global GIZ ProSol Program; the CRP-Livestock "feed and forages"[2], and the International Fund for Agricultural Development (IFAD) funded CLCA[3] phase 2), ICARDA and its national partners have introduced imported feed pellet machines that were donated with a 10% financial contribution (to ensure strong ownership of the technology) to some pre-selected professional farmer organizations (FO) (SMSA[4] and GDA[5]) and individual farmers including agri-preneurs, with the idea of developing small feed businesses using these machines and boosting the nutrition of local herds. After assessing the available feed resources for each region (Northern, Center, and Southern), the leading members of each FO, under the supervision of the project's scientific teams, developed various feeding formulas. Other farmers have been developing their own formulas based on consultation with local extension agents. Some of the formulas used by farmers are still under experimentation and will be the subject of this brief, aiming at validating their economic viabilities.

Even though the feed pellet machine is a relatively new technology for the local farmers in Tunisia, who are accustomed to the complex industrial production chains, it has proven its efficiency on multiple occasions. In fact, the electric flat die feed pellet mill has no complex requirements for raw materials (e.g., raw materials must be ground and should have between 15–20% moisture), thus making it the perfect match for the Tunisian context. It can process various kinds of ground solid grains and agro-industrial by-products, mixed with other resources and additives, into feed pellets for animals such as small ruminants, cattle, rabbits, and even fish.

The machine is imported and runs on electricity. Numerous models are available to suit the demands of each customer (the small models producing 100–150 kg per hour, and the industrial ones capable of producing 3 metric tons per hour)[6]. In this case study, we will focus on two different versions: the small model capable of producing 150 kg per hour (220 volt), and a relatively larger model with a production capacity of 0.5 to 0.6 tons per hour (380 volt). Every FO in the study managed to develop at least one formula based on available resources (barley grain, wheat bran, maize, faba beans, etc.) and agro-industrial by-products (such as downgraded dates, date core, and olive pomace).

Locally produced feed pellets
Photo: Udo Rudiger, ICARDA—2021

[1] SWC@Scale Project: Towards the effective scaling of soil and water conservation technologies under different agroecosystems in North and Central West Tunisia (https://mel.cgiar.org/projects/icardaprosol) as part of the Global GIZ Program (www.giz.de/en/worldwide/33459.html).
[2] CRP-Livestock Project (https://livestock.cgiar.org/).
[3] CLCA Project: Use of Conservation Agriculture in Crop-Livestock Systems in the Drylands for Enhanced Water Use Efficiency, Soil Fertility and Productivity in NEN and LAC Countries (https://mel.cgiar.org/projects/clca2).
[4] SMSA: Mutual Society of Agricultural Services (Société Mutuelle de Services Agricole).
[5] GDA: Agricultural Development Group (Groupements de Développement Agricole).
[6] There is at present only one importer (Juhaina Ltd), who is importing machines from China, but only on demand. He has no stock of machines. At present there are only 150 kg/h and 500 kg/h machines in Tunisia. However, *Juhaina* can provide eight different machines with between 100 kg/h and 3,000 kg/h capacity.

Manufactured feed pellets: Set up a sustainable cost-driven business

Why feed pellets are a promising technology for feed resources

- Feed pellets can partly replace expensive imported concentrates at a lower cost than conventional animal feeds (feed represents almost 70% of the total production costs).
- There is irregularity in the market supply of these feeds.
- Use of locally manufactured feed pellets instead of imported concentrates saves foreign currency and reduces dependency.
- The local production of feed pellets creates employment and can be a source of income for pellet-producing enterprises or farmer cooperatives.
- Feed pellets provide an additional source of feed, mainly during dry seasons and in dry areas.
- There is a lack of forage resources in several regions of the country, mainly during dry seasons and years.
- Pellets are an environment-friendly way to get rid of by-products and residues that can be valorized for livestock feeding.
- Pellets provide inexpensive and high-quality feed in periods of roughage deficit or when they are very costly or scarce in the local market.
- Pellets can provide a nutritional complementary feed.
- The composition of pellet ingredients can be easily adjusted to the requirements of different livestock species and ages.
- Pellets can be easily dosed and handled due to their small size.
- Pellets are easy to pack and store.

Cooperative producing pellets

Photo: Udo Rudiger, ICARDA—2021

Opportunities for using feed pellets

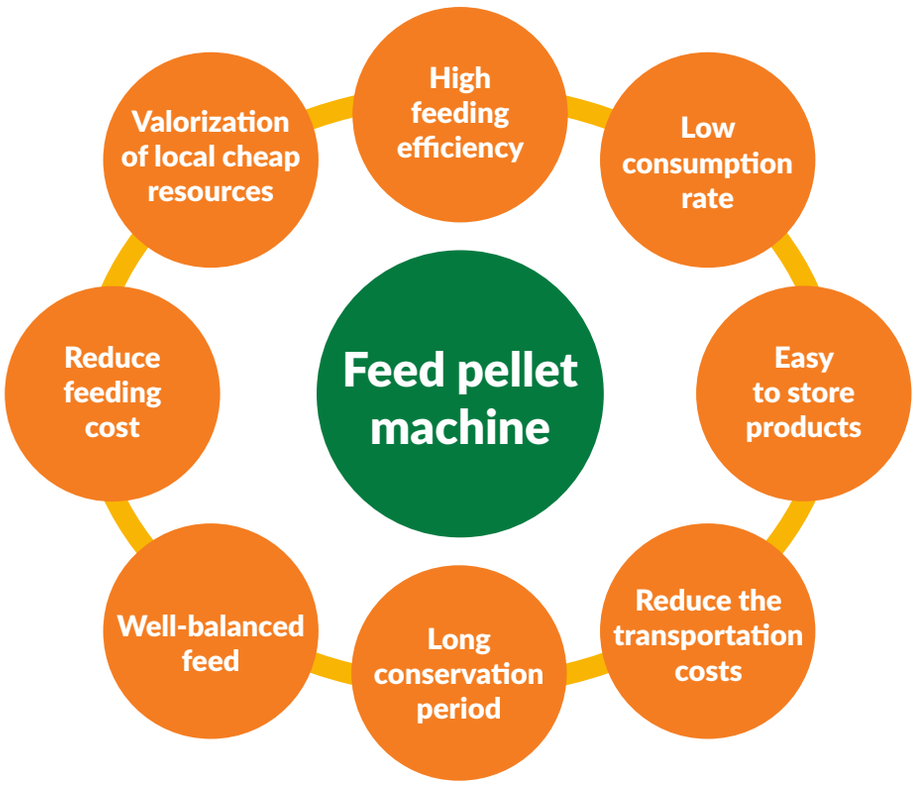
Technical advantages

The use of the pellet machine offers several advantages to potential users, whether these are private farmers, professional FOs, or even small businesses. Combined with average/low quality fodder, pellets can cover deficiencies in terms of nutritional needs. For example, it has been shown that feed pellets can sustain the growth requirements of sheep under intensive fattening systems. Good-quality pellets (well dried with dry matter >85%) have a long conservation period, allowing livestock farmers to better cope with some market shortage during the high-demand seasons (autumn, winter, religious celebrations like Eid). But the most important advantage of this technology is its ability to reduce the economic cost by valorizing almost all available feed resources.

Economic opportunities

In some cases, the use of a complete production unit integrating a grinder, a mixing unit, and a pellet mill machine, with crates for drying and cooling, will make some FOs less vulnerable to changes in market prices (given the use of local products and the low cost of the produced pellets), hence making the members of these organizations more resilient to these types of financial and market shocks.

Figure 1 Pellet machine usage opportunities



Source: Our elaboration based on several resources (2022).

Disadvantages and constraints of producing feed pellets

- Large dependency on availability of by-products (e.g., wheat bran).
- Only periodical production (by-products available at a specific time only).
- Barley grain and wheat bran are considered essential parts of pellets (up to 40%) and farmers need quota (subsidized barley and bran) to produce competitive pellets (low cost).
- Need for access to 380 volt power to produce big quantities (long procedure to obtain this from the electricity company).
- Need for well-dried raw material (about 20% moisture) to avoid technical problems (blockage of dies).

Pelleted feed technology—an overview

Feed pelleting can be defined as conversion of finely ground mash feed into dense, free-flowing pellets using a process of mechanical pressure. In the Tunisian case, feed pellets are solid mixtures consisting essentially of agro-industrial by-products such as olive cakes, wheat bran, or downgraded dates, legumes such as faba beans, combined with other products such as mineral and vitamin supplements (see feed pellet formulas in Table 1). The main use of this feed category is to complement poor-quality forages and partly replace expensive concentrates during feed shortages or deficit periods (late summer, autumn, and winter). It is important for ruminants not only as a nutritional supplement but also as a nutritional strategy if the animals are grazing very poor pastures.

Table 1 Feed pellet composition ingredients and formulas, as collected from various users (farmers organizations, development organizations and other private users)

Feed pellet composition ingredients	Feed pellet formulas (%)				
	Formula 1 (You feed 2)	**Formula 2** (SMSA Ankoud El Khaier 2)	**Formula 3** (private farmer)	**Formula 4** (SMSA Ettaouen)	**Formula 5** (OEP)
Downgraded dates	30	-	40	-	-
Faba beans	25	-	-	22.5	-
Cereal bran	26	20	15	22.5	16
Barley grain	15	30	15	23	30
Maize (corn)	-	26	-	-	-
Soybeans	-	20	-	-	-
Alfalfa	-	-	26	-	10
Almond shells	-	-	-	28	-
Commercial concentrate	-	-	-	-	16
Dates core	-	-	-	-	26
Salt	-	-	2	1	-
MVS—mineral-vitamin supplement	4	4	2	3	2
Total average cost (TND/metric ton)	714.0	956.8	341.5	552.3	513.0

Source: SWC@Scale, CLCA, and CRP-Livestock Projects Team—Tunisia (2021).

Note: 1 Tunisian Dinar (TND) = 0.32 US$ (average January–August 2022).

Figure 2 Pellet machines technical characteristics

Big model technical characteristics		Small model technical characteristics	
PRICE	9000 TND	PRICE	2600 TND
LIFE CYCLE	7 years	LIFE CYCLE	5 years
POWER	15 kw per hour	POWER	4.5 kw per hour
VOLTAGE	380 volts	VOLTAGE	220 volts
PRODUCTION CAPACITY	500 kg per hour	PRODUCTION CAPACITY	125 kg per hour
HUMIDITY	4 to 10%	HUMIDITY	2 to 4%

Source: Own elaboration from pellet machine (Juhaina—machine supplier) technical specification (2021).

Factors affecting pellet feed quality

High-quality pellets can be defined as pellets that can withstand repeated handling, such as during bagging, transportation, and storage, without excessive breakage or generation of fine particles (Farahat, 2015). Feed pellet quality and conservation can be affected by various factors, starting from the composition of the formula (raw materials and additives used). Some materials have a positive impact on the quality and durability of the pellets (conservative effects), while others can downgrade their nature. These aspects are beyond the scope of this R4D initiative and are the subject of separate research that is currently being undertaken in Tunisia.

Feed pellets business plan: Set up a sustainable cost-driven business and a helpful tool for decision-making

Technical characteristics

Two models of pellet machines were distributed by ICARDA and its national partners: a large model that can fulfill the needs of a relatively large community under the supervision of the FO technical staff, and a small one for individual farmers.

Business plan indicators

As feed block technology had not succeeded in Tunisia and adoption of this technology was low (Dhehibi et al., 2020), ICARDA started research in 2018 on the possibility of producing pellets made of locally available materials and by-products. A survey of 700 farmers conducted in Tunisian dryland areas (Zaghouan and Kairouan Governorates) showed that most were interested in this feed method. Pellets made

from alfalfa were already available to farmers but were costly as they were mostly imported. The survey showed that there were two types of pellet machines available in Tunisia. One was an imported model with a production capacity of 20 tons a day priced about €30,000 (euro). The other model was locally produced with a capacity of 1–2 tons a day priced about €2,700. The use of a locally manufactured machine generated some problems, such as drying of pellets and low production capacity. Based on that, the project team changed its strategy and used imported Chinese models from Juhaina. These are the models considered in the business model analysis.

The assessment of the financial and economic indicators of this business model reveals its profitability for investment with a discount rate of 5% for all cases considered (Table 2). The economic factors outlined in Table 2 suggest, in the worst case, an average net profit of about 2902.16 TND (Tunisian dinar) a year resulting from the use of this machine for personal use and under a working capacity of 8 hours/day for 180 days/year. In addition, there are calculated indicators for non-discounted profitability criteria such as profitability index (PI), known as profit investment ratio (PIR), payback period (PB), and return on investment (ROI) of this project under the two discount rates. This PI rule is a decision-making exercise that helps evaluate whether to proceed with the investment in this technology. The rule is that a PI ratio greater than 1 indicates that the project should proceed. A PI ratio below 1 indicates that the project should be abandoned. The PI indicator shows a ratio greater than 1 in the five case studies. This confirms the profitability of this business project. The second indicator is the PB. This indicator refers to the amount of time it takes to recover the cost of an investment. Under the 5% discount rate scenario, the PB of an investment reaches a break-even point in less than one year (i.e.,

Table 2 Locally manufactured feed pellet business plan—economic and financial indicators

Item	Indicators	Showcase 1 You feed 2 (large pellet machine)	Showcase 2 SMSA Ankoud El Khaier (large pellet machine)	Showcase 3 Private farmer (small pellet machine)	Showcase 4 SMSA Ettaouen2 (large pellet machine)	Showcase 5 OEP (large pellet machine)
	Production cost (TND/ton)	714.00	965.80	341.50	552.34	513.23
	Production per year (tons)	1200	1200	360	1200	1200
	Selling price (TND/ton)	750.00 (+5%)	Not commercialized Max +4%	Not commercialized (+5% = 358.57)	592.34 (+7.25%)	At the experimental level (+6% = 544.02)
Non-discounted profitability criteria	Average net profit (TND/year)	5877.73	13422.12	5380.92	8136.90	2902.16
	Profitability index (PI) (1 + (net present value/initial investment))	4.57	10.43	10.34	15.34	2.25
	Payback period (years)	1.18	0.52	0.40	0.85	2.31
	Return on investment (ROI)	19.94%	37.81%	110.65%	27.07%	3.32%
	Break-even analysis—ROS (return on sales per dinar invested)	1.40%	2.30%	2.50%	2.40%	0.10%
Discounted profitability criteria	Net present value (TND)	32144.14	84954.80	23304.50	48147.37	11315.13
	Benefit cost ratio (BCR)	3.57	9.43	9.34	14.34	1.25
	Internal rate of return (IRR) (%)	Very high	Very high	Very high	Very high	141%

Source: Own elaboration based on data collected from pellet machine beneficiaries (2022).

Note: Tons are metric tons.

almost one operating month). Thus, the desirability of an investment is directly related to its PB. In this case study, therefore, shorter paybacks mean more attractive investments. The ROI indicator used to measure the amount of return on a particular investment relative to the investment's costs highlights that higher returns mean more attractive investments. The ROI indicator is positive in the five case studies (between 3.32% and 19.94%) suggesting a gain from this investment in this machine business relative to its costs, and consequently the profitability of this investment. This statement is also confirmed by the discounted profitability indicators of benefit cost ratio (BCR) and internal rate of return (IRR). Overall, investing in locally manufactured feed pellet machines in the dryland mixed crops-livestock farming systems could save money, generate employment, and generate feed-driven resources businesses in the future, providing evidence for the model's profitability and self-sustainability (Table 2).

Potential risk

Given that this model involves an investment, it is worth assessing the potential associated risks. Overall, risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return when investing in a new technology. Risk includes the possibility of losing some or all of an original investment. This is usually quantified by considering several types of risk.

Cows eating pellets

Photo: Udo Rudiger, ICARDA—2021

In this type of investment, there are six main types of risk and several ways to quantify risk for analytical assessment.

- **Financial risks:** Financial risks are considered medium to high because feed pellet machines require the use of medium-cost and available by-products.
- **Operational risks:** Operational risks are low for services and skills. Agricultural services are provided in addition to the availability of expertise and labor. However, for the supply of feed pellet ingredients such as wheat bran, the risk is considered quite high.
- **Infrastructure risks:** The rural electricity grid is predominantly 220 V. It is not adapted to the requirements of the technology for large feed pellets, which need high-voltage intensity (380 V) and quite an expensive unit.
- **Market risks:** Market risk is low due to high demand for feed generally and during a large proportion of the year.
- **Physical risks:** Physical risks (weather, diseases) do not closely affect this type of business.
- **Maintenance risks:** This risk is low. Although the models used are imported, spare parts are available via the importer, Juhaina.

Overall, the risks to introduce and operate a feed pelleting business can be considered as minor. It is possible and prudent to manage investment risks by understanding the basics of the system, how risk is measured, and what strategies and procedures could reduce or mitigate these potential risks in the feed pellet business plan. Learning the risks that can apply to different scenarios and some of the ways to manage them holistically will help all types of investors and business managers (e.g., dryland crop-livestock farmers) to avoid unnecessary and costly losses.

Conclusions and sustainability perspectives

The economic and financial indicators reveal that locally made feed pellets have reasonable and encouraging upfront cost of investment. The elaboration of the business model for feed pellet machines suggests the potential profitability of investing in this type of machinery within crop-livestock farming systems. To ensure the business is sustainable, some key elements should be considered:

- Having a good design for the feeding formulas (i.e., diversification of the formulas to reach all categories of ruminants).
- Keeping expenses low and having a savings buffer.
- Starting with a basic business plan including a simple marketing strategy (e.g., at local level).
- Investing in knowledge and skills linked to the ingredients used in this technique and building partnership with other farmers, organizations, the private sector, etc.
- Incorporating feed pellet mills within a small industrial unit aiming to fulfill the needs of smallholders.

Box 1 Highlights

- Feed pellet machines are a potential development tool for managing scarce feed resources that shows promise for livestock farming systems and contexts in community programming.
- Feed pellet machines are a low-cost and profitable technology. It is a relevant and sustainable solution for food and nutrition not only for mixed crops-livestock farms but also for agropastoral, oasis, and desertic communities.
- The benefits associated with feed pellet machines from economic return include increased savings from reduced input, high yields, and affordability of this technique.
- Local feed pellet production is a potential source of income for farmer cooperatives serving their members.
- Local feed pellet production can create employment.
- Local feed pellet production helps the country to save foreign exchange currency and reduces transportation of imported ingredients like soy and maize, thus indirectly contributing to reducing emission of harmful carbon gases (mitigating climate change).
- Local feed pellet production is an environment-friendly technology.

Ingredients for pellet production

Photo: Udo Rudiger, ICARDA—2021

Happy farmer with produced pellets

Photo: Udo Rudiger, ICARDA—2021

Annex 1 Study cases: Formulas and expected selling prices used in the business plan analysis

Table A1.1 Farmer formulas

Feed pellet composition ingredients (%)	Feed pellet formulas (%)						
	Formula 1 (You feed 2)	**Formula 2** (SMSA Ankoud El Khaier 2)	**Formula 3** (private farmer)	**Formula 4** (SMSA Ettaouen)	**Formula 5** (OEP)	**Formula 6** (You feed 1)	**Formula 7** (SMSA Ankoud El Khaier 1)
Downgraded dates	30.0	–	40.0	–	–	30.0	–
Faba beans	25.0	–	–	22.5	–	–	22.5
Cereal bran	26.0	20.0	15.0	22.5	16.0	26.0	22.5
Barley grain	15.0	30.0	15.0	23.0	30.0	15.0	23.0
Maize	–	26.0	–	–	–	–	–
Soybeans	–	20.0	–	–	–	–	–
Alfalfa	–	–	26.0	–	10.0	25.0	–
Almond shells	–	–	–	28.0	–	–	–
Commercial concentrate	–	–	–	–	16.0	–	–
Dates core	–	–	–	–	26.0	–	–
Salt	–	–	2.0	1.0	–	–	1.0
Mineral–vitamin mix	4.0	4.0	2.0	3.0	2.0	4.0	3.0
Olive cake	–	–	–	–	–	–	28.0
Total average cost (TND/ton)	714.0	956.8	341.5	552.3	513.0	444.0	525.0

Source: Project team—Tunisia 2021.

Note: 1 Tunisian dinar (TND)=0.32 US$ (average January–August 2022). Tons are metric tons.

Table A1.2 Public sector formulas (OEP)

Feed pellet composition ingredients (%)	Feed pellet formulas (%)					
	Formula 1	**Formula 2**	**Formula 3**	**Formula 4**	**Formula 5**	**Formula 6**
Cactus	60.0	–	25.0	–	–	–
Hay	25.0	–	–	–	–	–
Barley grain	7.0	15.0	1.0	–	30.0	30.0
Faba bean	7.0	–	–	–	–	–
Olive cake	–	47.0	33.0	78.0	–	–
Olive twig	–	29.0	–	–	–	–
Soy cake	–	6.0	3.0	17.0	–	–
Salt	1.0	3.0	2.0	5.0	2.0	–
Downgraded dates	–	–	–	–	40.0	–
Dates core	–	–	–	–	–	26.0
Alfalfa	–	–	–	–	12.0	10.0
Cereal bran	–	–	–	–	15.0	16.0
Commercial concentrate (N°7)	–	–	–	–	–	16.0
Mineral–vitamin mix	–	–	–	–	1.0	2.0
Total average cost (TND/ton)	347.0	244.5	450.4	275.8	417.1	513.2

Source: OEP (2021).

Note: 1 Tunisian dinar (TND)=0.32 US$ (average January–August 2022). Tons are metric tons.

Table A1.3 Example commercialized formulas (private sector)

Feed pellet composition ingredients (%)	Feed pellet formulas (%)		
	Formula 1 Commercial provider 1	**Formula 2** Commercial provider 2	**Formula 3** Commercial provider 3
Corn	30.0	20.0	20.0
Cereal bran	20.0	25.0	27.0
Soy cake	20.0	22.0	24.0
Barley grain	25.0	29.0	25.0
Mineral–vitamin mix	5.0	2.0	2.0
Salt	–	2.0	2.0
Total average cost (TND/ton)	1110.4	948.7	967.9

Source: Local market, 2021.

Note: 1 Tunisian dinar (TND)=0.32 US$ (average January–August 2022). Tons are metric tons.

Further reading

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