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# Why Farmers Adopt Agro-Industrial By-Products in Animal Feed? Lesson Learned in Algerian Case



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## Abstract

The Algerian animal sectors suffer from a major handicap which is the insufficiency of fodder resources. The current structure of the animal feed industry is essentially based on the imported raw material (corn and soybean meal). It is in this logic that this study teat the problem of adoption of agro-industrial by-products as innovative inputs in animal feed. Our results based on a logistic model analysis with re-sampling applied to the survey data of farmers in the Souk Ahras region of northeastern Algeria show that the adoption of this innovation is determined by several factors related to the socio-professional profile of the farmer and the structure of the breeding. The seasonality that characterizes the availability of these by-products does not constitute an obstacle to their use by farmers. The diffusion of these new techniques will require public institutions' support through better dissemination of information and specialized training in this area.

**Keywords:** Algeria; By-products; Innovation adoption; Animal feeding; Farmer's choice

## Introduction

In the manner of all the semi-arid countries, the pastures provide the primary fodder source. Their surface in Algeria represents nearly 40 million hectares. The cultivated fodder resources consist of cereal stubble, vegetation grazed fallow representing 97.7% of the total forage area, some cultivated fodder (1.95%) and natural fodder (0.51%). These areas are characterized by low forage productivity [1]. The insufficiency in animal feeding, regression land, limited use of resources on the part of farmers, remains a topical issue given that availability is closely linked to market prices regulated by supply and request. Faced with this situation, Algeria chooses to import to fill the shortfall of feeds in the local market. According to the National Office of Animal Feed Food (ONAB) 3 million tons of maize are required to meet annual national needs. The Algerian government has decided to support and accompany the development of maize and barley. Thus, it is committed to filling the shortfall by encouraging the development of local production of barley and maize by buying at a higher price than the import. Local production of maize is well supported with 4500 DA/q (32€/q), against 17.9 €/q for the imported one. Despite efforts, Algeria could not meet the market needs in livestock feed

because it requires an estimated area of 200 000 and 300 000 hectares of maize (against less than 1000 ha cultivated actually in Algeria), knowing that this crop needs lots of water in a semi-arid country. Imported material feed matter generates significant costs to the Algerian state. In 2014, the purchase of maize cost 977.13 million \$ and barley 196.6 million \$. During the last twenty years, and to meet the growing demand for animal products, maize imports have increased more than 10,000 times and soybean meal by nearly 7,000 times (ONS 2017). However, agro-industrial by-products, "waste in their current state", are available in appreciable quantity, allowing their integration in the animal feed sector although their use requires nitrogen treatments or complementation. These can contribute to the improvement of animal feed in the region where they come from. These are, in particular, the milling bran, tomato and citrus pulp, molasses, olive-pomace, grape marc, brewers dried grains, and apricot pits. Some are energy supplements such as molasses and pulp, others are protein supplements such as almond of apricot and brewers dried grains [2]. The work of [3-5] has demonstrated the technical utility of using these by-products in the feed industry through

partial substitution of raw materials (soybean meal and maize).

Agro-industrial factories generate various by-products, farmers may be asked to use it in their food rations. However, accurate information and knowledge on these by-products seem necessary for their adoption in farms. This article aims to analyze the factors influencing the adoption by farmers of these by-products in feeding their flocks. This paper can serve as a guide to a public policy whose objective is to enhance feed resources management and animal production by developing an agroecological practice (valorize agro-industrial waste). It includes three sections. After this introduction presenting the context of the study, section 2 presents the methodology of the study starting from the sample to the establishment of the questionnaire, and finally, the choice of variables and statistical analyses used. Section 3 presents the results and discussion and includes two subsections: a food management characterization of the surveyed farms and an analysis of the determinants of adoption of innovative input in the diet of livestock. A conclusion at the end of the paper to return to the main results of this study and the prospects for their implementation by public power in livestock development.

## Material and Methods

### Study setting and sample

The objective is to analyze the factors that determine the use of by-products and their place in the food structure of livestock farms. Thus, we have investigated farmers in the region of Souk Ahras, the major cradle of animal production in Algeria. The choice of the survey area is justified by the geographical location of this region where farmers benefit from the proximity not only of livestock feed industries but also agro-industrial factories emitting by-products subject of our study. This region is also known for the diversity of farming systems adapted to its representative bioclimatic three floors of the country namely a rainy mountainous area (600 mm/year) temperate lowland area (400 mm/year) and finally an area of high semiarid trays (less than 350 mm/year). The survey was conducted in 2017 with a random sample of 57

farmers who agreed to be interviewed. The survey was conducted face-to-face in front of the feed outlets to target concentrated feed users, breeders subject to our study. After verification of survey results, only 40 questionnaires were validated and used in the analysis.

### Questionnaire and Variable selection

The study questionnaire consisted of four sections. The first relates to the individual characteristics of farmers interviewed (age, experience, level of education, agricultural training at the installation, participation in information days and agricultural training organized by the Chamber of Agriculture). The second section seeks to identify the farm characteristics and practices (UAA, labor, manpower and high species). The third part seeks to characterize the food management of livestock (feed used and their quantities, supplying). Finally, the last part is devoted to assessing the attitudes of farmers towards agro-industrial by-products. Here we first look to find out if farmers know these by-products before asking if they use them in the feed of their livestock and their perceived level of availability in the market.

To analyze the determinants to use innovative inputs (agro-industrial by-products) in animal feed, the collected data were transcribed and then treated by the SPSS statistical analysis software. Here we identified two dependent variables (Byprod\_know and Byprod\_use) (Table 1), but at the survey verification phase, we found that the surveyed farmers know at least two by-products from the list we presented to them (the milling bran, tomato and citrus pulp, molasses, olive-pomace, grape marc, brewers dried grains and apricot pits). That's why we did not do statistical analyzes in connection with the first dependent variable (Byprod\_know). To analyze in connection with the by-products use, we first characterized the feed management of surveyed farms and defined a set of variables describing the individual characteristics of the farmers, farm characteristics and finally by-products market characteristics (Table 1). These dimensions are considered by the literature specialized in the issue as the main factors influencing the decision to adopt the innovation in the agricultural environment [6-8].

Table 1: Variables presentation.

Variable	Definition	Mean	ES
Byprod_know	0 = no; 1 = yes	1	0
Byprod_use	0 = no; 1 = yes	0.9	0.04
Age	Farmer's age	48.7	1.94
Experience	Years of experience in breeding	20.32	2.32
Education	0 = unschooled; 1 = primary; 2 = fundamental; 3 = secondary; 4 = high school than	1.35	0.19
Training_instal	0 = no; 1 = yes	0.07	0.05
Information_day	0 = no; 1 = yes	0.42	0.13
Manpower	Number of labors in the farm	2.15	0.28
UAA	Agricultural area (ha)	14.27	2.09

Cattle	adult cattle in the farm (head)	10.55	1.54
Sheep	adult sheep in the farm (head)	13.12	2.54
Poultry	Poultry produces annually in the farm (head)	1475	1033
Supplying_difficulty	0 = infrequent; 1 = frequent; 2 = very common;	0.35	0.07
Supplier	0 = animal feed factory; 1 = cooperative; 2 = private; 3 = Agro-industrial factory; 4 = other	1.85	0.08
Byprod_availability	0 = no; 1 = yes	0.475	0.07

### Statistical analysis

A binary logistic model (Byprod\_use) with a bootstrap resampling (100 replicates) was employed to process the data. This method resampling is highly relevant to analyze the determinants of the innovation adoption and address the lack of answers or a low sample size [7]. It has the advantage of weighted estimates reflect the true population parameters [8-11]. To analyze the results of the model, three thresholds of statistical significance ( $p \leq 0.1$ ;  $p \leq 0.05$   $p \leq 0.01$ ) were fixed.

### Results and Discussion

The livestock farms surveyed use both dry forages (hay) but also concentrated feed (barley, compound feed). The amounts and diversity of feed inputs depend on herd size and production purposes (milk, red meat, white meat). The feed inputs of cattle farms surveyed are dominated by concentrated feed which

represents 60% of the total tonnage consumed, equivalent to 360 q/year (Table 2). These results confirm the importance of concentrated feed as a main input in the surveyed farms and show the relevance of our sample to address the issue of the place of by-products in the management of feed inputs and the possibility of conventional inputs substitution. The remaining 40% of feed inputs include barley that is another concentrated. By feed inputs insufficiency, the cereal straw is an agricultural by-product that systematically used in ruminant feed, so we did not consider it in our study as an innovative input into animal feed. Cereal straw represents 13.5% of consumed inputs (the equivalent of 80 q/year) which is a non-negligible share of feed inputs especially considering its cost of 290 DA/bale of straw of 18 kg for average annual spending of 130,540 DA/year. However, the first item of expenditure in feed inputs remains the concentrated feed with 1,284,287 DA/year before the hay that costs 290,320 DA/year.

**Table 2:** Descriptive statistics of the components of feed management.

Variables	Min	Max	Mean	SD
Consumed hay (haystack of 25kg/year)	0	2000	592.5	± 490.62
Price of consumed hay (DA/haystack)	400	500	490	± 31.62
Consumed straw (bale of straw of 8kg/year)	0	2000	448.75	± 460.83
Price of straw consumed (DA/bale)	200	300	290.9	± 30.15
Consumed barley (q/year)	0	50	8.12	± 13.52
Barley price (DA/q)	3000	3500	3444.44	± 166.66
Consumed concentrated feed (q/year)	0	1920	360.6	± 411.20
Price of consumed concentrated feed (DA/q)	2500	4850	3561.53	± 596.64
Distance feed supplier-farm (km)	1	700	26.25	± 109.47

Hay and straw are from the production in the farm and/or purchased from other farms during the harvest season. Concentrated feeds are exclusively purchased from animal feed dealers, cooperatives or directly from animal feed manufacturing units. Indeed, the substitution of a part of concentrated feed by innovative input would be an important opportunity to reduce the animal feed cost and consequently improve the farmer's income. The estimated logistic model shows that 10/13 explanatory

variables are significant (Table 3). All individual farmer's characteristics are determinant to by-products adoption as inputs in innovative animal feed. As against certain characteristics of the farm are not significant since it is the herd composition and its size that influence the choice of use of by-products in animal husbandry. Moreover, the type of supplier and the availability of by-products do not seem decisive in the adoption of these new animal feeding inputs.

**Table 3:** Results of logistic regression (Byprod\_use: 0 = no; 1 = yes).

	Coef.	bootstrap SE	z	p
Age	-11.61	2.91	-3.99	<0.001
Experience	2.93	1.57	1.87	0.06
Education	-98.07	23.65	-4.15	<0.001
Traingin_instal	413.3	144.04	2.87	0.004
Information_day	-109.81	35.79	-3.07	0.002
Manpower	83.87	30.41	2.76	0.006
UAA	0.98	2.19	0.45	0.652
Cattle	8.02	3.06	2.62	0.009
Sheep	-1.62	0.53	-3.05	0.002
Poultry	-31	0.31	-0.1	0.92
Supplying_difficulty	104.63	30.05	3.48	<0.001
Supplier	-40.2	8430.4	-0.01	0.996
Byprod_availability	-40.37	25.83	-1.56	0.118
Constant	615.39	16848.8	0.04	0.971

The individual characteristics of the farmers are all determinant to by-product adoption as inputs in livestock feed. The age of the farmer seems to influence a very significant decision to use agro-industrial by-products in animal husbandry. Several authors have reported similar results where young farmers are more prone to accept new techniques in agriculture [12-15]. Unlike most older farmers attached to their old practices, young farmers are often more enthusiastic to adopt new techniques in our case the use of new inputs in livestock feed. However, this result is to clarify the experience factor plays a decisive role in the adoption of by-products in animal feed. Results in this direction have been reported by several authors [16-21]. The farmer needs some experience to take this to a new feeding technique. It is usually the case of farmers who have low educational levels which not allowing them to have the needed skills to integrate new technologies in their breeding workshop. As against the farmers with a higher educational level are more skeptical about the by-product use efficiency as an animal feed input. Although several authors have made a positive correlation between the educational level and new techniques acceptance in agriculture [22-24], it seems the opposite in our case. A high educational level creates a perception of more complex and higher risk and makes farmers less receptive to the adoption of innovation [25]. The risk relating to by-products use in animal feed (nutritional values and unknown dosage, the presence of anti-nutritional factors, lack of skills of processing and storage ...) remains a blocking factor for by-product use by farmers even if they participate to information days organized by the Chamber of Agriculture. This is because, according to our investigations, that no information was provided by this agency on the by-product integration possibilities as a new feed source for livestock. The lack of communication on by-product utility as potential feed input strengthens farmer's risk perception on it. Therefore, it is essential to relativize the impact of

the professional network on the decision to adopt the innovation to the extent that it does not disseminate targeted information in its favor.

Our results, however, show that specialized training at the setting-up phase helps to motivate farmers to adopt this new feed technique. This is what was also reported by Yiridoe et al. [26]. In this training, the farmers get the information and skills necessary to use by-products in their breeding workshops. The constant need to provide more effective training to farmers to enable them to understand the characteristics of new technologies is evident in our case. It is always possible to increase the motivation of farmers to adopt innovations by providing them new knowledge through specialized training [27,28].

The results of the estimated model also show that farm characteristics influence the use of by-products. The availability of labor in the farm increases the probability of by-product adoption as inputs in animal feed. It can be explained by the need for additional work related to the by-products supply and process for their use (conservation, storage, dosage). As has been demonstrated by several authors [29-33], unavailability of labor limits new technologies adoption and encourage farmers to practice conventional production.

The farm size expressed by the UAA does not represent in our case a determining factor for the adoption of this new feeding technique. Several studies have had similar results where economies of scale advantage provided by a large farm is not an incentive for the adoption of an innovation [23, 34-35]. The herd composition and size are key factors in the use of by-products in animal husbandry. Our results show that it is the farms with a greater number of cattle that integrate more by-products in animal feed management. Sheep number has the opposite effect and does not encourage farmers to use the by-products. The heavy

use of compound and concentrated feed in cattle farming is the cause of this finding. Indeed, farmers rely on the by-products use to partially replace conventional feeds of their livestock. Small ruminants are less dependent on the provision of concentrated feed especially since these are small herds managed in a semi-extensive way with low inputs. Poultry is almost soilless breeding as it only receives industrial feeds made mainly from soybean and maize [36]. The economic context partly explains by-products adoption in animal feed. Indeed, supply difficulties on the livestock feed market (insufficient quantity, poor quality, and high prices) encourages farmers to look for cheaper alternatives even if they are seasonal [37]. This is also why the by-product's availability and the animal feed supplier type does not influence the farmer's decision to use the by-products. The seasonality that characterizes the production of agro-industrial by-products does not seem to be a barrier to their use in livestock farming, because their use is complementary to that of the concentrated feed and the basic ration. Therefore, different authors advocate thresholds of use to improve the nutritional efficiency of these by-products and to reduce their health risks on livestock [38-44].

### Conclusion

Algerian animal sectors suffer from a major handicap is the lack of forage resources. The current structure of the feed industry is built mainly on imported raw material (soybean meal and maize) where the share of domestic production is marginal. In this situation of the livestock sector fragility, the search for alternatives to import to reduce public spending and better use of local resources is more than ever a necessity. It is in this sense that our work fits. It is built around the issue of the valuation of agro-industrial by-products as an innovative input in livestock feed. We performed our study on the incentives for the adoption of a wide range of by-products available in the country that has undergone extensive nutrition research in animal feed (the milling bran, tomato and citrus pulp, molasses, olive-pomace, grape marc, brewers dried grains and apricot pits). Our study shows that the adoption of this innovation is determined by several factors, first of all, related to the farmers' socio-professional profile where specialized training in the installation can be an important lever for the State to strengthen the diffusion of this new feeding technique. Unlike the herd composition and size that may influence the farmer's decision, the farm size has not influenced the adoption of these innovative feed inputs in farming. Cattle breeding, given its high dependence on concentrated feed, seems more conducive to the use of agro-industrial by-products, hence the need to focus more research on that niche. Intensive farming is often synonymous with a higher need for feed resources opens the way for the by-products use to bridge the feed gap and to reduce costs that result. The seasonality that affects the agro-industrial by-products availability does not seem to hinder their adoption by farmers. However, the diffusion of these new technologies will require more public support through improved information dissemination and specialized training in this field.

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