



History and Current Situation of Commercial Ostrich Farming in Mexico

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ABSTRACT

As in many other countries, in Mexico, the ostrich aroused the interest of public and private entities for its broad productive qualities and quality of its products. The objective of the present study was to describe the history of ostrich introduction in Mexico as a kind of commercial interest, from the arrival of the first birds to the current farms. In 1988 the first farm was established, then a series of farms of significant size were appearing, all of them focused their business on the sale of breeding stock, a business that was profitable during the heyday of the specie in the country (1998-2008). The main client was the government that acquired ostriches to distribute them among a large number of new farmers. When the introduction into the activity of government and private individuals was no longer attractive, the prices of the breeders fell and the sector collapsed because the farms were inefficient and the infrastructure and promotion sufficient to position the ostrich products were not produced on the national or export market. In 2016 it was known that about 30 farms remained in the activity, of which 20 were located and provided information for this study. The farms that remained in the activity continued with significant difficulties in terms of their productivity, however, they had managed to mitigate part of the problem by sharing production practices among themselves and going to their counterparts abroad through digital media. On the commercial side, they had managed to develop standardized products using maquiladora companies, and placed them in niche markets that paid for higher prices than those that are paid for conventional substitutes. In the case of ostrich, in Mexico and many other countries, the sector failed because the market demand response was overestimated and the farmers ventured into the activity without adequate knowledge bases, infrastructure, and institutional support. These findings could be referred to many other species of nascent interest.

Key words: Emerging sectors, Exotic poultry, Niche market, Specialty livestock, Organization, Ostrich meat

INTRODUCTION

The commercial use of ostrich had its origin in South Africa, a country that led the production of this species with 60% of the meat, skin and feathers of the world market (Hoffman and Cawthorn, 2014). According to Benson (2012), the first countries that seconded South Africa in ostrich production were the neighbors Namibia, Zimbabwe and Botswana, as well as Australia, Germany, France and Belgium. Then, in a second wave, countries such as the United States, Canada, Spain, Portugal, Italy and Greece were incorporated. Finally, in a third wave, the ostriches arrived in territories of Argentina, Brazil, Peru, Colombia, Venezuela, Chile and Mexico. Ostrich aroused the interest of investors in different parts of the world, due to the productive qualities and integral use of the specie (Brand and Jordaan, 2011; Ghaffari Moghadam, 2016;

Abbas et al., 2018), as well as for the nutritional benefits of its meat (Majewska et al., 2009; Polawska et al., 2013; Al-Khalifa and Al-Naser, 2014; Medina and Aguilar, 2014; Abbas et al., 2018). The event that triggered the incorporation of ostrich as a productive specie in various territories was the outbreaks of Bovine Spongiform Encephalopathy in the years 1986 and 2002 in Europe and the United States, respectively, due to the sensory similarity between beef and ostrich meat (Shanawany and Dingle, 1999). In addition, deregulation of live bird exported from South Africa in 1998 was also a fact that facilitated the acquisition of breeding stock by other countries (Pittaway and Van Niekerk, 2015).

Although ostrich production has declined significantly in many countries, the specie remains of great zootechnical interest, because the consumption of its meat is considered an appropriate option for consumers who

liked red meat and were also concerned about their health (Akram et al., 2019). Similarly, interest in the species was reflected by the evolution shown by research in issues related to production efficiency (González-Redondo et al., 2014), improvement in skin quality which is extracted from the ostrich for the manufacture of leather goods (Jordaan et al., 2008) and in the optimization of methods for oil extraction, a product which is known to have important nutritional, cosmetic and pharmaceutical qualities (Ponphaiboon et al., 2018).

Mexico was part of the ostrich heyday. The authority responsible for regulating the management of this species had a record of more than 300 farms between 1991 and 2015. On the other hand, in 2012, the organization in charge the promotion of ostrich meat in Mexico estimated in 800 numbers of farms that incorporated the ostrich, considering all those that were not officially registered. The same promotional agency estimated that in 2016 there were no more than 30 farms whose main activity was the commercial production of ostrich. Under this context, the objective of the present study was to describe the history of the introduction of ostrich in Mexico as a species of commercial interest, from the arrival of the first birds to the current farms.

MATERIALS AND METHODS

The present investigation had a descriptive approach and was carried out based on a sequential mixed design. A mixed design was chosen because it allows generating unique research that answer questions about the complexity nature of the phenomenon being studied, from the point of view of the participants and from the expression of the measurable variables (Williams, 2007). On the other hand, it was sequential because of the study integrated two blocks of analysis, the first was qualitative and referred to the historical description of ostrich production in Mexico, meanwhile, the second was quantitative and described the profile of the farms that until the time of information gathering (Summer, 2016), they were in operation.

The history of commercial ostrich production in Mexico was built from the founding of the first formally registered farm, to the recent events that resulted in the farms that remained active until 2016. Historical description was elaborated according to aims of Laudan et al. (1986), with an analytical construction of social, cultural and economic events that form a present reality. Information on historical events were obtained from interviews with current farm owners, former farmers,

former leaders of the organizations now-extinct, officials and former government officials, and marketers.

The description of farms that remained active until 2016 and which had decided to collaborate providing information for the study was based on the descriptive statistics applied to variables and indicators that identify and measure different attributes. For this purpose, interviews were conducted with the owners and the interviewers stayed at least one working day at the farm to observe the internal processes. An observation guide and a semi-structured questionnaire for the interview were implemented as detection instruments. The information collected is related to the following items:

- General characteristics of the farm including name, age, location, scale, characteristics of the owner, importance of income and links with other farms, organizations, and institutions.
- Technical profile and productivity including technical practices implemented during the production process and productivity indicators.
- Products and activities for adding value including prices, presentations, the importance in incomes of each product, facilities for the transformation of products, brands, certifications, destinations and marketing channels, messages and means of promotion.

RESULTS

History of the sector

The story about commercial ostrich production in Mexico began on 1988 when 92 ostriches from South Africa arrived by air the city of Reynosa in the state of Tamaulipas. This was the first official registration farm dedicated to the production and marketing of ostriches and their derivatives. In 1992, this farm had 500 female ostriches and established the first large incubation center for this species in the country, which had an incubator with a capacity of 2600 eggs and a hatcher capable of hatching 380 chickens.

In 1995, there had been the first large distribution of ostriches in Mexico. The state government of Tamaulipas ran a livestock program that bought 600 breeders, and gave one pair (one male and one female) to 300 new farmers, who were largely unsuccessful in commercial management of the specie. A year later, in the state of Sinaloa, the second large farm dedicated to the commercial production of ostriches emerges, which acquired its flock of breeders of the first one that emerged in Tamaulipas. This second farm was distinguished by its

intense work of promoting ostrich meat, through its brand, mainly in the cities of Guadalajara and Monterrey.

In 1997, two more farms were born in the cities of Monterrey and Querétaro. This pair of companies was characterized by being founded by reputable entrepreneurs from sectors other than livestock and the primary sector, reflecting the attractiveness of ostrich production investments at that time. Noteworthy was the fact that these companies were the first to sell the meat they produced in self-service stores. In the same year, Funds Instituted in Relation to Agriculture (FIRA), one of the most important public institutions for financing, training, technical advice and technology transfer of the agricultural sector in Mexico, recognized ostrich as a highly productive specie and publish a manual entitled "The ostrich is a profitable alternative in livestock production in Mexico", so great was FIRA's interest in commercial ostrich production that it implemented a full-cycle demonstration module in the city of Morelia.

A significant number of respondents agreed to point out the year 1998 as the beginning of the ostrich heyday in Mexico, due to the consolidation of the interest shown by various public and private entities for that year. Since then, the responsible agency for regulating the ostrich production units in Mexico was the Secretary of the Environment and Natural Resources (SEMARNAT), through General Directorate of Wildlife (DGVS). Although there were already companies that marketed ostrich products at that time, the industry was generally at a stage of breeding and distribution of breeders and had as its main challenge the adaptation of the specie and domain of artificial incubation.

In 1998, other entrepreneurs emulated the actions of the industry's pioneers and imported ostriches from South Africa, Namibia, Botswana, and Zimbabwe and produced breeders which were bought and distributed by state governments with similar mechanisms as in Tamaulipas. As could be anticipated, the results were not very different from those obtained in that state.

In 1999, an alliance arose between a farm dismantled in Texas and that moved to the state of Morelos and a farm located in the state of Hidalgo. The alliance gave rise to a brand that managed to sell four tons of ostrich meat monthly in restaurants in Mexico City. Likewise, the alliance distinguished itself by achieving an important opening in media for the promotion of the qualities of ostrich meat.

As far as universities were concerned, it stood out in 2003 that the National Autonomous University of Mexico (UNAM) imported 24 ostriches from the United States to

create a practical teaching module; besides, UNAM included the ostrich in the subject of alternative poultry farming. The first farm to obtain the Federal Inspection Type certification was born on 2004 in Jalisco after visiting the UNAM module. This certification in Mexico confirmed that a company has facilities and procedures for slaughtering, cooling and industrialization of meat products that ensured its safety. These standards enabled the company to enter into contracts for the export of ostrich meat to Japan.

In 2004, with the resources of the Secretary of Agriculture, Council for the Promotion of Ostrich Meat (COMEPA) was created, an entity whose main task was to position ostrich meat in Mexican homes and markets. In addition to COMEPA, there were other organizations whose main function was to keep track of the inventories of the associated farmers. The Mexican Association of Ostrich Farmers was one of the most important associations of national coverage, however, there were many other state and regional associations.

The ostrich heyday which began in Mexico in 1998, lasted until 2008. During this period, the sector was promoted by SEMARNAT, FIRA and different state governments. So far, SEMARNAT had been the regulator of ostrich management but had never provided subsidies, because the ostrich was considered an exotic specie in Mexico and SEMARNAT programs focused on the conservation and use of endemic species. FIRA contributed significantly to the promotion of the specie and its products and training the new farmers. The subsidies for ostrich farmers came mainly from state funds, so that the lobbying of large enterprises in their respective federal states was essential to develop programs that distributed assets such as breeders, pens and incubators.

From 2009, the activity decreased. Given the poor results obtained by the great majority of the new producers, public funds for the promotion of the specie disappeared, and with them, a large part of the organizations that sourced resources from them. Likewise, private companies had stopped investing in ostrich farming. Large farms disappeared with discontinuation of breeders acquisition and distribution programs, as their business models focused heavily on the sale of breeding stock rather than the development and sale of finished products.

The event that buried the commercial ostrich farming occurred in 2012, when the farm with Federal Inspection Type certification was frozen for alleged involvement in organized crime. This was the last big ostrich production

farm that existed in Mexico. Its legacy was that it was a genetic source for most of the companies currently producing ostriches in Mexico, including one that had Federal Inspection Type certificate by 2016.

From 1988 to the present, SEMARNAT has a record of 320 commercial ostrich farms in Mexico. According to COMEPA data, the number of farms that had included ostriches in their livestock supply, but considering all non-officially registered farms, was close to 800. The latest COMEPA data referred to the year 2012 and reveal that 845 tons of ostrich meat was sold in Mexico that year, which was approximately 24,000 processed birds. This product was concentrated by a small number of producers located in the states of Coahuila, Zacatecas, Nayarit, Michoacán, Querétaro, Puebla, Tlaxcala, Guanajuato, Jalisco, Morelos, and the State of Mexico.

Current farms

The ostrich in Mexico is a very small and specialized sector of animal production. According to the current and former farmers, former FIRA officials and the leaders of the now-extinct producer organizations, were around 30 farmers who are still active in the market. In summer 2016, the present study identified 22 farms, of which 20 had agreed to provide information. Farms are located in the states of Tlaxcala (2 farms), State of Mexico (4 farms), Querétaro (1 farm), Guanajuato (3 farms), Michoacán (2 farms), Jalisco (3 farms), Nayarit (2 farms), Zacatecas (1 farm), Coahuila (1 farm) and Chihuahua (1 farm).

Table 1 indicates the profile of Mexican farms that on 2016 produced ostrich and incorporated their products into the market. On average, the farms were small because they had a flock with around 30 breeders, which was in contrast to the size of the companies that existed in Mexico a few decades ago. On average, the farms were around 15 years old, although some were more than 20 years old and others that were created recently in 2016. The farms were in temperate and slightly elevated areas and produced predominantly on their land. The third part also produced ostriches and other species such as sheep and goats as well as other birds such as turkeys, ducks, emus and pheasants. More than half of farmers had higher education, and for more than half of them represented the ostrich as their main source of income. Another aspect that attracted attention was that most farmers had no experience in animal husbandry. Finally, it should be noted that the link was a property that existed on farms and their owners, as about half of them had contact with universities, media, and ostrich farms outside of Mexico.

Table 1. Profile of ostrich farms in Mexico in 2016

Characteristic	Value (n=20)
Farm age (years)	11.5 ± 6.4
Altitude of the territories (masl)	1740 ± 687
Temperature of the territories (°C)	18.9 ± 3.9
Flock size (birds)	32 ± 28
Farms that produce other species (%)	35
Farms that produce on their land (%)	75
Farms that interact with universities (%)	60
Farms that have had contact with the media (%)	40
Farms that maintain contact with a farm abroad (%)	50
Farms with owners with higher education (%)	60
Farms that represent the main source of income for their owners (%)	55
Farms with owners with livestock experience (%)	40

Source: Elaboration with field information 2016. *masl = meters above sea level.

The technical profile and productivity of current Mexican ostrich farms are described in Table 2. The description was organized considering three phases of the production process including reproduction, incubation and birth, as well as breeding and fattening.

Concerning the breeding stage, half of the farms produced their breeding stock and the other half acquired it. The breeders had an average age of around seven years in 2016. The productive unit is mainly used by trios consisting of two females and one male. The most of farmers changed the pen of breeders to achieve better productivity. The pens, in which each breeder's trio was housed were about 450 square meters, so each breeder had about a third of this space. The most farmers feed their breeders with specialty food in this stage of production. In terms of husbandry, all farmers immediately collected the eggs, managed to collect an average of 50 eggs per female, the vast majority of them was disinfected, and it took an average of one week for the eggs to be introduced into the incubator.

In terms of incubation and birth, all of the farms had an incubator, although the capacity of these devices varied greatly, ranging from 36 to 480 eggs. The incubation condition was homogenous with an average at 36 ° C and with 24% relative humidity. The incubators perform the flips automatically, with the number of flips per day programmed by the owners between one and four. Ovoscopy was performed on all farms, mainly on the 21st incubation day, but only one-third of the farmers had an electronic ovoscope. If the owners considered it appropriate, they moved the eggs to the hatchery, some days before day 40, others later. Therefore, the number of days that the chicks spent in the hatchery varied and on

average they remained three days. In most cases, chicks were assisted at birth and they received navel disinfection with iodine solutions. The chicks that could be born received food in the third day on average. Up to this step approximately 30 chicks per female were obtained.

In the breeding and fattening phase, most of farmers separated the chicks by age for their development and fattening. During this phase, less than half had access to veterinary services and ostrich production specialists. Due to the low commercial management of the species in

Mexico, most of farmers had fattened their ostriches with other species' food or with mixtures formulate by them. Only about 18 ostriches per female had reached the weight and slaughter age of 110 kg and 13 months on average. There were a few farms which the birds were slaughtered within their facilities under backyard conditions. On average, 63 kg of channel were obtained by ostrich (57% yield based on the weight of the live animal) and 33 kg of meat extracted (30% yield based on live weight).

Table 2. Technical profile and productivity of ostrich farms in Mexico in 2016.

Stage	Characteristic	Value (n=20)
Reproduction	Farms with purchased breeders (%)	50
	Age of the breeders (years)	6.7 ± 2
	Farms that form breeding triplets - two females and one male - (%)	80
	Area allocated by breeder (m2)	156 ± 133
	Farms that perform breeder rotation (%)	65
	Farms that supply specialized food for reproduction (%)	80
	Farms that perform egg disinfection (%)	95
	Storage of eggs prior to incubation (days)	7 ± 3.5
Eggs obtained per female per year	50 ± 19	
Incubation and birth	Farms that have their incubator (%)	100
	Incubator capacity (eggs)	158 ± 126
	Incubation temperature (°C)	36.2 ± 0.8
	Relative humidity in incubation (%)	24.3 ± 5.3
	Rotation during incubation (flips / day)	16 ± 10
	Farms that have an electronic ovoscope (%)	35
	Stay in the hatchery (days)	3 ± 2
	Farms assisting the birth of their chicks (%)	65
Breeding and fattening	Farms that perform navel disinfection (%)	70
	Start of feeding (days)	3 ± 2
	Chicks obtained per female per year	31 ± 18
	Farms that separate the chicks by age during their breeding and development (%)	90
	Farms that had access to specialized production consultancy (%)	40
	Farms with veterinary service (%)	40
	Farms that gain weight with specialized ostrich food (%)	15
	Birds achieved per female per year	18 ± 8
Breeding and fattening	Age of sacrifice (months)	13 ± 2.5
	Weight reached at slaughter (kg)	110 ± 9
	Farms that sacrifice in backyard conditions (%)	40
	Channel Weight (kg)	63 ± 11.5
	Yield in channel (%)	57 ± 7.5
	Meat obtained per bird (kg)	33 ± 7
	Yield in meat (%)	30 ± 6

Source: Elaboration with field information 2016.

Table 3 presents the commercial profile of ostrich producing mexican farms that were active in 2016. As demonstrated, ostrich farmers in Mexico generated revenue from sales of meat, skin, leather, leather goods,

standing ostriches, eggs, shells, feathers and fat. In general, the sale of meat and live birds generated most of the income. However, some farms had obtained attractive benefits from selling finished leather goods and ostrich-based cosmetics. There were big differences in the prices

with which the farms could market the different products, and also in the weights that each product had in the composition of the income of the farms.

Regarding the added value, half of the farms had their meat processing facilities and obtained special cuts. However, only three offered meat in presentations of less than one-kilogram content, only two farms had an official safety certificate and only one of them sold meat by self-service stores. The favorite message for promoting meat was that it was a source of animal protein with excellent

nutritional qualities. Tanning, the manufacture of leather goods and the manufacture of cosmetics were tasks outsourced to other companies, to which farmers supplied raw materials and were returned standardized end products. Just less than half of the farms had their brand through which they marketed their products, and only a one-third repeatedly exported some of their products. The most important advertising media were digital social networks.

Table 3. Products and activities for adding value to ostrich farms in Mexico in 2016

Characteristic	Value (n = 20)
Price per kilogram of meat (US \$)	10 ± 4
Price per skin (US \$)	84 ± 29
Price for leather (US \$)	302 ± 230
Price per live animal sold (US \$)	176 ± 93
Price per egg sold (US \$)	9 ± 4
Price per shell sold (US \$)	5 ± 3
Percentage of income from meat sales	37 ± 27
Percentage of income from skin sales	5 ± 7
Percentage of income from sales of leather and leather goods	14 ± 22
Percentage of income from sales of live birds	32 ± 32
Percentage of income from egg sales	4 ± 8
Percentage of income from the sale of pens	1 ± 2
Percentage of income from fat sales	4 ± 8
Percentage of income from shell sales	2 ± 2
Farms with meat processing facilities (%)	50
Farms that sell meat in specific cuts (%)	55
Farms that sell meat in presentations smaller than one kilogram (%)	15
Farms with meat safety certification (%)	10
Farms that sell their products in self-service (%)	5
Farms that highlight the nutritional qualities of ostrich meat in their promotional work	75
Farms that perform tanning of the skins (%)	5
Farms that manufacture leather goods (%)	0
Farms that have a brand for their products (%)	40
Farms that promote their products through social networks (%)	45
Farms that have exported a product (%)	30

Source: Elaboration with field information 2016.

DISCUSSION

Mexico had adequate climatic conditions for the commercial production of ostrich, labor and food were cheaper compared to other producer countries and for a whole decade (1998-2008) the activity was strongly promoted by different instances of the public sector. These circumstances made Mexico one of the countries with the greatest potential for commercial ostrich production (Carbajo, 2006). However, 30 years later, the sector collapsed and only a small number of small-scale individual producers remained.

In the words of the interviewees of this study, the large ostrich producers that existed in Mexico in recent years did not survive because their business depended heavily on the sale of breeding birds, which were massively marketed at high prices during the Mexican heyday. As the number of people interested in entering to an activity decreased, the price of the breeding stock collapsed and the decline began since productivity was low and the preparation and sale of value-added products in the business model was not yet consolidated the companies. In Kuwait and Greece ostrich production had a similar fate, the big farms concentrated on increasing the

number of birds and not on the sale of meat. In addition, they lacked adequate knowledge of management and nutrition, and the activity ended up was done by small individual producers (Theodoropoulou et al., 2001; Al-Nasser et al., 2003).

For their part, small farmers in Mexico faced various problems in both production and marketing which prevented them from succeeding. Low incubation efficiency and high mortality were the main problems on the production side. The lack of knowledge about incubation, nutritional formulation and disease management was the reason for the low productive efficiency of the farms. Similar reasons had been reported in countries such as Botswana (Moreki et al., 2012), Colombia (Mariño-González et al., 2017), Kazakhstan (Shameyeva et al., 2018) and Pakistan (Abbas et al., 2018). The lack of knowledge for the proper management of the ostrich could be resolved with competent extension services that enabled ostrich producers to develop their activities on a scientific basis (Abbas et al., 2018). In Mexico, however, there were only a few professionals specializing in the management of this specie. Indeed, it was known that the Mexican farms that remained in the business did not obtain their knowledge from institutional sources, but by experimenting and interacting with their national and international counterparts (Islas-Moreno and Rendón-Medel, 2019).

On the commercial side, Mexican small farmers encountered problems in the development and sale of value-added products, as there was a lack of infrastructure and because in general, ostrich products were little known in Mexico. This despite the evidence that exists on the qualities of the main products including meat, skin, oil, and feathers. In Botswana, the activity collapsed mainly due to the lack of infrastructure for the slaughter and processing of ostriches (Moreki et al., 2012), and in Pakistan the promotion of ostrich meat national consumption was recognized as an important task that those involved should include on their agenda (Abbas et al., 2018). The failure to find a demand for ostrich products was the main reason for the failure of commercial production of this species in many countries where it was incorporated (Benson, 2012). Future demand, which was mainly for meat, was overestimated, because it was assumed that ostrich meat would replace beef after the outbreaks of Spongiform Encephalopathy in 1986 and 2003 in Europe and the United States, respectively. However, such a substitution was never made.

Similar weaknesses in the ostrich farms professionalization, infrastructure, regulation and market

had been identified in recent studies in Nigeria (Buochuama, 2018) and Pakistan (Abbas et al., 2018). On the other hand, the countries where commercial ostrich production was developing successfully had something in common, the participants were well organized. South Africa, the world leader in the production and export of ostrich products, was the best example, which had a national business chamber of commerce consisting of a farmer organization, a processing organization and two major export cooperatives focused on commercialization (Mabaya et al., 2011). An example of the strength of the South African structure of the sector was that it had succeeded in reestablishing itself thanks to the biosecurity measures carried out by all participants following the outbreak of H5N2 avian influenza, which in 2011 caused the loss of 10% of ostrich population in the country (Van Helden et al., 2016).

Zimbabwe was another country where ostrich production was deeply rooted. For the ostrich farmers of this country, associativity allowed them to had slaughterhouses and tanneries to guarantee the strict export controls, and thus had a 15 years prosperity period (1985-2000). However, the sector had experienced a sharp decline due to the agrarian reform, which would lead to a decline in agriculture and hyperinflation in 2000, reaching its most critical point in 2008. As a result, the inputs reached prohibitive prices and generated an environment of great uncertainty among investors (Cooper, 2007).

Poland was another country that successfully developed commercial exploitation of ostriches. Its success was due to its admission into the European Union, and the ability of its sector to organize and establish certified farms for the export of meat. 95% of the meat was exported to Western Europe, where ostrich meat was considered a good quality product that complements the meat offering. At the same time, ostrich farmers in Poland were taking advantage of their land, food and labor costs, and they had found a way to generate additional income in agritourism (Horbańczuk et al., 2008).

In Mexico, as in many other countries, commercial ostrich production had experienced an ephemeral heyday, based mainly on expectations and not on the realities of market demand. In addition, the rapid expansion of supply did not allow the natural development of processes for the production and dissemination of knowledge on the commercial management of the specie. As a result, there were large and small farmers who were productively inefficient and had great difficulty in developing, standardizing and marketing their products. The farms that remained in the business, continued with great difficulties

in terms of their productivity. However, they had managed to mitigate some of the problem by exchanging production practices and using digital media to consult their counterparts overseas. On the commercial side, they had managed to develop standardized products using maquiladora companies and placed them in niche markets where prices were higher than for conventional substitutes.

CONCLUSION

The high productive quality of a specie, the recognized attributes of its products and the great interest of different entities in participating in their use are not sufficient conditions for their economic success. In the case of ostrich, in Mexico and many other countries, the sector failed because market demand was overestimated and activity was started without adequate knowledge bases, infrastructure, and institutional support. Nevertheless, the surviving farms demonstrated that it was possible to stay in the activity by acquiring knowledge from interaction with other farms and developing standardized products for niche markets. These findings can refer to many other species of nascent interest.

DECLARATIONS

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Competing interests

The authors declare that they have no competing interests

Author's contribution

Both authors contributed equally to the manuscript.

Consent to publish

All authors informed their consent prior to inclusion in the study

REFERENCES

Abbas G, Maqsood C, Rehman U, Asif M and Sajid M (2018). Ostrich Industry: A Beautiful U Turn in Poultry Industry of Pakistan. *International Journal of Animal Husbandry and*

Veterinary Science, 3(1): 1–6. Available at: <http://www.ijahvs.org/index.php/issues?view=publication&ask=show&id=22>

Abbas G, Zahid O, Ahmad Khan MS, Sajid M and Saeed H (2018). Future of Ostrich Farming in Pakistan. *Advances in Zoology and Botany*, 6(2): 55–65. DOI: <https://doi.org/10.13189/azb.2018.060202>

Akram MB, Khan MI, Khalid S, Shoaib M and Azeema S (2019). Quality and Sensory Comparison of Ostrich and Goat Meat. *International Journal of Life Sciences*, 5(1): 2168-2175. DOI: <https://doi.org/10.21276/SSR-IJLS.2019.5.1.9>

Al-Khalifa H and Al-Naser A (2014). Ostrich Meat: Production, Quality Parameters, and Nutritional Comparison to Other Types of Meats. *Journal of Applied Poultry Research*, 23(August): 784–790. DOI: <https://doi.org/10.3382/japr.2014-00962>

Al-Nasser A, Al-Khalaifa H, Holleman K and Al-Ghalaf W (2003). Ostrich Production in the Arid Environment of Kuwait. *Journal of Arid Environments*, 54(1): 219–224. DOI: <https://doi.org/10.1006/jare.2001.0876>

Benson F (2012). Ostrich Farming Business Planning. World Ostrich Association, Israel, pp. 1-36. Available at: <https://world-ostrich.org/>

Brand TS and Jordaan JW (2011). The Contribution of the South African Ostrich Industry to The National Economy. *Applied Animal Husbandry & Rural Development*, 4(1): 1–7. Available at: <https://www.sasas.co.za/AAH&RD/the-contribution-of-the-south-african-ostrich-industry-to-the-national-economy/>

Buochuama A (2018). Ostrich Farming: A Wildlife Management Option for Restraining Nigeria's Lingered Farmers – Herders Conflicts. *World News of Natural Sciences*, 18(2): 232–240. Available at: https://www.researchgate.net/publication/336601908_Ostrich_Farming_A_Wildlife_Management_Option_for_Restraining_Nigeria's_Lingered_Farmers-Herders_Conflicts

Carbajo E (2006). Ostrich Production to Mature. *World Poultry*, 22(8): 24–26. Available at: www.WorldPoultry.net

Cooper RG (2007). History of Zimbabwean Ostrich Production. *Avian and Poultry Biology Reviews*, 18(2): 39–45. DOI: <https://doi.org/10.3184/147020607x250943>

Ghaffari Moghadam Z (2016). Economic Evaluation of Ostrich Production Using Fuzzy Approach in Sistan. *Iranian Journal of Applied Animal Science*, 6(3): 685–690. Available at: http://ijas.iaurasht.ac.ir/article_524823.html

González-Redondo P, Estévez M, Molina A and Valera M (2014). Effect of Laying Month and Storage Length on the Hatchability of Ostrich (*Struthio camelus*) Eggs. *International Journal of Agriculture & Biology*, 16(2): 314–320. Available at: <http://www.ijoabs.com/>

Hoffman LC and Cawthorn D (2014). Exotic and Other Species. *Encyclopedia of Meat Sciences* (Vol. 2). Elsevier Ltd, Matieland, South Africa. DOI: <https://doi.org/10.1016/B978-0-12-384731-7.00029-5>

Horbańczuk JO, Tomasik C and Cooper RG (2008). Ostrich Farming in Poland - Its History and Current Situation after Accession to the European Union. *Avian Biology Research*,

- 1(2): 65–71. DOI: <https://doi.org/10.3184/175815508X360470>
- Islas-Moreno A and Rendón-Medel R (2019). Diffusion of Innovations in Specialty Livestock Systems: Ostrich Companies in Mexico. *RIVAR*, 6(17): 15–26. Available at: http://revistarivar.cl/images/vol6-n17/art02_RIVAR17.pdf
- Jordaan JW, Brand TS, Bhiya and Aucamp BB (2008). An Evaluation of Slaughter Age on the Profitability of Intensive Slaughter Ostrich Production. *Australian Journal of Experimental Agriculture*, (48): 916–920. Available at: <https://www.publish.csiro.au/an/EA08040>
- Laudan L, Donovan A, Laudan R, Barker P, Brown H, Leplin J, Thagard, P and Wykstra S (1986). *Scientific Change: Philosophical Models and Historical Research*. Synthese, 69(2): 141–223. DOI: <https://doi.org/10.1007/BF00413981>
- Mabaya E, Tihanyi K, Karaan M and Van Rooyen J (2011). Case Studies of Emerging Farmers and Agribusinesses in South Africa. A. S. MeDIA, Ed., Stellenbosch, South Africa. Available at: https://books.google.com.mx/books/about/Case_Studies_of_Emerging_Farmers_and_Agr.html?id=IUw9AQAAQBAJ&redir_esc=y
- Majewska D, Jacubowska M, Ligocki M, Tarasewicz Z, Szczerbinska D, Karamucki T and Sales J (2009). Physicochemical Characteristics, Proximate Analysis and Mineral Composition of Ostrich Meat as Influenced by Muscle. *Food Chemistry*, 117: 207–211. DOI: <https://doi.org/10.1016/j.foodchem.2009.03.100>
- Mariño-González GA, Ramírez-Hernández A and Cortés-Vecino JA (2017). *Libyostrongylus douglassii* (Strongylida: Trichostrongylidae) in Ostrich (*Struthio camelus*) Farms from Colombia. *Veterinary Parasitology*, 235(January): 53–56. DOI: <https://doi.org/10.1016/j.vetpar.2017.01.007>
- Medina FX and Aguilar A (2014). Ostrich Meat: Nutritional, Breeding, and Consumption Aspects. The Case of Spain. *Journal of Food and Nutrition Research*, 2(6): 301–305. DOI: <https://doi.org/10.12691/jfnr-2-6-6>
- Moreki, JC, Kebonye NM and Tiroesele B (2012). Commercial Ostrich Farming in Botswana: A Case Study of Dibete Ostrich Multiplication Unit. *Journal of Life Science and Biomedicine*, 2(5): 192–195. Available at: [http://jlsb.scienceline.com/attachments/article/17/J.%20Life%20Sci.%20Biomed.%20\(5\)%20192-195,%202012,%20B37.pdf](http://jlsb.scienceline.com/attachments/article/17/J.%20Life%20Sci.%20Biomed.%20(5)%20192-195,%202012,%20B37.pdf)
- Pittaway T and Van Niekerk P (2015). Horizon-Scanning the Ostrich Industry with Bibliometric Indicators. *African Journal of Agricultural and Resource Economics*, 10(1): 64–71. Available at: <https://econpapers.repec.org/article/agsafjare/200602.htm>
- Polawska E, Cooper RG, Józwick A and Pomianowski J (2013). Meat from Alternative Species – Nutritive and Dietetic Value, and Its Benefit for Human Health – a review. *CyTA-Journal of Food*, 11(1): 37–42. DOI: <https://doi.org/10.1080/19476337.2012.680916>
- Ponphaiboon J, Limmatvapirat and Chaidedgumjorn A (2018). Physicochemical Property, Fatty Acid Composition, and Antioxidant Activity of Ostrich Oils Using Different Rendering Methods. *LWT - Food Science and Technology*, 93(February): 45–50. DOI: <https://doi.org/10.1016/j.lwt.2018.03.024>
- Shameyeva UG, Janabekova GK, Zhumageldiev AA and Khussainov DM (2018). Effect of Supplement Feed on the Composition of the Black Ostrich's Eggs. *Journal of Pharmaceutical Sciences and Research*, 10(4): 929–932. Available at: <https://www.jpsr.pharmainfo.in/Documents/Volumes/vol10Issue04/jpsr10041855.pdf>
- Shanawany M and Dingle J (1999). *Ostrich production systems*. FAO, Ed., Roma, Italia. Available at: <http://www.fao.org/3/a-x2370e.pdf>
- Theodoropoulou E, Theodoropoulos G and Apostolopoulos G (2001). Ostrich Farming in Greece. *Agricultura Mediterranea*, 131: 147–152. Available at: https://www.academia.edu/40929681/Ostrich_Farming_in_Greece
- Van Helden LS, Sinclair M, Koen P and Grewar JD (2016). Description of an Outbreak of Highly Pathogenic Avian Influenza in Domestic Ostriches (*Struthio camelus*) in South Africa in 2011. *Preventive Veterinary Medicine*, 128: 6–11. DOI: <https://doi.org/10.1016/j.prevetmed.2016.03.019>
- Williams C (2007). Research methods. *Journal of Business and Economic Research*, 5(3): 65–71. Available at: <https://clutejournals.com/index.php/JBER/article/view/2532/2578>