# Intensification, diversification and specialization to improve the competitiveness of sheep production systems under pastoral conditions: The Uruguayan´s case.

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## Implications

- Significant changes occurred in global sheep production systems, lamb meat and wool markets. The demand is mainly oriented towards fine and superfine wool and lamb meat.
- Sheep production intensification, efficiency, differentiation and adding-value to products and processes, minimizating environment impacts, are the main driven factors towards increasing industry competitiveness.
- More profitable and environmentally friendly sheep production systems are linked with "producing more high value-added products with less sheep".
- The alignment between research proposals, production systems and market demands is a key approach to be succeeded. As an example, the Uruguayan´s case is developed in this article.

**Key words**: lamb meat, fine and superfine wools, sustainability, innovation.

## Introduction

Particularly, in the last two decades, it has observed major changes in the international market for wool and sheep meat, which determined important movements in meat and textile consumption´s patterns. These influenced decisively in the way that we produce, industrialize and commercialize sheep meat and wool products, principally in those countries that historically exported the majority of their production to the international market. Within them, it can be highlighted: the huge improvement of the productivity, efficiency and competitiveness of alternative industries (e.g. synthetic, cotton, pork, poultry), business scale, international trade agreements, negative international policies taken for the wool industry (e.g. regulations of the Australian´s wool stock), changes caused by the application of new quality assurance schemes as well as products and processes certification, branding and promotion, environmental protection policies, animal health and welfare regulations, food issues (amongst others; security, consistency, differentiation, continuous supply, human health, culinary attributes), modern dressing style (lightness, strength, versatility, natural product, softness, appearance, comfort, easy care, all-season, fashion, etc.), availability of skilled labor and social responsibility for all members of the industry.

Despite of the overall growth seen in world population and its better purchasing power, these trends and other related factors resulted in: a) the global wool consumption remained generally stable between 1.5 to 2.0 million t., while cotton and synthetic consumption levels rose sharply and currently reached 22.8 and 42 million t. respectively, and b) the global sheep and goat meat production (with the exception of beef) grew less than the poultry and pork meats, being these growths of 37% (9.1 vs.

12.5 million t.), 17% (54.1 vs. 63.1 million t.), 108% (39.9 vs. 83.0 million t.) and 56% (68.7 vs. 99.1 million t.), respectively (Montossi et al., 2011a).

Wool market studies showed that general trends favor the production of finer wools (Montossi et al., 2011b). In the case of sheep meat, future world production will be less than that required by the market, which will result in strong demand and firm prices (OECD-FAO, 2012). Using positive scenarios for world economy growth, without major crises, high-value markets will be favorable for sheep meat consumption (particularly for lamb meat) and for fine and superfine wools.

Associated with these market trends, significant reductions were observed in sheep populations in the major global sheep meat and wool exporters (**Table 1**). These reductions ranged between 34.3 and 56 %, being the lowest for Uruguay compared with Australia and New Zealand. Forecast projections (next 5 years) estimated that sheep stocks will be maintained or increased on those countries accompanied by increases in productivity and efficiency.

Taken Australia and New Zealand as key examples, in a further analysis of these observed changes, some questions and doubts raised as; Do the sheep stock reductions observed in these countries were partially or totally offset by changes in productive orientation, productivity and/or technological modifications?. For example, in Australia, the reductions in wool production were not similar for the different ranges of fiber diameter. In fact, the greatest reductions were observed in wools with fiber diameters greater than 19.5 micron. Instead, the trend was clearly towards the production of superfine and ultrafine wools, where the production of these wools increased

substantially (**Table 2**). The same trend was observed for the production in favor of fine and superfine wools in New Zealand (New Zealand Merino, 2003). Moreover, in terms of meat production, there were also interesting changes (**Table 3**).

**Table 1**. Sheep stock reductions occurred between 1990 and 2009 in Uruguay, Australia and New Zealand.

| Country /Year | 1990 | 2000 | 2009 | Change (%) 1990 vs. 2009 |
|---|---|---|---|---|
| **Australia** | 170.3 | 118.6 | 72.7 | -42.7 |
| **N. Zelanda** | 57.9 | 42.3 | 32.4 | -56.0 |
| **Uruguay** | 25.2 | 13.2 | 8.7 | -34.3 |

**Table 2**. Evolution of wool commercialization (clean base; tons.) in Australia based on fiber diameter (FD; μ) ranges comparing the periods of 1991/1992 vs. 2009/2010 (AWTA, 2013).

| Fibre Diameter (microns) | 1991/1992 (t) | 2009/2010 (t) | 1991/1992 vs 2009/10 (%) |
|---|---|---|---|
| **Ultrafine (<15.6)** | 26 | 1270 | 4885% |
| **Superfine (15.6 – 18.5)** | 32340 | 75599 | 233% |
| **Fine (18.6 – 19.5)** | 64958 | 62376 | -4% |
| **Others ( >19.5)** | 720130 | 224849 | -69% |
| **TOTAL (t)** | **817454** | **364094** | **-44.5** |

**Table 3**. Evolution of sheep meat production indices in Australia for the period 2001-2010 (MLA, 2013).

| | 2001 | 2010 | Change (%) |
|---|---|---|---|
| **Stock (m)** | **111.0** | **68.0** | **-39.0** |
| **Lambs slaughtered (millions)** | **18.0** | **18.6** | **3.3** |
| **Carcass weight (kg)** | **19.7** | **21.6** | **9.6** |
| **Meat production (thousand tons)** | **353.0** | **402.0** | **13.9** |
| **Meat exported (thousand tons)** | **125.0** | **186.0** | **48.8** |

The case of New Zealand is presented in **Table 4**, where the trends observed in sheep meat production are showed for an extended period of time (1986-2012).

**Table 4**. Evolution of sheep production indices in New Zealand for the period 1986-2012 (Beef & Lamb New Zealand, 2012).

| | 1986 | 2003 | 2012 | Change (%) 1986 vs. 2012 |
|---|---|---|---|---|
| **Sheep Stock (millions)** | **67.0** | **40.0** | **35.0** | **-60** |
| **Lambing (%)** | **98.0** | **124.0** | **130.0** | **33** |
| **Lambs slaughtered (millions)** | **32.0** | **26.0** | **27.0** | **-16** |
| **Carcass weight (kg)** | **13.0** | **16.9** | **17.3** | **33** |
| **Meat production (carcass weight eq., thousand tons.)** | **418.0** | **434.0** | **468.0** | **12** |

Beyond the productive, cultural, climate, market, products, technology, and economy differences found between New Zealand and Australia, it is important to highlight the common elements and trends which are influencing productivity, efficiency, and competitiveness of the sheep industries at the primary sector. This information is summarized in **Table 5**.

**Table 5**. Consolidated trends observed at sheep production system level in Australia and New Zealand during the last decades.

| ***CONSOLIDATED TRENDS IN AUSTRALIA AND NEW ZEALAND:*** |
| --- |
| ***SHEEP PRODUCTION SYSTEMS*** |
| • **High value wool**<br>• **Production of high quality meat**<br>• **Higher price of land and inputs**<br>• **Measurement of processes and products**<br>• **Differentiation and added value**<br>• **Higher farm scale**<br>• **Lost of farmers**<br>• **Lack of qualified human resources**<br>• **More contracting services**<br>• **Higher society sensitivity for environmental sustainability and animal welfare**<br>• **Traceability in process**<br>• **More products and processes certification**<br>• **Highly efficient genotypes**<br>• **Strategic alliances along the wool-textile and meat industries.**<br>• **Healthy and safe food production**<br>• **More professional farmers** |
| ***<u>Productivity and Efficiency Key Factors</u>*:**<br>• **Productive pasture and forage species**<br>• **Food nutritive value**<br>• **Fertilization**<br>• **Subdivisions/electric fencing**<br>• **Pregnancy test**<br>• **Genetic improvement**<br>• **Supplementation (Australia)**<br>• **Automatization** |

The information documented in this introduction highlighted that there were significant changes in the productive systems of both countries, which had important influences on:

• The promotion of productive specialization based on the predominant characteristics of the production systems and market demands and orientations,
• The improvement in production efficiency, particularly in reproductive rates, carcass weight and product quality.
• The incorporation and adoption of new technological innovations, principally increases in pasture productivity, more intensive use of supplements, more efficient genetics, and the progressive automation of production management practices.
• The growth of alliances among the sheep industry members favored by the payment of premiums based on product quality and differentiation, product and process certification as well as adding-value along the sheep industry.

This article describes and analyzes the productive and technology proposals generated by INIA and other research organizations which resulted in new technology innovations and contributed to increase sheep industry competitiveness. The information presented in this article is mainly focused on the Uruguayan sheep industry´s experience, which could be applied mainly to other developing countries situations.

**The alignment between research proposals, production system orientations and market demands**

The research proposal thought and developed for the Uruguayan sheep industry was generated during a special market context, characterized by low wool prices and

increased competitiveness of beef, cropping and forestry sectors. The negative effect of low wool prices was particularly observed in the medium to coarse micron FD range (26-32μ). This was especially relevant to Uruguayan´s conditions given the predominance of Corriedale breed within the national flock, ranged between 65-75%, accompanied also negatively by competitive prices of alternative fibers like synthetics and cotton in the market place.

This effect influenced sheep numbers in Uruguay, where the national flock decreased substantially from 25.2, 13.2 to 8.3 million heads of total sheep numbers for the years 1990, 2000 and 2010, respectively. As a consequence, most of the sheep population is currently concentrated mainly in northern and east regions of Uruguay, where extensive and semi-extensive production systems are predominant and marked by the prevalence of marginal areas for intensive agriculture production. This fact is a key issue to be considered when new technologies and sheep production orientations are proposed and developed, where wool production and price differentiation is relevant under such circumstances.

In November 2004 (Montossi, 2004a), the National Institute of Agriculture Research (INIA) of Uruguay presented a strategic plan and actions to improve the competitiveness of the national sheep industry. This conceptual proposal aligned research initiatives, production and market orientations (**Table 6**).

**Table 6**. Conceptual model proposed by INIA to develop a more competitive sheep industry in Uruguay (Montossi, 2004a).

| Facts | Extensive Systems | Semi-Extensive Systems | Intensive Systems |
|---|---|---|---|
| **Productive Orientation** | **Mainly breeding operations** | **Breeding operations with or without the use of terminal sires for lamb fattening** | **Specialized breeding operations with the use of terminal sires for lamb fattening** |
| **Type of soil** | **Shallow** | **Shallow-Medium** | **Medium-Deep** |
| **Main products generated by the production systems** | **Fine and superfine wool + Sheep meat as sub-product** | **Fine wool + lamb meat** | **Lamb meat + wool as sub-product** |
| **Predominat breed orientation** | **Merino** | **Modern double purpose** | **Prolific sheep (maternal) + high lamb growth and heavy carcass weight (terminal)** |

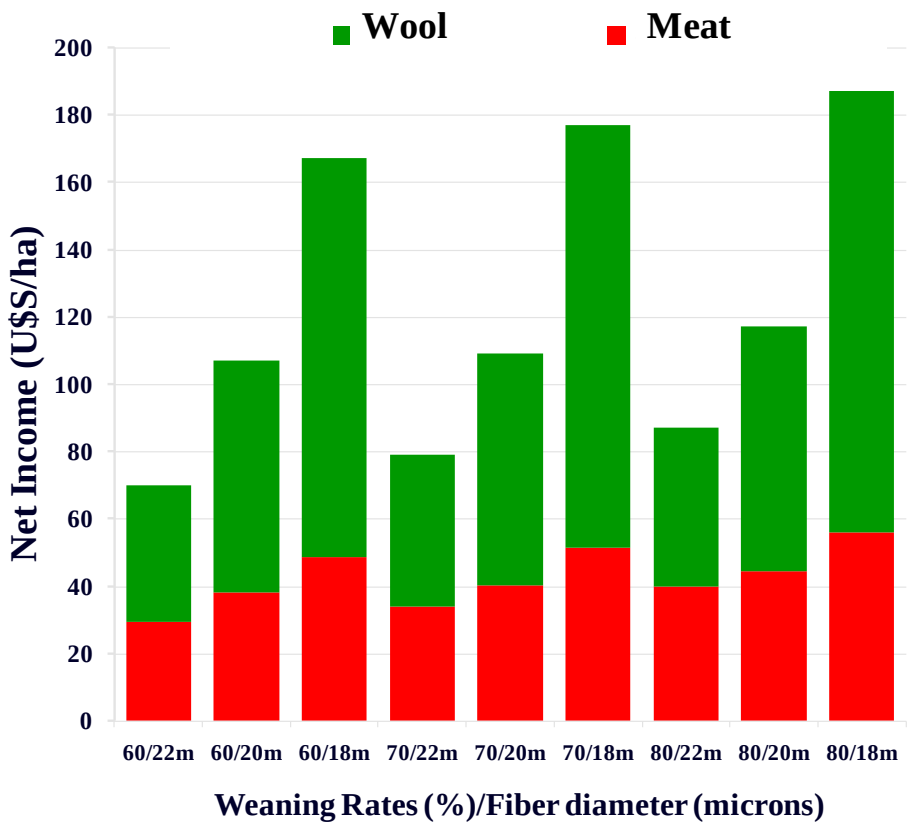
The approach described in **Table 6** does not deny that several production systems could develop within the same ecological region or even between different regions of the country. The specialization and intensification of sheep production systems will continue, but having a different expression in each region. In this scenario, essentially breed orientation and genetic improvement will play a very important role in getting the productive potential in each ecological region. Animal husbandry and feeding systems must be adjusted to those conditions, where high value wool will be produced on soils with low biomass productive potential; while intensive lamb production will be

concentrated on soils with high improve forage production potential using prolific breeds crossed by terminal sires promoting high lamb growth and heavy and lean carcass weight. In semi-extensive productive conditions, lamb production will combine fine or even superfine wool as well as lamb production. Automatization and supplement use will be applied along of all production system options. Therefore, if the specialization will continue, it seems clear that is necessary to match technology proposals with production systems and market opportunities.

## Innovations and productive and economical impacts achieved by research proposals on different production systems

### Extensive sheep production systems

The economic impact of reducing fiber diameter under different reproductive scenarios on extensive wool production systems was simulated and evaluated on the basis of an area of 1000 hectares' farm. This is developed primarily on shallow soils, where the implementation of improved pastures does not exceed 10% of the total area and a common stocking rate of 0.72 stock units/ha is used. It was also evaluated the combination of different weaning percentages (60, 70 and 80%) and differential wool production of 22, 20 and 18 microns (**Figure 1**).




**Note**: The values of 22, 20 and 18 microns fleece wools are assumed to be 8.88, 9.59 and 14.54 US$/kg clean, respectively. Prices 2008-2012.

**Figure 1**. Evaluation of the eeconomical impact (US$/ha) of the combination of different weaning rates (60, 70 or 80%) and fiber diameters (22, 20 or 18 microns) applied on extensive production system.

Reducing fiber diameter increased sheep farmer´s income and the economical impact is greater by the change of producing 22 versus 18 microns. Regardless of the different wool orientation scenarios studied, most of the farmer´s income comes from wool production (60 to 70%) rather than from sheep meat (mainly from cull ewes and lambs). This information is contextualized to a wool system that sells lambs (22 to 25 kg) at weaning, but other producers may sell later these males as 2 year-old wethers on their second fleece. This option would increase further the differences in income in favor of

the systems that produce finer wool. The increase in weaning rate percentages augmented farmer´s income, but its contribution is greater in the coarse fiber diameter range.

It is noteworthy that the process of reducing fiber diameter within Merino does not require the change of breed or even drastic changes in the orientation of the productive system. But, it does require the use of genetic with merits to achieve this goal. Uruguay has this information available to commercials farmers and farm consultant through the use of the breeding values provided by the across-flock genetic evaluations of the Merino breed, carried out by SUL (Uruguayan Wool Secretariat) and INIA. The breeding values are available for most all the economically important productive traits as well as selection indices, which resulted in positive genetic trends towards to improve the profit of the Merino sheep farmers (INIA, SUL and ARU, 2013). These are mainly concentrated on the most extensive regions of Uruguay (e.g. Basaltic region). During the last 14 years, the reduction of the fiber diameter in the Uruguayan Merino has been driven by three very major projects: a) The Uruguayan Fine Merino Project (Montossi et al., 2007; Montossi et al., 2011b), b) Fine Merino Club (Montossi et al., 2007), and c) The Regional Consortium of Innovation for Uruguayan Ultrafine Wool (CRILU, 2013).

It should be highlighted that this process to produce finer wools was accelerated at farming level by the intensive and better use of genetic resources with objective information, artificial insemination and health, feeding and husbandry practices. This was favored by premium incentives and contracts developed between farmers and mill companies. In 1998, the production of wools under 20 microns was lower than 40.000

kg. However, actually, the production of this type of wools in Uruguay is higher than 2.000.000 kg (Pedro Otegui, per. com.).

**Semi-extensive sheep production systems**

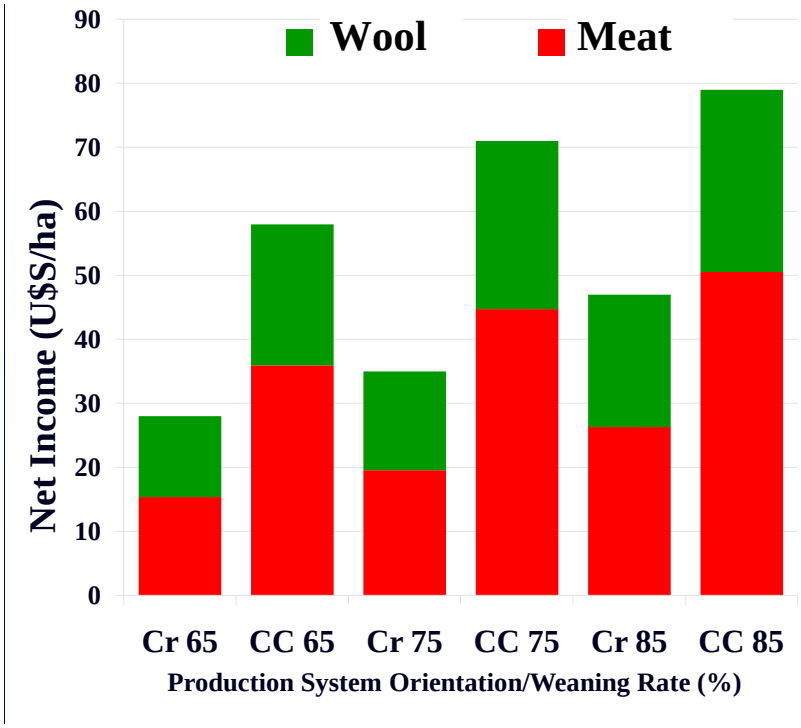
A model of 1000 hectare´s farm base, carrying out 0.72 stock units/ha, was used to assess the economic impact of increasing the reproductive efficiency and including the production of heavy lambs (35 to 38 kg) on semi-extensive production systems. This simulation was developed on the basis of the use of double purpose system (lamb meat + wool), with sheep that produce wools of 28 microns. There were evaluated the combination of different percentages of weaning (65, 75 and 85%) and the production of two different types of lambs (light lambs weaned at 25 kg - Cr System versus heavy lambs fatted up to 35 or 38 kg - CC System)(**Figure 2**).

For the production of heavy lambs and increased reproduction performance, it was incorporated a 10% forage improved area (around 100 ha). Additionally, a strategic short supplementation strategy ("focus feeding") was also implemented to be used in feeding ewes in two key different moments: pre-mating and pre-lambing (preferentially for feeding ewes with low body condition and/or carrying twins). The dual-purpose oriented systems is very clear the positive influences of increasing weaning percentages, which improved farmer´s income per ha in the range of 25 to 68% in relation to the traditional production systems (65% of weaning rate).

Regardless of the orientation of the dual-purpose production system studied (with wools of 28 microns), sheep meat represent between 55 and 65% of the total income. There

are further opportunities to increase the revenue of sheep farmers by the production of 26 microns wool within the Corriedale breed and particularly by crossing this breed with other double purpose finer wool type of breed (e.g. Merino Dohne). However, these options are not evaluated here.

Beyond the weaning percentage, the inclusion of heavy lambs fattening in the semi-extensive production systems increased by at least 100% in producer´s income.




**Note**: Heavy lambs sold with 38 kg liveweight (LW) at 2.64 US$/kg LW or light lambs sold with 25 kg LW at 2.40 US$/kg LW; 28 microns wool price at US$ 4.5/kg clean). Prices 2008-2012.

**Figure 2**. Evaluation of the economical impact of the combination of different weaning rates (65, 75 and 85%) and production system orientation (Cr or CC) applied to semi-extensive production systems.

The impact of heavy lamb fattening on farmer´s income in the CC system could be limited by increases on reproductive efficiency. This is explained by the competition for

forage resources among ewes and lambs particularly during the winter period when the growth of native and improved forages is lower in comparison with other seasons and the heavy lambs are normally finished between 10 or 12 months of age. Increasing reproductive efficiency and the inclusion of heavy lambs fattening in these production systems allow an increase up to 170% in producer´s income compared with the more traditional system (weaning rate of 65% and Cr system-producing light lambs). This information highlights the relevant productive and economical importance of the development of the heavy lamb innovation for the Uruguayan sheep industry, which was generated in 1996 by SUL (Azzarini, 1996). Further research information favored the growth of this technology and business option in the main sheep productive regions of Uruguay (Montossi et al., 2004bc).

Furthermore, since 2003, INIA evaluates the effects of crossing Corriedale (C) ewes by Dohne Merino (MD) sires on productive and economic traits, where the research information obtained showed the positive response by the introduction of MD. This research innovation promoted the rapid growth in the use of this new breed in the country (Montossi et al., 2011b). The increase in the proportion of MD in the composite breed up to levels of 3/4 MD blood brings positive effects in producing finer wool of highest quality, faster lamb growth producing heavier and leaner carcasses and more valuable cuts yield. On the negative side, it should be noted the lower fleece weights pf MD crossbreds compared to the pure C bred, but far outweighed by the other positive traits found in MD crossbreeding alternatives evaluated (**Tables 7** and **8**).

**Table 7**. The effect of crossbreeding of Corriedale (C) by Dohne Merino (MD) on different growth and carcass characteristics.

| Biotype | 100C | 50MDx50C | 75MDx25C | p Biotype |
|---|---|---|---|---|
| LWS (kg) | 34.0 a | 38.1 b | 39.0 c | <.0001 |
| REA ($cm^2$) | 9.8 a | 10.9 b | 10.9 b | <.0001 |
| $^1REA^{LWS}$ ($cm^2$) | 10.4 a | 10.8 b | 10.7 ab | 0.046 |
| FAT (mm) | 3.46 | 3.59 | 3.49 | n.s. |
| $^1FAT^{PVS}$(mm) | 3.75 a | 3.55 ab | 3.40 b | 0.0415 |
| FLW (kg) | 42.1 a | 45.9 b | 47.1 b | <.0001 |
| CW (kg) | 18.0 a | 20.1 b | 20.5 b | <.0001 |
| GR(mm) | 7.6 a | 8.8 b | 8.2 ab | 0.0033 |
| $^1GR^{PCC}$ (mm) | 9.2 a | 8.3 b | 7.3 c | <.0001 |

**Note**: p Biotype (Statistical Significance), ns = not significant. LWS (liveweight at first shearing adjusted at 365 days), REA=rib eye area, and GR=thickness of subcutaneous tissue measured on the 12$^{th}$ rib at 11 cm from the midline of the carcass, CW=Hot Carcass Weight, LWS=liveweight at shearing adjusted at 365 days, Fat=subcutaneous fat thickness on the REA, and FLW=Final liveweight before to slaughter. [1] = Traits adjusted by different co-variates factors.

**Table 8**. The effect of crossbreeding of Corriedale (C) by Dohne Merino (MD) on different wool characteristics.

| Biotype | 100C | 50MDx50C | 75MDx25C | p Biotype |
|---|---|---|---|---|
| FW greasy (kg) | 2.62 a | 2.48 b | 2.38 b | <.0001 |
| FW clean (kg) | 2.04 a | 1.86 b | 1.77 c | <.0001 |
| Yield (%) | 77.5 a | 74.2 b | 74.1 b | <.0001 |
| FD (microns) | 24.8 a | 21.5 b | 20.2 c | <.0001 |
| ST (cm) | 12.5 a | 11.0 b | 10.0 c | <.0001 |
| Y | 63.5 b | 64.5 a | 64.5 a | <.0001 |
| Y-Z | 2.6 a | 1.9 b | 1.7 b | <.0001 |

**Note**: p Biotype (Statistical Significance), ns = not significant. FW=greasy or clean fleece weight, FD=fiber diameter, SS=staple strength, Y=wool brightness, and Y-Z=wool yellowing.

This research proposal developed by INIA was complemented by similar results found by SUL. Based on economic simulations, INIA has also demonstrated the positive economical impacts of the inclusion of this MD breed on the traditional C semi-extensive farming systems, producing finer wool and faster growth and heavier and leaner lambs (Montossi et al., in press).

**Intensive sheep production systems**

The case of intensive sheep meat production systems is promoted on highly productive soils. For the evaluation, the proposal was evaluated on the basis of a 100 ha farm model, where 90% of the total area is enhanced by the use of high-productivity pastures

and fattening heavy lams sold at 10 or 6-8 months old for pure Corriedale bred and prolific and meat crossbred biotypes, respectively.

This model integrates the productive, economic and social dimensions in this particular research proposal and uses the concept of family income (FI)/ha, which incorporates within the farmer´s income the economical compensation which goes to pay the "salary" of such farmer (**Table 9**). This is a relevant issue to the sustainability of family farms with small scale and reduced financial and economical support.

**Table 9**. Evaluation of the economic impacts of the combination of different maternal biotypes (e.g. pure C bread or prolific Frisona Milchschaf and Finnsheep composite ewes) and the potential of using or not of terminal sires (e.g. Texel, Poll Dorset) to produce fast growing lamb in intensive sheep production systems.

| Dam biotype | Corriedale | Corriedale | Corriedale | Prolific |
|---|---|---|---|---|
| **Ram biotype** | **Corriedale** | **Corriedale** | **Terminal** | **Terminal** |
| **Ewes weight (kg)** | **45.0** | **69.0** | **45.0** | **55.0** |
| **Ewes/ha** | **8.0** | **6.6** | **10.0** | **29.0** |
| **Ewe Weaning (%)[1]** | **90.0** | **112.0** | **90.0** | **155.0** |
| **Lamb hogget Weaning (%)[2]** | **0.0** | **0.0** | **0.0** | **78.0** |
| **Wool production (kg/ha)** | **39.7** | **35.0** | **50.2** | **51.3** |
| **Meat production (kg/ha)** | **187.0** | **190.0** | **236.0** | **370.0** |
| **Family income (US$/ha)** | **382.0** | **390.0** | **500.0** | **841.0** |

**Note:**[1] Includes ewes and 2 teeth hoggets and [2] lamb hoggets mated at 7 months old.

With the Corriedale´s (ewe and ram) option is possible to produce between 35 and 40 kg of wool/ha and about 190 kg liveweight/ha, generating a family income (FI) in the range of 380 to 390 US$/ha. For this comparison, the increase of the maternal weight of the Corriedale ewe from 45 up to 69 kg has a minor positive economic impact, because

the increase in the weaning rate achieved associated with a heavy ewe is almost offset by the reduction in the stocking rate of the production system modeled, with no economical response observed.

The use of terminal sires on Corriedale ewes has a very interesting positive effect on production and FI, mainly through better lamb growth rates reducing also the age to slaughter and augmenting forage on offer to feed more sheep in the system which has added effects in increasing stocking rate/ha and lamb meat production/ha.

By using prolific breeds and terminal sires is possible to achieve high weaning rates of 150%, producing heavy lambs weighing between 35 and 38 kg and being 6 to 8 months old at slaughter. The stocking rate of this very intensive system could range between 9 to 10 ewes/ha, generating productions of lamb meat and wool production in the range of 236 to 370 kg/ha, and 50 to 51 kg/ha, respectively.

Under these sheep intensive conditions, it is highlighted the productive and economical impacts of using terminal crossbreeding and high prolific ewes with moderate adult size, generating FIs in the range of 500 to 840 US$/ha. This is an interesting productive and economical option for a large group of small family farm operations, which are of a great social significance for the country. This technology initiative can also be extended to medium to large scale farms through the intensification and diversification of sheep meat production at least in a part of the total farm area, complemented with other productive options (e.g. beef and/or cropping). The same approach has complemented with the relevant research work done by the Agronomy Faculty of Agriculture, University of the Republic (Bianchi, 2007).

**Final Comments**

In this paper we have presented evidence of the significant changes occurred in global sheep production systems, sheep meat and wool markets. Under those changes, new opportunities and challenges have been addressed, where countries like New Zealand and Australia led to increased productivity and efficiency. More market opportunities appear to be liked specially with the production, processing and marketing of fine, superfine, ultrafine wools and high quality lamb meat. The information presented shows that it is possible to be more profitable through "producing more with high value-added products with less sheep". Uruguay is not the exception to this new reality. This approach could also have other extra benefits like to reduce greenhouse emissions and to cope with new scenarios of lower and less qualify labor available to work on sheep farming.

As research and innovation organizations of Uruguay, INIA and other institutions generated new technology proposals considering the particularities of the different productions systems and market orientation and demand. These have a positive and consistent effect on farm productivity and income.

Technology adoption processes are very complex. They involve a series of technological factors and non-technological ones, where the latter acquired great relevance when producers have to be change significantly the way and orientation of their production systems and productivity. To make it happen, this process requires a reasonable period of technology adjustment, maturation and adaptation, accompanied

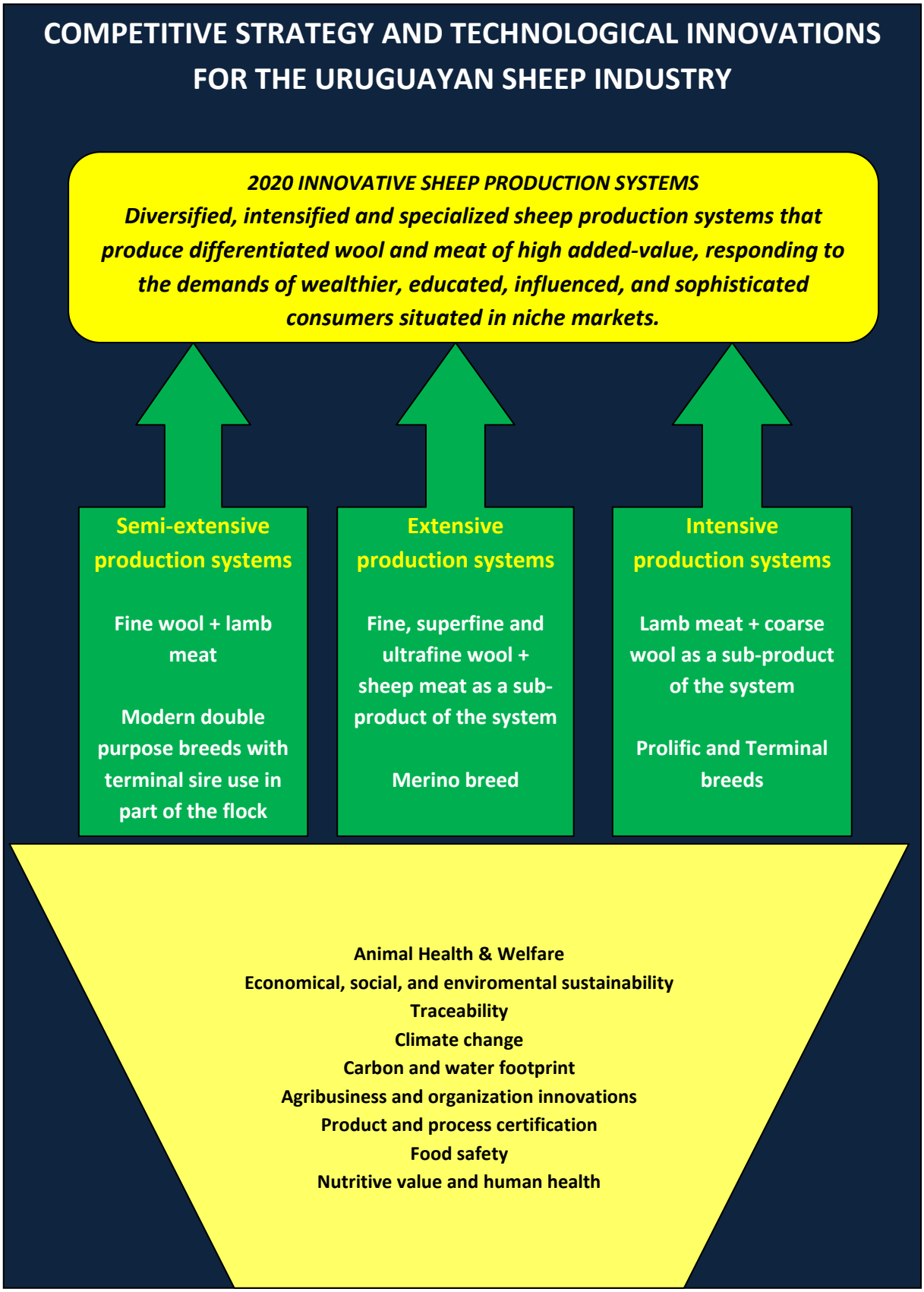
by keeping market positive signals through a certain period of time, which at the end resulted in more confidence farmers to be proactive to make a change.

It is highlighted that when the different members of the sheep industry share a vision and a common strategy, this process is accelerated and changes could occur. Some successfully examples were given here, particularly for the production of fine and superfine wools and heavy lambs in Uruguay.

According to our experience, to adopt progressively and successfully new innovations by an important number of sheep farmers in Uruguay, several factors and procedures have to be considered. This innovation process has common key elements which can be summarized by: a) demand orientation, b) a common industry vision, c) joint alliances between private and public sectors, d) new proposals developed under crisis situations, e) organizational strengths and cooperation, f) “learning by doing together”, g) the parties established alliances based on contracts, h) team work and strong leadership, and i) highly educated, trained and motivated people.

In a continuous improvement process and strategic analysis, technological innovation can and must play a key role in improving the competitiveness of the Uruguayan sheep meat and wool industry. The most recent approach and conceptual model generated by INIA to develop a highly sheep competitive industry is presented in **Diagram 1**.

**Diagram 1**. Illustration of a research innovation model generated by INIA to promote the competitiveness of the Uruguayan Sheep Industry under the pressure and influences of a globalized world market.



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