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Characterization of Patagonian Salicornia: nutritional, sensory and microbiological aspects

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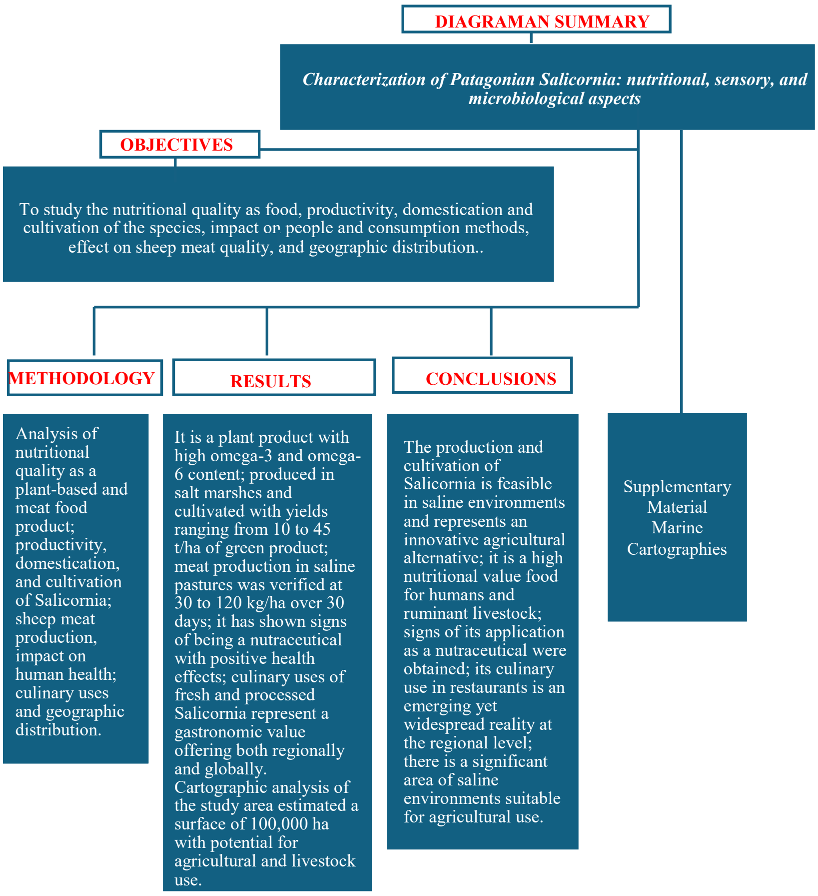

Highlights

- *Cultivation with halophytic plants and forage using seawater or saline water irrigation.*
- *High-quality food for humans and ruminants, rich in omega-3 and omega-6 fatty acids.*
- *Vegetables containing complex salts, including trace elements and antioxidants.*
- *Meat with low cholesterol and high levels of CLA-complex fatty acids.*
- *Nutraceuticals with potential to prevent non-communicable diseases.*
- *Valorization of salt marshes and salinized depressions.*

Abstract

Halophytic plants offer an alternative for food production by using species adapted to high salinity, such as Salicornia. *Salicornia magellanica*, in Tierra del Fuego, and *Salicornia neei*, in the provinces of Chubut and southwestern Buenos Aires, are species widely distributed across the coastal marine intertidal plains and inland saline lagoons of the Patagonian territory. Studies conducted in natural Patagonian environments allowed for the analysis of their spatial distribution, plant productivity, and cultivation methods, both in open fields and in pots for home gardens, using seawater or saline wastewater from the fishing industry. These efforts aim to diversify agricultural production for human consumption and forage for ruminant livestock. This halophytic plant has proven to be a high-quality food, with 60% of its fatty acid content in the form of essential omega-3 and omega-6, a protein content ranging from 6% to 10%, and high levels of complex salts. Its cultivation is viable in both coastal areas and domestic settings with minimal seawater supply. In the studied region, between 70,000 and 100,000 hectares of salt marshes with Salicornia were estimated, with yields ranging from 15 to 40 tons per hectare of fresh product. Moreover, as summer forage, it has been used in mixed pastures with *Puccinellia*, *Suaeda*, *Agropyron*, or *Atriplex*, for the production of sheep and cattle with low cholesterol levels. Preliminary results from evaluations on the health effects of Salicornia consumption have been promising. Indicators such as an increase in HDL (good cholesterol) showed significant differences between the beginning and end of intake.

Keywords: Salt Marshes. Salicornia. Food. Nutritional Quality. Nutraceuticals.

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INTRODUCTION

Irrigated agriculture has increased soil salinity and accelerated the depletion of freshwater aquifers, leading to the underground intrusion of saline or seawater. It is estimated that between 20% and 30% of irrigated agricultural land (230 million hectares) is affected by salinization. This scenario calls for a rethinking of traditional agriculture, which relies on plant species with low salinity tolerance — glycophytes, which tolerate levels below 250 ppm (parts per million) — and encourages consideration of alternative agriculture based on edible plant species adapted to medium and high salinity levels, exceeding 500 ppm — halophytes[1,2,3]. Several studies highlight this group of plants as promising for the direct production of food as well as for forage for ruminant livestock or as dietary supplements for animals in general. Among these, annual and perennial species of the genus Salicornia have been evaluated with regard to genetics, physiology, and cultivation techniques[4,5,6]. Currently, the development of halophytic crop systems allows for the production of biofuels, the treatment of saline effluents in constructed wetlands, landscaping, the cultivation of gourmet vegetables, and forage production for animals[7,8,9]. These plants are also used as bioindicators of increasing ultraviolet B solar radiation caused by the stratospheric ozone layer depletion[10].

One annual species — S. bigelovii — has emerged as a successful crop in the coastal desert of Baja California, cultivated over large areas irrigated with seawater[3,9]. This plant is a significant seed oil producer (30%), with high essential fatty acid content and potential for high-quality biodiesel production. Rueda & colleagues[11] investigated the biofertilization potential in cultivars of S. bigelovii — SOS and SOS-10-7 — using growth-promoting bacteria (Azospirillum and Klebsiella) to mitigate the effects of increased soil salinity due to nitrogen-based chemical fertilizers commonly applied in desert coastal agricultural systems along the Pacific Ocean[9].

These species are viable for cultivation using seawater or saline water irrigation, naturally developing within plant communities along the marine coastline or in inland saline depressions. Additionally, they show high tolerance to salinity levels ranging from 500 to 34,000 ppm[12,13]. They accumulate macro- and micronutrients and can be cultivated as desalinizing plants for treating wastewater from shrimp farming[14] and the fishing industry, after appropriate pre-treatment. Excellent results have been reported for the cultivation of this halophytic species in association with Atriplex in the province of Chubut, yielding between 30 and 40 t/ha (Bianciotto O., personal communication, 2024). Similar yields have been observed in Brazil (Ceará desert)[14,16]. In Baja California, there are enterprises covering over 1,000 ha of S. bigelovii; and in Abu Dhabi (United Arab Emirates), a pilot plant of the Sea Water Energy and Agriculture (SEAS) project includes 2 ha of mixed aquaculture (shrimp and Salicornia) and 150 ha of crop cultivation with the same species. In all cases, yields range from 10 to 30 t/ha[15,16].

From a nutritional standpoint, the plant contains high levels of essential fatty acids (omega-3 and omega-6), as well as sodium, calcium, potassium, and trace elements[6,7]. It also presents high concentrations of phenolic compounds (antioxidants – 25 mg GAE/g dry matter), surpassing those found in soybeans and rice bran[17,18].

As observed, the cultivation of coastal deserts and the preservation of salt marshes — the primary habitat of halophytic plants worldwide — represent new paradigms in agricultural production, with significant current advancements. It is estimated that global coastal zones total 7 million km², with 1.3 million km² classified as potentially usable agricultural land with saline water irrigation. In northeastern Brazil, saline-affected soils represent an area of approximately 1 million hectares[14], along with the Southwest Atlantic marshes of the country[18,19]. In Patagonia, about 1 million km² of the Atlantic coast is undergoing desertification, with 35% to 40% corresponding to sabkha ecosystems (salinized depressions). In this region, the distribution of marsh types clearly depends on latitude, with a marked transition at Península Valdés (Central Patagonia): south of 40° latitude, coastal marshes are dominated by Salicornia, present in 27 salt marshes along the 225 km Patagonian coast[20-23]. The species is also found at river mouths and in inland saline lagoons. The area with potential for biosaline agricultural production is estimated at 70,000 to 100,000 ha, with variable productivity ranging from 25 to 40 t/ha of green biomass[15,23].

As a clarification regarding the different names attributed to the genus, the monophyly of Salicornioideae is confirmed. Therefore, Salicornia and Sarcocornia should be treated as congeneric. The correct name for the genus is Salicornia, which has taxonomic precedence over Sarcocornia by more than 200 years[24,25].

Based on this regional and global context, a hypothesis was formulated in 2001 that Patagonian salt marshes could serve as alternative areas for agricultural and livestock production, drawing on the naturally occurring halophytic communities, through species domestication techniques and cultivation design. The goal was to promote the value of these saline natural systems, which are often undervalued in terms of their environmental functions and productive potential, despite playing a key ecological role in protection, regulation, and the provision of environmental goods and services. Most of these intertidal areas are used as waste disposal sites, oil extraction zones, or, at best, as grazing lands for sheep and other herbivores[26,27].

Within this proposal, studies were conducted on productivity and nutritional value for both human consumption and domestic animal feed[12,21,22]. The effects of Salicornia consumption in humans were examined, as well as its application in sheep farming using saline pastures; different forms of consumption were explored, including fresh and processed products; and the geographical distribution of the species was mapped in the far south of Tierra del Fuego and in the provinces of Chubut and southern Buenos Aires. These projects received public funding, although limited, which restricted the number of analyses on plant and meat product quality, as well as the scope of environmental studies. Forming a long-term research team also proved challenging, although various institutions contributed personnel and infrastructure, both for research development and dissemination of results.

METHODOLOGY

Sample collection and preparation

• Sample selection: Samples were collected using a 0.25 m circular frame of *Salicornia neei*, obtained from the trial conducted in Chubut Province, in natural pastures of the Caleta Malaspina salt marsh – Bahía Bustamante. Likewise, samples of S. magellanica were collected from natural pastures in the Río Chico marsh; from marshes established along the Beagle Channel coastline, with plants grown with and without wind protection (with natural tidal irrigation); as well as from greenhouse cultivation and raised-bed cultivation with furrow irrigation.

• Preparation: The samples, differentiated by origin, were oven-dried at 70 °C to constant weight for determination of dry matter content and proximate nutritional composition analysis.

Nutritional composition analysis

The nutritional quality analysis of Salicornia and lamb meat from animals fed with Salicornia-based pastures was performed at the National Institute of Industrial Technology – INTI, an institution with internationally accredited physicochemical laboratories. Analyses were carried out to determine fatty acid profile, mineral content, and cholesterol levels, following methods recommended by international bodies such as the Food and Agriculture Organization of the United Nations (FAO) and the Association of Official Analytical Chemists (AOAC).

Proximate analysis:

• Proteins: KJELDAHL method using the KJELTET system (Tecator Application Note AN – 300/97 -09-18/1997 FOS TECATOR AB);

• Chlorides: MOHR method. PIRSON (1970);

• Ash: Muffle furnace calcination at 500 °C ± 10 °C.

• Lipids and cholesterol:

• Lipid extraction following the J. Folch et al. method (1957) and fatty acid profiling by gas chromatography, to quantify saturated, monounsaturated, and polyunsaturated fatty acids, including omega-3 and omega-6 and their breakdown.

• Cholesterol: AOAC method Vol. 76, 1075–1068 (modified); Fatty acid profile according to IRAM 5650 standard.

Minerals:

• Mineral content analysis (sodium, potassium, calcium, magnesium) by atomic absorption spectrophotometry (Analytical Method for Atomic Absorption Spectrophotometry, Connecticut, USA. 530 pp). Prior to this determination, the samples underwent wet digestion with HNO3 and HCLO4).

Evaluation of food quality and safety

• Microbiology and Contaminants: In order to ensure the quality and safety of Salicornia sprouts, bromatological and heavy metal content studies were conducted during the nutritional analysis.

• Microbiological analysis for detection of pathogens and assessment of contaminants such as heavy metals and pesticides (Bromatological Laboratory of the Municipality of Ushuaia);

• Aerobic mesophile count: ISO STANDARD 4833:2003;

• Mold and yeast count: ISO STANDARD 7954:1988;

• Most probable number of coliforms; E. coli; coagulase-positive Staphylococcus aureus (ICMSF, 2nd Edition); Salmonella spp.;

• Heavy metals: ICP-AES method – inductively coupled plasma optical emission spectrometry (IACA Laboratory).

Evaluation Of Human Health Benefits

• Clinical trials and observational studies: Based on nutritional information, a pilot observational study was conducted with a non-probabilistic sample of 20 adults over approximately 6 months. Participants were regular consumers of Salicornia and seawater, with various diagnoses including hyperglycemia, type II diabetes mellitus, and dyslipidemia. The product was supplied to participants in its dry, pure form, as capsules or tablets containing 750 mg, according to the dosage prescribed by medical professionals. The capsules were prepared and provided by Farmacia Santa Catalina in Buenos Aires, using 20 kg of *Salicornia magellanica* oven-dried at 70 °C, with accompanying bromatological and mineral contaminant analyses to ensure sanitary quality. The dried material was ground using a specialized processor, as these are non-conventional vegetables with unique grinding characteristics.

• Clinical studies were conducted to evaluate the effects of Salicornia on health parameters such as lipid profile, clinical biochemistry (glycemia), endocrinology, and other relevant biomarkers, performed in clinical analysis laboratories.

• Glycemia – glucose oxidase method;;

• Uric acid – uricase-peroxidase method;

• Blood creatinine – enzymatic method, calibrated against NIST-SRM 914 reference material;

• Total cholesterol, HDL, and LDL – enzymatic colorimetric method;

• Triglycerides – glycerol phosphate oxidase method;

• TSH – electrochemiluminescence method;

• Free thyroxine – electrochemiluminescence method;

• Hemoglobin (HGB) – Celldyn 3200 hematology analyzer with laser reader;

• Insulinemia – electrochemiluminescence method;

• Glycemia – enzymatic method.

Sheep meat production trial

Two trials were conducted with sheep, involving 12 animals in two distinct geographic locations, each in 1-hectare pasture plots:

• In Tierra del Fuego (Lat. 53° S – Estancia Violeta), with weaned Corriedale lambs (initial weight: 8 kg). Ten lambs were fed in paddocks with Salicornia and *Puccinellia* pastures, while two lambs were fed in Coirón pastures (Festuca gracillima)

• In Chubut Province (45° S – Estancia Bustamante – Soriano S.A.), with multi-purpose Merino lambs (initial weight: 30 kg); ten animals were fed on Salicornia pastures and compared with two control animals that grazed in the region's native shrub-steppe pastures.

Product development and culinary uses

Development of Food Products:

• Shelf-life and preservation tests were conducted for Salicornia in its fresh, dehydrated, and pickled forms.

• Fresh product preservation method: storage at 0–4 °C in micro-perforated packaging containing 340 g of cleaned Salicornia sprouts. Shelf-life was tested for 30, 40, and 60 days.

• Pickling method: 85 g of Salicornia blanched for 1 minute in a 2% saline solution, packed in 170 g hexagonal glass jars. The covering liquid consisted of 50% acetic acid at 0.5% and 50% citric acid at 0.7%. The jars were sealed and pasteurized at 72 °C for 15 minutes.

• Dehydration method: drying in an air-circulating oven at 75 °C for 10 hours.

• Freezing method: frozen at –18 °C, followed by vacuum packaging.

Gastronomic Research:

• Initial tests were carried out at INTI (Mar del Plata) with sensory evaluations and participation of culinary professionals, involving fresh (refrigerated) products, pickles, and prepared dishes — all assessed through tasting and sensory analysis. Later, INTA of Río Grande conducted culinary workshops using Salicornia as a central ingredient. Local chefs (Ushuaia) also contributed, bringing their own creative identity to dishes representative of the region.

Field and pot cultivation

Trials were conducted using two cultivation methods, with prior seedling production in a greenhouse from stem cuttings (10 cm segments). The seedlings were cultivated for three months until they reached a height of 5–8 cm and developed two branches, using 25% seawater irrigation (10–15 g/l):

• Field cultivation with S. *magellanica*, at a planting density of 12 plants per square meter, using furrow irrigation with pure seawater (salinity 30–33 g/l), pumped directly from the marine coast (Beagle Channel – Tierra del Fuego).

• Field cultivation with *S. neei*, at a planting density of 6 plants per square meter, using furrow irrigation with pre-treated saline water from the fishing industry (salinity 18–20 g/l – Chubut – Puerto Rawson).

• Pot cultivation in 3 to 5-liter containers, irrigated by drip systems using seawater from 800-liter tanks with adjustable nozzles, and supplemented with 15 g of 15-15-15 fertilizer, applied once a year per pot.

RESULTS

1. Nutritional quality analysis of Salicornia

Figure 1 - Plants of S. (*Amerocornia*) *magellanica* (left) and S. (*Amerocornia*) *neei* (right)

From the nutritional quality analysis of Salicornia sprouts, it can be observed that, for human consumption, they offer the advantage of low fat content (2.20 to 3.5 g/100 g) and relevant protein levels (5.5–9.9%), comparable to species known for high protein content. Another notable feature is the high levels of omega-3 and omega-6 fatty acids, with variation between species, and the possibility of consuming them in the fresh form (green sprouts). Also significant is the ω6/ω3 ratio: in *Salicornia magellanica* it is 1:1, and in S. neei it is 3:2 — both considered suitable for human consumption. The analyses indicate the presence of complex salts, with a predominance of sodium, magnesium, and potassium (Table 1).

Based on this data, the species was officially recognized as a food crop by Resolution No. 11/2023, dated 04/24/2023, issued by the Argentine Secretariat of Agriculture, Livestock and Fisheries, and the Secretariat of Health Quality. This followed a proposal from the Foundation for Agriculture, Food and Health – Salicornia of the Province of Tierra del Fuego A.I.A.S., and was also supported by a FAO classification, which included *Salicornia L.* in vegetable group 013 – Code VL – VL2757 (sea fennel) as suitable for human consumption. In the CONAL (National Food Commission) list, it is registered in the chapter "Stems and Petioles": Salicornia – *Salicornia* (*Amerocornia*) *magellanica* and *Salicornia* (*Amerocornia*) *neei*.

Table 1 - Comparative data on salts and fatty acids in g x 100 g of S. *magellanica* (Tierra del Fuego, Argentina) and S. *neei* (Chubut, Argentina); Based on Bianciotto *et al.* (2014, 2019)[12-28]; Arce *et al.* (2016)[29].

	Species / Origin			
	S. magellanica salt		***S. neei salt marsh***	
Fatty Acids and Salts	**%**	**ds**	**%**	**ds**
Saturated fatty acids	0.92	0.01	0.88	0.01
Monounsaturated (oleic)	0.2	0.04	0.42	0.01
Polienoicos (Ω3 + Ω6	1.9	0.03	0.9	0.01
Total unsaturated (mono + poly)	2.11	0.02	1.32	0.01
n-3 (ω3-linolenic)	0.96	0.01	0.36	0.01
n-6 (ω6-linoleic)	0.94	0.02	0.53	0.03
ω6/ω3 ratio	0.98 (1:1)	-	1,47(3:2)	-
Total lipids (Folch method) (%)	3,03	0.07	2.20	0.02

to be continued...

... continuation - table 1

	Species / Origin			
	S. magellanica salt marsh		*S. neei salt marsh*	
Fatty Acids and Salts	**%**	**ds**	**%**	**ds**
Calcium (g/100 g)	0.94	-	0.77	-
Magnesium (g/100 g)	1.66	-	1.1	-
Potassium (g/100 g)	0.97	-	1.02	-
Sodium (g/100 g)	8.54	-	13.75	-
Proteins (g/100 g)	9,91	-	5.56	-
Ashes	29.44	-	45.24	-

Table 2 - Detail Fatty Acids (%) of *S. neei* and *S. magellanica*; Bianciotto *et al.* (2019)[28].

Fatty Acid		*Salicornia neei*		*Salicornia magellanica*	
(g/100 g of sample)	Systematic Name	Mean %	sd	Mean %	sd
14:0	Tetradecanoic acid	0,05	0	0,05	0,01
15:0	Pentadecanoic acid	0,03	0	0,04	0,01
16:0	Hexadecanoic acid	0,77	0,03	0,92	0,06
16:1*	trans-Hexadecenoic acid	0,09	0	0,09	0,01
17:0	Heptadecanoic acid	0,03	0	0,01	0
17:1	Heptadecenoic acid	s/d	s/d	0,02	0,01
18:0	Octadecanoic acid	0,15	0,01	0,01	0
18:1*	6-Octadecenoic acid	0,61	0,02	0,32	0,05
18:1 trans.	trans-Octadecadienoic acid	0,02	0,01	0,03	0,01
18:2 w6	9.12-Octadecadienoic acid	0,53	0,01	0,77	0,07
20:00	Eicosanoic acid	0,03	0	0,03	0
18:3 w3	9.12.15-Octadecatrienoic acid	0,69	0,02	0,88	0,04
20:1*	13-Eicosenoic acid	0,04	0,01	0,01	0
22:00	Docosanoic acid	0,05	0,01	0,03	0
22:2 w6	Docosadienoic acid	0,04	0	0,03	0
24:00	Tetracosanoic acid	0,03	0	0,02	0

The significant proportion of essential fatty acids, ranging between 40% and 60% polyunsaturated, meets the FAO recommendation, which indicates a total intake of n-3 fatty acids (omega-3) between 16% and 41% of total energy (%E), as well as the minimum dietary requirement for ALA (alpha-linolenic acid – omega-6: >0.5% E) to prevent deficiency symptoms in the adult population.

Also noteworthy is the ω6/ω3 ratio, considered appropriate by several experts (FAO, 2012), ranging from 1:1 to 4:1, with the ideal estimated at 2:1. Based on the data obtained, the ω6/ω3 ratio in S. magellanica is 1:1, while in S. neei it ranges from 1:3 to 3:2 (Table 1).

Food quality and safety

In general, the analysis of heavy metals in fresh sprouts collected from both cultivated fields and salt marshes indicated that cadmium levels in Río Grande (0.004 mg/kg) were four times higher than in Ushuaia (0.001 mg/kg). Regarding lead content, levels in Río Grande (0.77 mg/kg) were twice as high as those in Ushuaia (0.36 mg/kg), although in both cases they remained below the limits established by the National Food Code. However, for lead, the values exceeded the thresholds set by the European Economic Community. Microbiological results showed either absence or acceptable levels of bacteria, in compliance with the parameters established by the Food Code.

Impact on individuals who systematically incorporated the plant into their diet as a dietary supplement

The observational study, conducted as a pilot test with a non-probabilistic sample of 20 adult individuals who were provided with pure salicornia in 750 mg capsules—taken three times daily for six months—was led by medical specialists. These specialists performed clinical analyses at the beginning and end of the study, complemented by monthly follow-up interviews or additional ones upon request, all free of charge.

Ethics committee approval was not obtained, as the study was not experimental in nature, but rather a test involving patients of naturopathic doctors who were already regular consumers of the product.

The results of the clinical analyses showed significant differences only in the increase of HDL (good) cholesterol. From the interviews, patients reported a lower incidence of respiratory illnesses and improvements in arthritic conditions.

Table 3 - Statistical treatment of two laboratory data of two patients.

Variable	Initial	Final	t-Statistic	p-value (P(|T|>=t))
Glycemia (70–100 mg/dL)	105.7	104.9	0.1408	0.8889
Total cholesterol (<200 mg/dL)	205.4	217.1	-0.9707	0.3379
LDL cholesterol (100–130 mg/dL)	122.7	132.3	-0.7663	0.4482
HDL cholesterol(>60 mg/dL)	52.9	64.75	-1.84	0.07745
Triglycerides (<150 mg/dL)	144.5	136.9	0.4497	0.6555
TSH (0.35–4.94 µUI/mL)	1.767	1.996	-0.6327	0.5307
Free thyroxine (0.75–1.85 ng/dL)	1.216	1.393	-0.5032	0.6178
Hemoglobin A1c (4.8–6.0%)	5.769	5.741	0.1299	0.8974
Insulinemia (5–30 µUI/mL)	7.665	8.08	-1.193	0.2403
Uric acid (2.4–5.7 mg/dL)	6.162	5.574	1.154	0.2567
Urea (mg/dL)	35.65	34.7	0.436	0.6653
Creatinine (0.6–1.10 mg/dL)	0.906	0.9515	-0.9431	0.351

Ovine meat production on pastures of S. neei and Frankenia sp. in Caleta Malaspina (Chubut), and S. magellanica and Puccinellia sp. in Tierra del Fuego

The results obtained in the two trials were similar, although with variations depending on the sheep breed involved. In both cases, the intake of Salicornia-based pasture represented 45–60% of the initial forage volume, estimated at approximately 2,500 to 3,500 kg/ha of dry matter. In all cases, the stocking rate was 10 animals per hectare for a period of 30–40 days. Weight gain reached 15 kg for Merino sheep in Tierra del Fuego and 3 kg (weight maintenance) for Multipurpose Merino sheep in Chubut (Table 4). On the other hand, differences were observed in the nutritional content of the meat from the animals analyzed. No health problems were recorded among the animals, and their adaptation to halophyte grazing was adequate.

At the end of the trial, it was observed that the lambs effectively used between 50% and 100% of the available surface of the saline pastures, consisting of Salicornia and Frankenia in Chubut and Salicornia and Puccinellia in Tierra del Fuego, respectively.

Table 4 - Lamb weight and biomass production in Salicornia pens (kg DM) at the beginning and end of grazing. Average weight gain (kg/animal) of lambs fed *Salicornia sp*.

Available forage in low salt marsh and lamb weight by sheep breed	Initial Weight (kg)	Final Weight (kg)	Observations
Dry matter (DM) – S. neei marsh, Chubut (kg/ha)	3.480	2.240	45% of pasture consumed (1)
Weight – Multipurpose Merino lambs (kg)	30,2	33,2	No significant weight gain over 30 days
Dry matter (DM) – S. magellanica marsh (kg/ha)	2.500	950	60% of pasture consumed (2)
Weight – Corriedale lambs, Tierra del Fuego	8 - 12	23 - 25	15 kg weight gain in 25 days

In general, meat from lambs fed with *Salicornia sp.* showed lower levels of saturated fatty acids and trans fats, along with a statistically significant increase in polyunsaturated fatty acids, particularly omega-3 and omega-6 (with year-to-year variations). A significant reduction in cholesterol content was also observed in 2016, ranging from 12.8% to 50%, depending on the animals' latitude and breed, when compared to control groups fed on non-saline natural pastures (Table 5). The 2004 trial with the Corriedale breed was not statistically analyzed and is presented only as a reference against the trials conducted in Chubut. A notable finding is the increase in eicosapentaenoic acid (EPA) and docosapentaenoic acid (DPA), both from the omega-3 family, which may be beneficial in specialized diets for individuals with cancer, cardiovascular diseases, or for women during the prenatal period.

Table 5 - (1) Essential fatty acids differentiated in a trial with lambs from Prov. De Chubut - Arce & Col.[29] (Estancia Soriano S.A. 2015) and (2) Tierra del Fuego - Bianciotto & Col.[8,12] (Estancia Violeta). Analysis of Turkey Test (95%) for the Merino Multip. breed. 2015 and 2016. Different letters indicate significant differences.

				Merino – Chubut				*Corriedale – Terra do Fogo*	
Year			2015			2016		*2004 mg/g fat*	
Denomination		Control (Chubut)	With Salicornia	p-value < 0.005	Control (Chubut)	With Salicornia	p-value < 0.005	Control (T. del Fuego)	With Salicornia
SFA	Palmitic	252.81b	239.21b	ns	260.17a	189.45b		457	474
SFA	Stearic	198.96c	178.54c	ns	229.89b	192.16b	ns		
SFA	Pentadecanoic	7.03a	6.38b	<	10.77a	6.53b	<		
ω 9	Oleic	257.65a	290.00a	ns	199.07a	241.78b	<	420	320
	Vaccenic	7.19a	11.98b	<	7.19a	11.98b	<		
ω 6	Linoleic	14.26a	21.05b	<	17.38a	21.05b	<		
ω 6	α-Linolenic	0.082a	0.13b	<	0.08a	0.13b	<		
ω 3	Linolenic	5.76e	7.40e	ns	11.22d	7.88d	ns	2.17	4.29
ω 6	CLA cis-11t	3.22a	5.1b	<	1.6a	2.11a	ns	7.32	14.13
ω 6	Eicosatetraenoic	0.14c	0.35b	<	0.21a	1.74b	<		
ω 6	Eicosanoic	0.18a	0.23b	<	0.19a	0.42b			
ω 6	Arachidonic	0.95a	2.89b	ns	0.89a	0.23a	ns		
ω 3	EPA	0.25a	0.59b	<	0.32a	0.43a	ns		
ω 3	DPA	0.22a	0.41b	<	0.19a	0.35b	<		
	Cholesterol	86a	78a	ns	176.50a	103.66b	<	122.2	52.4

• Evaluation of flavor and gastronomic quality of lamb meat:

The meat was cooked on a traditional spit (or "cross-style"), without the addition of table salt, and tasted by six participants. Overall, preference in terms of flavor and lower fat content was given to the meat from animals fed on Salicornia pastures (Table 6).

Tabla 6 - Degustación cordero, alimentado con y sin *Salicornia neei*. Personas que participaron de la degustación. n = 6 personas

Parameter	*Grazing without S. neei*	*Grazing with S. neei*
Flavor	Less flavorful	More flavorful
Color	Same	Lighter and fresher
Overall impression	Tasty	Tastier
Tenderness	Yes	Yes
Perceived fat content	Higher visible fat content	Less fatty mouthfeel


Figure 2 - Lambs raised on the salt marsh of Caleta Malaspina – Chubut. Lambs roasted on a spit for tasting.

Culinary Uses of *Salicornia*

As The first culinary applications of Salicornia accompanied by nutritional analysis were developed by INTI, featuring preparations such as Salicornia with lamb preserves, bruschettas, pickles in vinegar and wine, raw salads, and as a side dish for meats and fish, as well as dehydrated Salicornia used as a snack or ground into "Salicornia salt"[8]. However, it was through the work of renowned chefs such as Emanuel Herwin (Chez Manú Restaurant), Luis Bernal with the award-winning TV show La Cocina de Luis, and Lino Ardillón (Volver Restaurant), among others, that Salicornia gained traction as a gastronomic innovation, expanding across Patagonia and gaining international recognition. For now, its use remains limited to gourmet cuisine and has not yet become a common household vegetable.

Institutions associated with the Prohuerta National Program, led by INTA Río Grande (Tierra del Fuego), have held annual cooking workshops using Salicornia, covering both preparation techniques and harvesting/cultivation methods. Efficient preservation methods have also been developed: when refrigerated at 3 °C, it remains stable for up to 30 days with minimal deterioration; it can be frozen at –18 °C, pickled in vinegar, or dehydrated at temperatures no higher than 75 °C to preserve its nutritional properties (Figure 3).

Figure 3 - Common culinary and nutraceutical uses of S. magellanica. a) Dehydrated (as salt) or snack; b) Pickled; c) Fresh sprouts; d). Lyophilized nutraceutical tablets.

Salicornia Recipes

<table>
<tr>
<td>Salads with Salicornia
The sprouts can be used in salads after a brief blanching (immersed in boiling water for 1 minute, with or without added salt), then combined with chopped tomatoes, garlic, boiled eggs, and seasoned with olive oil and vinegar.</td>
<td>In vinaigrette with lamb
First, cook the meat in water for an hour or more with spices such as oregano, tarragon, thyme, among others. Separately, prepare a vinaigrette with garlic, parsley, pepper, oil, and vinegar. In the final minutes of cooking, add the Salicornia sprouts and the sliced meat. It can be served hot or cold. For storage, keep it refrigerated in open trays or cellophane bags at two degrees Celsius or on the upper, colder shelves. Do not freeze. The product should be consumed within a few days.</td>
</tr>
<tr>
<td colspan="2">Pickled – preserved
A brine or vinaigrette is prepared with vinegar and white wine (70 mL of each), flavored with spices such as whole peppercorns, mustard seeds, and oregano. The mixture is boiled for 15 minutes. In hexagonal jars with a nominal capacity of 170 g, fresh and clean Salicornia sprouts (approximately 50 g) are placed. The hot vinaigrette is then added, and the jar is sealed immediately. The process may be completed with pasteurization or simply by hot-filling and hermetically sealing the jar. The preserve has an approximate shelf life of 6 months.</td>
</tr>
</table>

As a general consideration, in salads, Salicornia is best consumed fresh, without prior blanching, or in preserves, adding the sprouts only at the end over the hot vinaigrette. When blanching is used, it should not exceed 1 minute in order to preserve the fatty acid content.

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Figure 4 - Paella, roasted lamb, and Salicornia tart.

Cultivation of Salicornia in Tierra del Fuego and Production in the Salt Marshes

Both species of Salicornia were used in cultivation and domestication efforts, aiming to develop appropriate planting and management techniques, both in open field conditions in coastal marine areas — using seawater irrigation and protective tunnel structures — and in 3-liter pots (Figure 5-d). Additionally, cultivation using salinized and recycled water from the fishing industry is under development (Figure 5-a), with an approximate salinity of 18 g/L (~28 dS/m). In all cases, production began with seedlings propagated from cuttings, which after about 10 cm of growth (in three months) were transplanted to the final cultivation site. In field cultivation, irrigation was done through furrows, with pumped seawater or salinized water. With a planting density of 6 plants/m² for S. neei, yields reached 55 t/ha; for S. magellanica, with 12 plants/m², yields were 24 t/ha without tunnel protection and 40 t/ha with tunnels, in terms of green biomass production (Figures 5-b and 5-c), equivalent to 3 to 5 t/ha of dry matter. The use of protective tunnels in Tierra del Fuego served as windbreaks, which were essential for mitigating cold and dehydration caused by strong winds. In pot cultivation, drip irrigation with adjustable nozzles was used, with yields ranging from 300 to 500 g per pot[30].

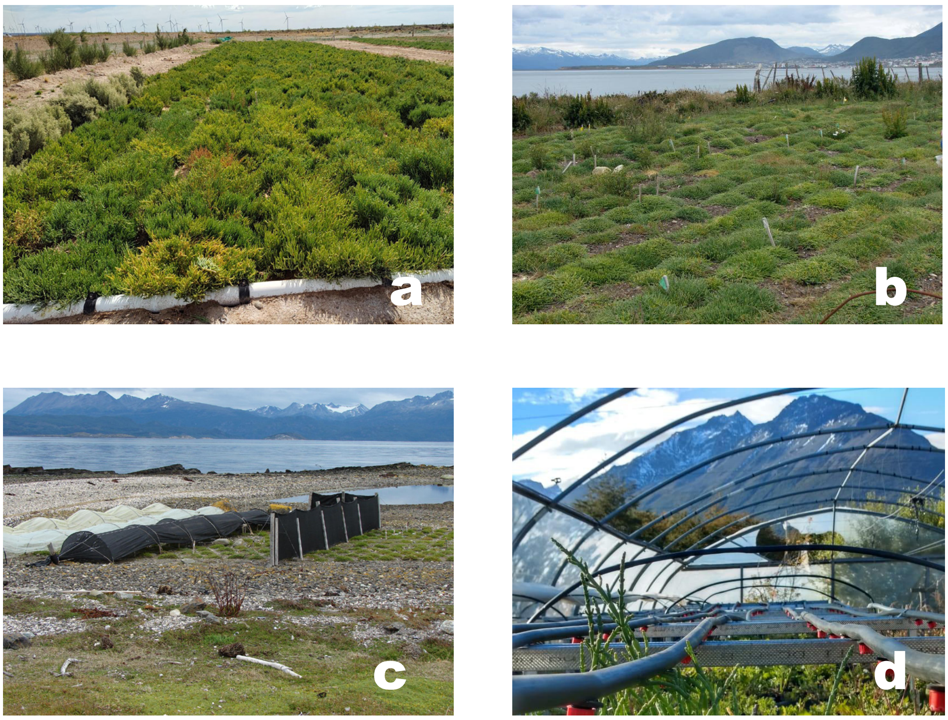

Figure 5 - a) Cultivation of S. neei (Chubut – 45°S) using water from the fishing industry; b) Cultivation of S. magellanica on the coast of the Beagle Channel (Tierra del Fuego – 54°S) with plants grown for 2 years; c) Protective tunnel system; d) Cultivation of S. magellanica in 3-liter pots for household gardening.

Table 06 - Comparative table of yields obtained at different latitudes and cultivation methods. References: TDF: Province of Tierra del Fuego A.I.A.S.; CH: Province of Chubut; SM: *Salicornia (Amerocornia) magellanica*; SN: *Salicornia (Amerocornia) neei*; 1. Bianciotto *et al.* (2016)[22]; 2. Bianciotto *et al.* (2020)[15]; 3. Bianciotto *et al.* (2021)[30]; 4. Bianciotto, pers. comm. – preliminary data Rawson Ambiental; 5. Arce *et al.* (2016)[29].

Latitude / Province	Type of Cultivation	Plants/m²	Green Biomass (kg/m²)	Kg/ha	Reference
54ºS - TDF	Field cultivation with tunnel cover	12	4,3	43.000	1. SM
54ºS - TDF	Field cultivation without protection	12	1,8	18.000	2. SM
54ºS - TDF	3-L pot cultivation	20	2,4	24.000	3. SM
45ºS – CH	Field cultivation without protection	6	5,5	55.000	4. SN
45ºS – CH	Bustamante salt marsh	-	3,4	34.000	5. SN

The estimated cost calculated by Bianciotto & col.[28] for one hectare of field cultivation using seawater pumping and a planting density of 120,000 plants/ha is approximately 100,000 USD. The unit cost per product was estimated at 7.5 USD/kg.

DISCUSSION

Salicornia, an illustrious unknown until just over 20 years ago in Latin America, lives and "works" as a retainer of sands and silts along marine coasts and saline lagoons. It coexists in community with other plants adapted to marine salinity, which is why it is classified as a halophyte. It also serves as food and shelter for birds, crustaceans, various insects, and both marine and terrestrial fauna[12,13,23].

It first surprised us with its taste, similar to salty pickles; then, with its history. European fishermen — and most likely the indigenous peoples of our lands — collected it for use as food, a preventive remedy against scurvy, a raw material for glassmaking, forage for domestic livestock and guanacos. Greek soldiers and, later, Napoleon's army consumed it before battle for its tonic properties[12].

Based on these historical accounts, we began to investigate its value as food, confirming that it is a vegetable suitable for human consumption and already included in the list of the Argentine National Food Commission. With high levels of the CLA complex (linoleic acid), polyunsaturated fatty acids in general, as well as a range of calcium, magnesium, potassium, sodium salts, trace elements, and proteins important to human and animal nutrition, *Salicornia spp.* communities can be considered highly nutritious food sources. Other studies have confirmed similar findings[8,31], along with significant antioxidant concentrations, including phenolic compounds at levels of 25 mg GAE/g of dry matter[17]. In general, halophytic species prove to be excellent natural sources of phenolic compounds, outperforming even soy bran and rice[18].

We found protein contents higher than those found in chard leaves (Beta vulgaris cycla, 2.9 g) and spinach[17]. In the case of S. neei (5.56 g), the values approach those of fresh alfalfa leaves (Medicago sativa, 6.6 g), while *S. magellanica* (9.91 g) even surpasses fresh pea seeds (Pisum sativum L., 8.9 g)[32].

When it comes to omega-3 and omega-6 fatty acids, it is well known that they are essential for vital functions and cannot be synthesized by the human body. Alpha-linolenic acid (ALA) must be obtained exclusively from the diet, and the human and ruminant organism converts it into long-chain polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)[33]. On the other hand, most omega-6 fatty acids, such as linoleic acid (LA), are consumed through vegetable oils or fresh plants in general — including halophytes like Salicornia. The body converts LA into long-chain acids like gamma-linolenic acid (GLA) and arachidonic acid (AA)[34]. These essential fatty acids (ALA and LA complexes) show variable concentrations across species: in the case of omega-3, *S. neei* contains 0.36 g/100g and *S. magellanica*, 0.96 g/100 g (Figure 3), values comparable to those found in radish (0.7 g/100 g) and spirulina (0.8 g/100 g)[32].

The three main omega-3 fatty acids — ALA, EPA, and DHA — are also present in fish, seafood, and the meat of lambs fed with Salicornia. They may help prevent and treat inflammation, contribute to cardiovascular health, and play an essential role in brain and visual system development and maintenance (DHA), making them recommended during pregnancy and lactation[33,35]. The daily intake recommended by the

WHO, ranging from 400 to 1000 mg of EPA and DHA (or their precursors), can be met with two 3 g capsules of freeze-dried Salicornia as a dietary supplement or with 60 to 100 g of fresh Salicornia per day in a regular diet.

In this regard, parameters associated with non-communicable chronic diseases (NCDs), such as hyperglycemia, type II diabetes mellitus, and dyslipidemia, were assessed in individuals who consumed Salicornia regularly over a six-month period. Positive effects were observed in biomarkers such as HDL (good cholesterol), with significant differences between the beginning and end of the intake, along with clear reductions in blood glucose, glycated hemoglobin, triglycerides, and uric acid (Table 3). The general condition of most patients proved positive. Achieving near-normal glycemic control and reducing plasma lipid levels is a constant concern in global medicine, aiming to minimize the risk of cardiovascular complications — the leading cause of premature death in people with type 2 diabetes.

In other species of the genus, such as S. herbacea, hypoglycemic and hypolipidemic effects have been observed in rodents fed high-fat diets or animals with induced type 1 diabetes. Consumption of ethanolic extract from this species led to a significant reduction in plasma triglycerides and cholesterol. Furthermore, dietary supplementation with 5% to 20% Salicornia powder in mice resulted in significant reductions in blood glucose. It appears that the hypoglycemic effect of the powder may be stronger than that of the extract, with dietary fiber being the active component responsible. In turn, the reduction of triglycerides and cholesterol is likely associated with the ethanolic extract's inhibitory effect on pancreatic lipase[36].

Feeding lambs with halophytic pastures has shown that Salicornia can also be an excellent forage for animal growth[15], with weight gains ranging from 2 to 15 kg over a period of 30 to 45 days (Table 4), results similar to those obtained from diets with halophyte mixtures applied to sheep in Australia[31]. These diets confer meats with lower cholesterol content (12% to 50% less), higher levels of salts and essential fatty acids such as omega-3 and omega-6, including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (Table 5).

With the support of the Instituto Nacional de Tecnología Industrial (INTI), appropriate methods for the storage and preservation of Salicornia sprouts were defined, along with assessments of taste, aroma, color, and consumer preference in culinary preparations. Cold storage in perforated bags maintains the color and flavor for 20 to 40 days with minimal changes, and deep freezing in vacuum-sealed packaging preserves the product for several months. Sprouts dehydrated at 70 °C become a nutritious snack, and can also be ground and compressed into nutraceutical tablets with long shelf life. In pickled form, they retain pleasant taste and aroma for up to 90 days. Microbiological and quality analyses of these preservation methods confirmed their suitability for distribution and commercialization, either as fresh vegetables or pickled products[8,12]. In other countries, products like Salicornia salt (made from dehydrated and ground shoots and stems), antioxidant nutraceuticals, and dermal creams are already on the market[16,37].

In tasting sessions involving lambs fed with pastures containing Salicornia, the meat stood out for its unique flavor — milder and slightly salty — and lower fat content, which supports its appeal to niche markets demanding lean meats, rich in beneficial salts and low in cholesterol (Table 6).

Among the most appealing dishes made with Salicornia sprouts are salads with tomato, garlic, and olive oil (after blanching for no more than 1 minute), as well as side dishes for pasta, pizza, fish, or paella — with the sprouts added just before finishing to retain their crunch and nutritional value. Highlights also include burgers, Salicornia lamb escabeche, roast or spit-roasted lamb, and countless other creative preparations[12].

In the process of domesticating these halophytic species, it was found that they can be propagated without damaging their natural habitats — which play a vital role in protecting marine coastlines against erosion caused by daily tides[20]. Propagation was successful via seeds, stem fragments, or even biotechnology, using small pieces of plant tissue to generate plants suitable for cultivation and fresh sprout production for human consumption[17,38]. Encouraging home cultivation in pots aims to prevent direct harvesting from natural marshes, which are often located near urban areas and at risk of contamination from untreated industrial waste. This raises concerns about ensuring the quality of Salicornia as an organic food free from heavy metals when sourced from uncontrolled environments.

In both Salicornia species, irrigation with seawater was observed to promote the emergence of a greater number of shoots and higher biomass production, anticipating sprouting by up to two months and reducing by approximately 30 days the time required for initial sprouting and branching, when compared to freshwater irrigation[15,29]. Biomass yields in Chubut ranged from 30 to 50 tons per hectare, both in natural marshes and in cultivated fields irrigated with saline water (salinity of 18–20 g/l) (see Figures 5 and Table 6)[22,29]. Other studies in the state of Ceará, Brazil, reported yields ranging from 14.7 to 21.7 t/ha after 24 weeks under salinity greater than 20 dS/m (15–18 g/l), using S. neei[13,14].

At high latitudes, such as Tierra del Fuego, harsh environmental conditions — extremely low temperatures and strong winds — can be managed using low tunnels (1 meter high) with plastic covering. This technique enabled increases of 70% to 170% in the production of green, tender shoots suitable for fresh vegetable consumption, at an estimated cost of 10 to 12 U$D/kg.

Marshland surveys revealed noteworthy findings regarding both surface area and floristic composition: more than 50,000 hectares of saline environments are located in Tierra del Fuego (Argentina), and between 15,000 and 20,000 hectares are distributed across Chubut and southern Buenos Aires Province.

Similar surveys were conducted in the Magallanes region (Chile), mapping the distribution and condition of Salicornia populations, particularly in inland saline lagoons, coastal marshes along the Strait of Magellan, and the San Sebastián–Bahía Inútil depression on the Chilean side of Isla Grande de Tierra del Fuego[37]. Regarding mapping efforts of marshes near river mouths, changes in land use were observed in the marshes of Tierra del Fuego, including increased anthropogenic impact from urban and industrial waste discharge, as well as urban expansion in the marshes of the Chico and Grande rivers. In contrast, although oil and livestock production activities have also grown, they have not significantly altered the distribution or initial state of these environments[27,39].

Surveys along the coastal Patagonia indicated that the Caleta Malaspina marsh, in Chubut Province, is the largest in the region and remains in excellent condition. Evidence of past seaweed harvesting and livestock use was identified. Currently, activities are mainly focused on ecotourism and extensive grazing, with the marsh used especially during the lamb weaning season, as demonstrated in research conducted in partnership with Soriano S.A., the owner of Caleta and Bahía Bustamante. In the Chubut River marsh, agricultural and livestock activities were recorded, including Salicornia grazing and the discharge of sewage effluents into saline lagoons in the basin. In Buenos Aires Province, initial surveys identified two areas with the presence of *Salicornia sp.*, where interested local producers allowed fieldwork to take place. Maps of the western and southern shores of Epecuén and Bargar lagoons, respectively, show Salicornia in association with Distichlis and Agropyron, currently grazed by cattle — suggesting a potential improvement in meat quality from these systems.

These mixed areas, hosting communities of Salicornia, Suaeda, Distichlis, and Agropyron, allow for grazing during periods of forage scarcity and in highly saline environments that are unsuitable for conventional crops, often flooded with water even saltier than seawater. In such conditions, halophytes exhibit high nutritional value for livestock[15,28].

The market potential for Salicornia is virtually unlimited, especially for varieties native to southern Patagonia, due to the tenderness and mildness of their green shoots. It is estimated that there are currently around 10,000 hectares of Salicornia cultivation worldwide, primarily concentrated in North America (Baja California) and Africa, with very limited surface area in South America and Europe. Considering that yields rarely exceed 30 t/ha, global production amounts to no more than 10,000 to 20,000 tons — insufficient to meet the potential demand for fresh product or ensure its regular presence in mainstream distribution networks.

Beyond its food value, Salicornia is a key component of salt marshes, which are often included in coastal protected areas such as the Ramsar site of the Atlantic Coast Reserve in Tierra del Fuego or the Interjurisdictional Marine Coastal Park of Southern Patagonia in Chubut. Valuing these transitional environments between land and sea is a crucial challenge for the sustainable management of our coastal zones. As stewards of these protected natural areas, we have the responsibility to preserve them so they can be passed on to future generations.

Future research — currently still focused heavily on halophyte physiology and their potential as food or energy sources — should increasingly aim to improve cultivation techniques, building upon existing studies on salinity adaptation, nutrient requirements, and the distribution of saline environments. It is also necessary to propose government programs that provide technical and financial support for the establishment of Salicornia cultivation and adapted livestock systems, fostering the production of healthy food and strengthening food sovereignty — all with species that require only 20% of the freshwater used in conventional agricultural systems. Agricultural sustainability faces a new challenge here: applying knowledge of saline environments and the resources they offer to expand arable land and the production of healthy foods.

CONCLUSIONS

Over the past 25 years, salt marshes and some of their plant species have become better understood, revealing themselves — through accumulated knowledge — as resources of great potential. Salicornia, in particular — popularly known as sea asparagus, sea pickle, glasswort, perce-pierre, agrotti, among other names — has emerged as an agricultural innovation. It has gained national and international recognition for its potential to support both plant and animal production sustainably, without

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relying on freshwater — a scarce and heavily demanded resource in conventional agriculture.

Based on these advances, it is now feasible to consider increasing productivity in saline areas of South America and beyond, areas that are currently viewed as marginal or unsuitable for farming. New paradigms are emerging, incorporating technologies based on seawater irrigation or the use of saline aquifers — both abundant and underutilized — which could bring over 40% of currently idle saline land into productive use.

These species also provide high-quality food, rich in essential fatty acids (omega-3 and omega-6) that are beneficial to human health. In addition, they confer special nutritional properties to the meat of ruminants raised on halophytic pastures, which tend to contain lower fat levels, reduced cholesterol, and higher concentrations of conjugated linoleic acid (CLA), a compound with documented health benefits for meat consumers.

This new food offering allows for the introduction of healthy and original products into restaurant menus, which are beginning to adopt them — albeit still cautiously. The limited availability of these products is partly due to the small cultivation area and also to the global lack of awareness regarding the benefits of incorporating halophytes into the human diet.

In this context, we initiated the development of pot cultivation for household use, aiming to encourage the inclusion of Salicornia in urban and family gardens, especially in coastal areas. There are already indications of positive health impacts among people who have begun consuming fresh Salicornia shoots, but further research in humans is needed to conclusively determine the nutraceutical potential of this innovative food.

It is also essential to adapt cultivation technologies to the specific geographic realities where such practices are being tested. This is a promising beginning, one that is expanding — but it requires greater outreach efforts so that these alternative agricultural technologies can reach producers interested in sustainable food production, integrating saline environments into agriculture and bringing value to salt marshes, which remain undervalued and little known on a global scale.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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MATERIAL SUPLEMENTARIO

Distribución geográfica de las marismas

1. METODOLOGÍA DE LA CARTOGRAFÍA:

Para la Cartografía se llevaron a cabo trabajos en el área costera de las Provincias de Chubut y Tierra del Fuego A.E.I.A.S., y marismas de lagunas saladas de la Provincia de Buenos Aires; con imágenes en formato digital: Imagen satelital Landsat y Spot actualizadas, además se corroboró la información con las imágenes Landsat 8 del año 2013 y 2014 para mayor actualización, así mismo se trabajó en la actualización de la información cartográfica de Tierra del Fuego[1] (Fig. 1 a y b).

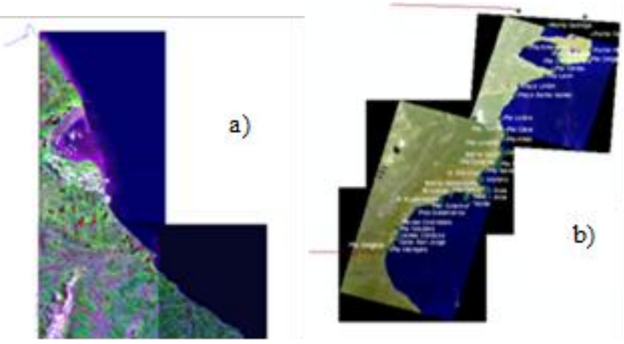

Figura 1: a, b: Mosaico de imágenes satelitales de las áreas de estudio

Se utilizaron los programas Arcview 3.2 y 9.2, Envi 3.6, Erdas 8.4. El sistema Arcview 9.2 se utilizó para digitalizar los datos existentes. Mediante el Sistema de Información Geográfica (GIS)[2] fueron procesados los datos espaciales, generando una base de datos computarizados que contiene información espacial en formato digital.

Se utilizó el sistema Envi 3.6[3] para el tratamiento digital de las imágenes y la realización de las combinaciones de bandas más adecuadas.

La clasificación supervisada y los diferentes índices se obtuvieron mediante el sistema Erdas 8.4[4,5].

En el sistema Arcgis 9.2, se realizó el MDT y los mapas derivados que luego fueron utilizados para la interpretación visual por ordenador siguiendo los pasos establecidos en el manual de metodología[6,7].

2. **Las Marismas y el potencial productivo de Salicornia**

La localidad de San Julián, a los 49° de Latitud Sur, definiría el límite de distribución de dos especies del género que tratamos: *S. (Amerocornia) neei* al Norte de esta latitud abarcando el norte de Santa cruz y la Provincias de Chubut, hasta el sur oeste de la Provincia de Buenos Aires. Al Sur de esta latitud *S. (Amerocornia) magellanica* (Figura n° 1) abarcando el sur de Santa Cruz y Tierra del Fuego[8,9]. Las Marismas de Santa Cruz dominadas por Salicornia tienen una productividad entre 17 a 60 Tn/ha de producción verde (1,8 a 7 t/ha de materia seca)[10]. En Chubut, Caleta Malaspina la superficie total ocupada por *S. (Amerocornia) neei* es de aproximadamente 147,4 ha y la producción de biomasa verde (en peso seco) osciló entre 0,780 a 3,5 Tn/ha de materia seca (10 a 35 Tn/ha de producto verde – Tabla n° 7)[8,11,12]. En general las marismas de Chubut podrían estimarse en 8.000 a 10.000 ha.

En Tierra del Fuego, las marismas cubren una superficie de aproximadamente 54.500 hectáreas. Los primeros estudios tenían como objetivo determinar la capacidad de la especie en cuestión, como bioindicador del aumento de la radiación UV-B resultante de la depresión del ozono estratosférico, el agujero de ozono, que se produce cada año durante la primavera austral. A continuación, y basándose en los conocimientos adquiridos sobre la biología de Salicornia, su sabor agradable a pickle salado, motivaron el inicio de ensayos para determinar su potencial como productor de alimentos frescos, la calidad alimentaria para consumo humano y como forraje para la producción animal[5,10,13].

De esta manera, las evaluaciones de productividad, contenido de nutrientes y potencialidades como cultivo de este género, se llevaron a cabo en dos extremos de la Patagonia, al norte templado cálido en la marisma de Caleta Malaspina, cerca de Comodoro Rivadavia y en el sur frío templado y subhúmedo, en la marisma de Río Chico y San Sebastián de Tierra del Fuego. Así también en la Provincia de Buenos Aires la cuenca salina del Lago Epecuén y lagunas circundantes.

El sur de la Patagonia cubre 490.000 km^2 en Chubut, Santa Cruz y Tierra del Fuego con una población de 900.000 personas. El clima es templado frío con pocas precipitaciones en el sector extra andino. Según el índice de aridez el 4,2% de la superficie patagónica es híper-árido. Sólo el 9% corresponde a las zonas bioclimáticas subhúmedas o húmedas. Predominan los suelos aridisol, pobres en estructura y materia orgánica, baja retención de agua y arena en la superficie; Molisols en zonas más húmedas y con mejor contenido en materia orgánica y Entisols sin desarrollo de perfil definido. En las marismas suelos Solonetz, Solonchack y Fluvisoles eutricos, con subsuelos limosos y arcillosos y alcalinidad medida en términos de pH entre 7 y 8,6[14,15]. Con procesos erosivos entre 6 y 20% de la superficie, depresiones salinas con marcada erosión eólica, desertificación por falta de lluvias y alta evapotranspiración, actividad ganadera de fuerte impacto, agricultura exclusiva bajo riego en márgenes de ríos[16,17].

Las marismas donde crecen plantas halófitas, potenciales alimentos de calidad, capaces de desarrollarse en suelos de alta salinidad y en los más diversos climas, tienen diferencias en la composición de especies vegetales, en función de la latitud, el clima y el régimen de mareas o el régimen hídrico, el relieve del suelo que determina la zonificación respecto al nivel del mar o de las lagunas saladas (Tabla n°2). Estos ambientes asemejan a pantanos salados formados con sedimentos que acarrean los ríos junto con arenas y limos transportados por las mareas diarias, los que se conjugan para depositarse en capas horizontales que van formando los pisos de marismas: baja (intermareales fangosas), media (Mesolitoral) – con influencia diaria de mareas - y alta (Supra litoral - pastizales salinos con influencia esporádica de mareas excepcionales).

Los suelos francos, limo arenosos y arcillosos tienen altos contenidos de sales, alcalinidad entre 6,9 a 8,7 y salinidades entre 5,7 a 34 g/l (Tabla n°1).

Tabla 1: Calidad del suelo de los diferentes ambientes salinos suelos.

Ubicación geográfica	PH	Fósforo Disp. (ppm)	Materia Orgánica %	Nitrato Disp. (ppm)	Ca. meq/l	SO_4 meq/l	Cond. Elect. mΩ/cm2	Salinidad mg/l	Observaciones
RIBERA	7,19						24,19	15936	Salicornia - Distichlis -L 37° S
RIBERA	9,23						14,3	9152	Bargar. Agrop /Salicornia – L 37° S
EPECUÉN	8,47						53,2	34048	Peladal Rolandi – L 37° S
EPECUÉN	9,59						19,2	12288	Puccinellia Borde laguna – L 37° S
Agua Surgencia campo Rolandi	7						8,9	5696	L 37° S
Ushuaia	7,59	26,9		4,4	9,9	27,1	22,21	14214	Canal Beagle – L 54°S
Río Grande	6,21	47,4		2,4	11,8	8,9	18,84	12057	Marisma R. Grande – L 53° S
Río Chico	7,37	27,4		2,4	15,3	28,6	35	22272	Marisma R. Chico – L 52° S

Caleta Malaspina	7,33		1,4		9		6.64		Marisma B. Bustamante – L 45°S

Lista de especies halófitas estrictas, tolerantes a salinidad y Glicofitas de Tierra del Fuego, Chubut y Carhué (Sur oeste de Buenos Aires).

Tabla 2: Lista de especies halófitas estrictas o tolerantes a salinidad. Ref.: (a) Halófita estricta (He); Halófita no estricta (HNe); Glicofitas (Gl) Nativa (N); Endémica (E). En base a Bianciotto *et al.* (2004; 2019)[8].

Familia	Género y especie	Estatus (a)	Posición topográfica (b)	Latitud	Provincia
Marismas Provincia de Chubut					
Ulvaceae	*Ulva*	He/N	Marisma Baja	45° S	Chubut
Poaceae	Spartina densiflora (Brongniart) (espartina)	He/N	Marisma baja	45° S	Chubut
Amaranthaceae	Salicornia (Amerocornia) neei (salicornia – Espárrago de mar)	He/N	Marisma baja, media y alta	45° S	Chubut
Plumbaginaceae	Limonium brasiliense (Boiss.) Kuntze	He/N	Marisma media Mesolitoral	45° S	Chubut
Amaranthaceae	Atriplex patagónica (camefita) (atriplex)	He/E	Marisma media Mesolitoral	45° S	Chubut
Amaranthaceae	Suaeda divaricata (Moq.)	He/N	Marisma media y Alta	45° S	Chubut
Frankeniaceae	Frankenia juniperoides (Spegazzini)	He/E	Marisma Alta (Lagunas Salinas)	45° S	Chubut
Asteraceae	Chuquiraga aurea	GL/N	Marisma Alta (Lagunas Salinas)	45° S	Chubut
Tamaricaceae	Tamarix ramosissima (tamarisco)	HNe/N	Marisma Alta (Lagunas Salinas)	45° S	Chubut
Poaceae	Distichlis sp. (pasto salado)	He/N	Marisma Alta (Lagunas Salinas)	45° S	Chubut
Anacardiaceae	Schinus johnstonii (molle blanco)	GL/E	Marisma Alta (Lagunas Salinas)	45° S	Chubut

Berberidaceae	Berberis microphylla (calafate)	GL/N	Estepa arbustiva xérica	45° S	Chubut
Rhamnaceae	Retanilla patagónica	GL/E	Estepa arbustiva xérica	45° S	Chubut
Verbenaceae	Mulguraea ligustrina. (Lag.) N. O'Leary & P. Peralta	GL/E	Estepa arbustiva xérica	45° S	Chubut
Asteraceae	Baccharis darwinii	HNe/N	Estepa arbustiva xérica	45° S	Chubut
Frankeniaceae	Frankenia spp	H	Estepa arbustiva xérica	45° S	Chubut
Marismas Provincia de Tierra del Fuego					
Amaranthaceae	Salicornia (Amerocornia) magellanica (salicornia)	He	Marisma Baja – Marisma media	53° S	TDF
Poaceae	Puccinellia magellanica,	He/E	Marisma Media	53° S	TDF
Poaceae	P. biflora	He/N	Marisma Media	53° S	TDF
Poaceae	Hordeum pubiflorum Sub. Halofillum (cola de zorro)	HNe/N	Marisma Alta	53° S	TDF
Poaceae	Hordeum lechleri (Steud.)	HNe/N	Marisma Alta	53° S	TDF
Poaceae	Elymus agropiroides (elimus)	HNe/N	Marisma Alta	53° S	TDF
Asteraceae	Lepidophyllum cupressiforme (mata verde)	He/E	Marisma Alta	53° S	TDF
Plantaginaceae	Plantago maritima	HNe/N	Marisma Alta	53° S	TDF
Plumbaginaceae	Armeria marítima (flor de papel)	HNe/N	Marisma Alta	53° S	TDF
Ericaceae	Empetrum rubrum (murtilla)	Gl/E	Estepa Magallánica	53° S	TDF
Poaceae	Festuca gracillima (coirón)	Gl/E	Estepa magallánica	53° S	TDF
Asteraceae	Chiliotrichum diffusum (mata negra)	Gl/E	Estepa magallánica	53° S	TDF
Berberidaceae	Berberis microphylla (calafate)	Gl/N	Estepa magallánica	53° S	TDF
Berberidaceae	Berberis empetrifolia (calafatillo)	Gl/N	Estepa magallánica	53° S	TDF
Marisma de Epecuén (Provincia Buenos Aires)					

Amaranthaceae	Salicornia (Amerocornia) neei (salicornia)	He/E	Marisma baja (Peladar) y media asociada con Agropyron y Suaeda.	37° S	Epecuén
Poaceae	Distichlis sp. (pasto salado)	He/N	Marisma media	37° S	Epecuén
Poaceae	*Agropyron cristatum* (L.) Gaertn (agropiro)	HNe/N	Marisma media y alta	37° S	Sistema de las Encadenadas
Fabaceae	*Prosopis caldenia* (caldén)	HNe/N	Marisma alta y bosques	37° S	Bosque del Espinal

3. Las marismas del Norte Patagónico

La Patagonia norte esteparia xérica de arbustos altos y a 45 grados de Latitud Sur se encuentra caracterizada por los fuertes vientos dominantes del oeste de velocidad media anual 43 km/h, principalmente en verano generados por el anticiclón del Pacífico que se desplaza más hacia el sur que el del Atlántico alcanzando los 45° LS. La precipitación media anual de 210 mm, temperatura media anual de 13,7 °C con máximas de verano de 42 °C y mínimas de invierno de -12°C. estas condiciones junto con la evapotranspiración potencial de 720 mm define a la zona del Golfo San Jorge – área del trabajo - como semiárida inferior[18,19].

En este ambiente de semi-desierto costero, se desarrollan comunidades de estepa arbustiva y marismas costeras en desembocaduras de ríos al mar, o en lagunas salinas interiores. La especie que nos ocupa *S. (Amerocornia) neei,* es un subarbusto robusto de 50 – 80 cm. de altura, con un sistema caulinar subterráneo profusamente ramificado, con tallos plagiotropos y ortótropos. A partir de ellos surgen raíces adventicias y vástagos aéreos. Esto define una estructura modular. Su desarrollo vegetativo es un factor determinante en la formación de la marisma. El crecimiento se inicia a principios de otoño concentrando el mayor desarrollo de yemas durante el invierno. En primavera continúa el crecimiento de las ramas. Promediado el verano (febrero) se inicia el desarrollo de las flores. Fructifica y disemina en marzo y abril y se encuentra presente en prácticamente todos los pisos de mareas, desde la marisma baja con inundación diaria de mareas hasta la marisma alta. (Figuras n.° 3 a-c)

Estas marismas o Salt Flats, desde la estepa circundante hacia la marisma baja costera, se ordenan de la siguiente forma (Figura n° 2):

a) Marisma baja con fondo de arcilla, arena y gravas con manchones dispersos de *Spartina sp, Frankenia juniperoides, Distichlis sp. Salicornia (Amerocornia) neei, Tamarix ramosissima.*
b) Marisma media y baja cubierta de *Salicornia neei* con *Spartina spp.* y suelo arcillo-arenoso con grava. Por sectores la textura es franco arenosa con pH 7,75, 1% de materia orgánica, salinidad mediana Además se registran en esta zona, leves depresiones húmedas o inundadas pobladas por comunidades de microalgas denominadas bioderma. Los organismos que la componen han sido clasificadas como: Cyanophyceae: Orden Oscillatoriales: *Microcoleuschthonoplastes* (Thuret ex Gomont 1892); Orden Nostocales: *Calothrixcrustacea* (Thuret 1876); Bacillariophyceae: Diatomeas pennadas; además de Bacterias y Nematodos.
c) Marisma media con alfombras de *Salicornia neei* y borde de *Suaeda divaricata* (arbustos de 2,5 m), *Grindelia chiloensis, Schinus johnstonii* achaparrado *Senecio sp., Erodium cicutarium, coirones, Lycium chilense*.
d) Lagunas salinas secas con baja cobertura vegetal (30%) abierta de *Chuquiraga aurea.*
e) Estepa arbustiva de *Berberis microphylla, Retanilla patagonica, Schinus johnstonii, Mulguraea ligustrina, Baccharis darwinii, Frankenia spp.*

Algunas marismas tienen un uso ganadero, con ovinos en época de destete y equinos, como la marisma de Caleta Malaspina en el establecimiento Ganadero de Soriano S.A. (Bahía Bustamante), con actividad mixta: ganadería, servicios turísticos (alojamiento, restaurante, excursiones y avistaje de aves), extracción de algas para exportación de producto deshidratado y alginatos. Se estima alrededor de casi 300 ha de pastizales salinos por donde pastorean las ovejas y 90 ha de marisma con *Salicornia, Spartina y Suaeda*.

En marismas que rodean a la desembocadura del Río Chubut (Figura n° 1), se observa un alto impacto antrópico, más acentuado por el desarrollo urbano de la localidad de Rawson y Puerto Rawson con fábricas procesadoras de pescados y mariscos. Un impacto menor en lagunas salinas y chacras agrícolas con presencia de *Salicornia* en los predios con mayor salinidad. Otras marismas como la de Riacho San José tienen un uso residencial de baja densidad en marisma alta y pesca artesanal.

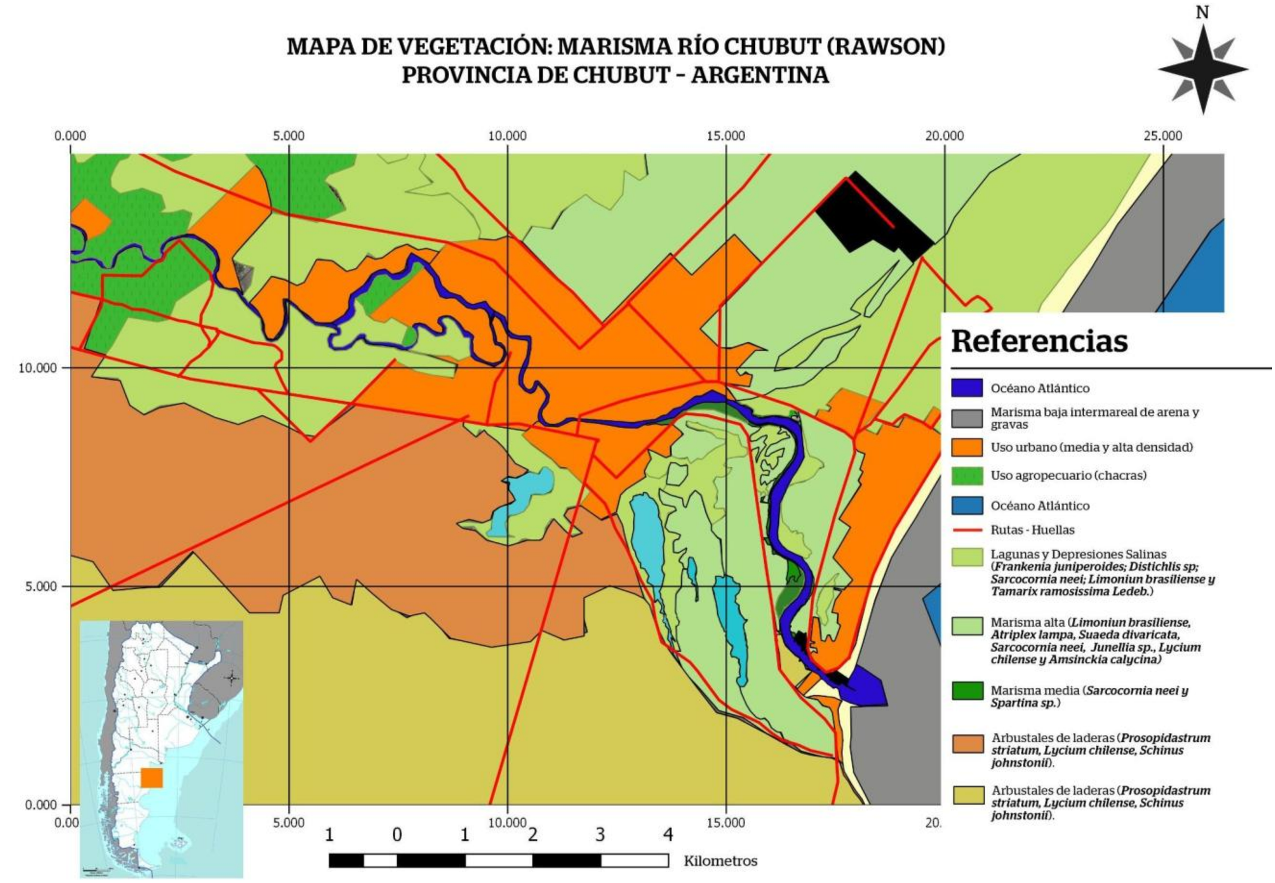

Figura 2: Marisma del Río Chubut y la zonificación en función de la distancia al mar o al río. *(Cartografía Alicia Blessio)*

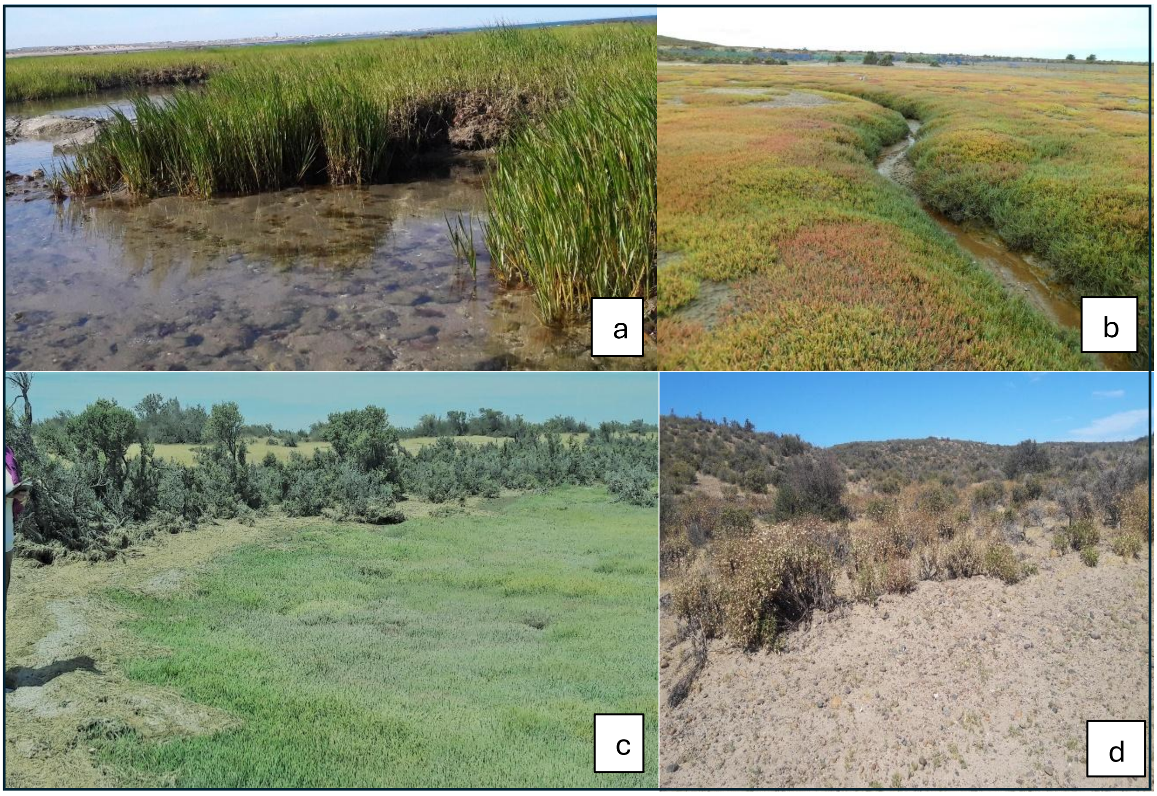

Figura 3: a, b, c y d: Marisma Chubut: a-b) Marisma baja y canales de marea con *Spartina y Salicornia*; c) marisma media y alta de borde de *Suaeda divaricata (*arbusto de 2,5 m) *y Salicornia;* d) Estepa rala (Cobertura de suelo menor al 50%) de *Berberis, Retanilla y Mulguraea.*

4. Marismas del Extremo Sur Patagónico - Provincia de Tierra del Fuego.

El clima en la Estepa Magallánica de Tierra del Fuego donde se desarrollan las marismas, se define como Trasandino con degeneración esteparia y templado - frío sin ningún mes de bienestar[20,21,22]. con un invierno térmico todo el año. Desde el punto de vista fitogeográfico se trata de una Estepa semiárida fría[23]. En este ambiente estepario se conjugan vientos fuertes del Oeste y Norte, con velocidades medias de 29 Km/h y máximas de 200 km/h. Lluvias entre 250 a 330 mm/año y un balance negativo del agua en el suelo en verano (déficit de 60 mm) y nevadas frecuentes en invierno[24]. Las temperaturas tienen una marcada influencia de la corriente oceánica fría de Malvinas, con una temperatura media de invierno de -0,2 °C y la media de verano de 11 °C[8]. La mayoría de los días son nublados representando el 60% del total del año. En este ambiente frío casi todo el año se desarrolla la vegetación de arbustales de estepa y marismas en desembocaduras de los ríos al mar y lagunas salinas interiores (Figura N° 4). Los suelos se definen como Solonchak gléyico, con pH entre 6,9 y 8,8 y salinidad entre 1,8 y 3,5 % NaCl[8]. La vegetación de marismas se caracteriza por una estación breve de crecimiento que empieza en octubre–noviembre y termina en marzo–abril. En esta alta latitud, *S. (Amerocornia) magellanica* es un subarbusto de ramas suculentas de 5 -12 cm. de altura, ascendentes erectas o decumbentes (semi-rastreras), algo leñosas en la base por su característica de planta perenne con un período de dormancia donde lignifica las ramificaciones del año. Hojas pequeñas, opuestas, balanceadas y pegadas a los brotes segmentados. Raíces adventicias que en suelos sueltos pueden alcanzar gran profundidad, que se desarrollan de un sistema caulinar subterráneo profusamente ramificado, desde donde nacen vástagos aéreos. El crecimiento -primeros brotes- comienza a fin de octubre - noviembre, luego del deshielo de primavera, y las ramificaciones durante principios de diciembre enero; la floración a fin de enero febrero.

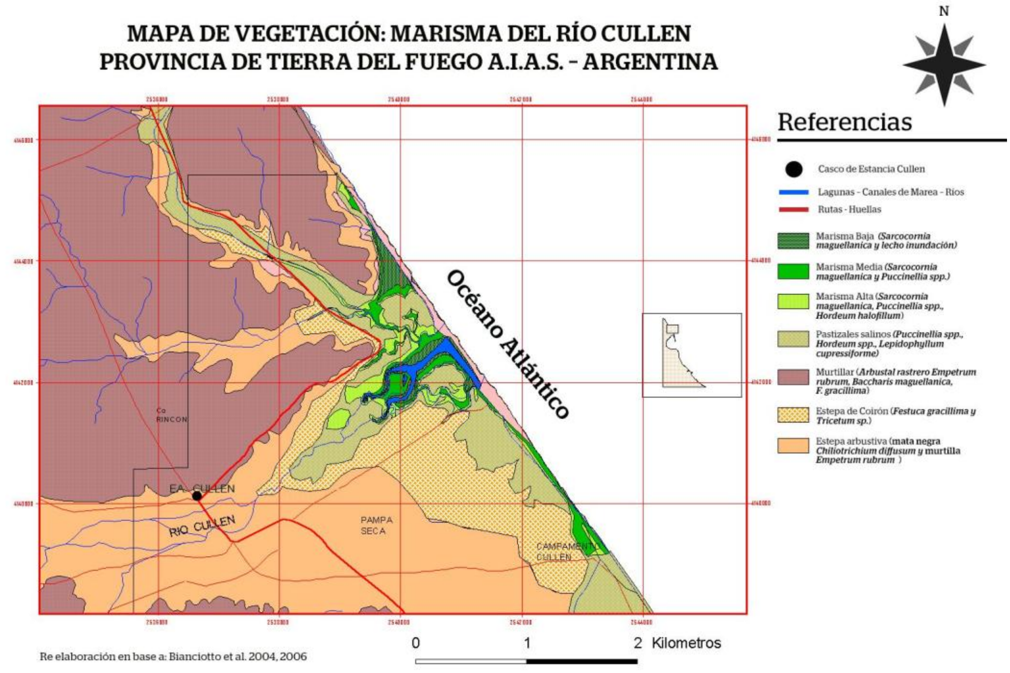

Figura 4: Mapa de la Marisma del Río Cullen en la Provincia de TDF. (Cartografía Alicia Blessio)

Figura 5: a, b y c: a) Marisma Baja de *Salicornia*; b) marisma media y pastizal salino de *Salicornia*, *Puccinellia* y *Lepidophillum* (mata verde); c) Estepa de *Festuca magellanica* y *Chilliotrichum* (coirón y mata negra).

Las marismas del extremo Sur Patagónico (Sur de Santa Cruz y Tierra del Fuego) se ordenan en sectores desde las planicies intermareales en el borde de los océanos o de lagunas, hacia la Estepa Magallánica circundante en una secuencia que puede describirse de la siguiente manera (figura a, b, c):

Marisma baja y canales de mareas: En todo el ámbito de la marisma este sector se encuentra con suelo desnudo dada la presencia de macro-mareas y fuerte erosión, con canales de marea que facilitan el ingreso de agua de mar durante las pleamares. En estos canales la fuerza de la corriente ejerce influencia erosionándolos y penetrando 1,5 km tierra adentro sobre la marisma media y alta. En los bordes de estos canales se desarrollan comunidades casi puras de Salicornia denominadas "Alfombras de Salicornia".

Marismasmedia: *S. magellanica* forma rodales continuos, en especial sobre la rivera del Río Chico donde se instalan comunidades asociadas de Salicornia y Puccinellia que se transforman en manchones más o menos aislados, con forma de rodales circulares de 1 a 2 m de diámetro en planicies más secas e influenciadas por mareas excepcionales.. En este sector de marisma se realizaron los primeros ensayos de calidad de carne en corderos Corriedale en 2004. Son zonas de pastoreo del establecimiento (figura n°5 b).

Marisma Alta y Pastizales Salinos: comunidades de *Puccinellia spp. (P. Magellanica, P. biflora*), asociada o no con *S. magellanica, Hordeum Sp. y Armeria marítima;* forman prados con buena cobertura, que dominan amplias zonas planas de marea, en los suelos Solonchak órtico, que presentan pH entre 7,7 y 8,7 y la salinidad entre 0,8 y 1,5 % NaCl.

Murtillares y Estepas de Coirón: bordean la marisma y se ubican sobre planos de marea antiguos (paleo playas con formas características de semicírculo) y mesetas bajas. El sobrepastoreo de estos ambientes ha generado comunidades con dominancia de *Empetrum rubrum* (murtilla) y matas ralas de *Festuca gracillima* (coirón) con dificultades para competir por los nutrientes en suelos del tipo aridisoles con matriz de arena gruesa, gravas y marcada acidez. Finalmente las serranías de Carmen Silva del Eoceno, con suelos Crioboroles, en general de pH ligeramente alcalinos y pastizales de coirón y mata negra rodean esta depresión marina fluvioglacial (figura n° 5 c).

Situación ambiental de la marisma:

El borde externo de sedimentos correspondientes a planos de marea antiguos con aridisoles y suelos aluvionales donde crecen Murtillares y arbustales de *Chilliotrichum* (mata negra) y *Festuca*, junto a pastizales salinos, sirven de asiento a diversas actividades como urbanizaciones que avanzan sobre marismas medias, con rellenos de áridos, donde se edifican plantas industriales, vertederos de residuos sólidos y cloacales, tratamientos de aceites de descarte, urbanizaciones y minería de petróleo y áridos para la construcción vial y de edificios. Como actividades de menor impacto pueden considerarse la ganadería y la pesca artesanal. Esto ha generado fuertes impactos teniendo en cuenta que se fiscalizan en forma relativa los líquidos de descarte de fábricas o del vertedero.

Estos ambientes salinos relacionados a la costa del Océano Atlántico Sur, el gobierno de la Provincia de Tierra del Fuego A.I.A.S. a generado por ley provincial N° 415, la Reserva Costa Atlántica y Sitio Ramsar (septiembre 1995) que abarca el sector de costa desde Cabo Nombre – extremo norte de Bahía S. Sebastián - hasta la desembocadura del Río Ewan. Esta Reserva tiene 220 km de longitud y 28.600 ha con amplitudes de marea de 6 a 8 m y dejando descubiertas en bajamar, 2 km de playa de barros, limos y restingas. Estas playas alimentan el 40% de las poblaciones de Becasa de Mar (*Limosa haemastica),* Playero Rojizo (*Calidris canutus rufa)* y Playerito Rabadilla Blanca (*Calidris fuscicollis)*[25].

5. **Carhué y los humedales halófitos relacionados a dos lagunas salinas: Epecuén (margen oeste) y campo Bargar (margen sur campo de pastoreo actual)**

El Sistema de las Encadenadas

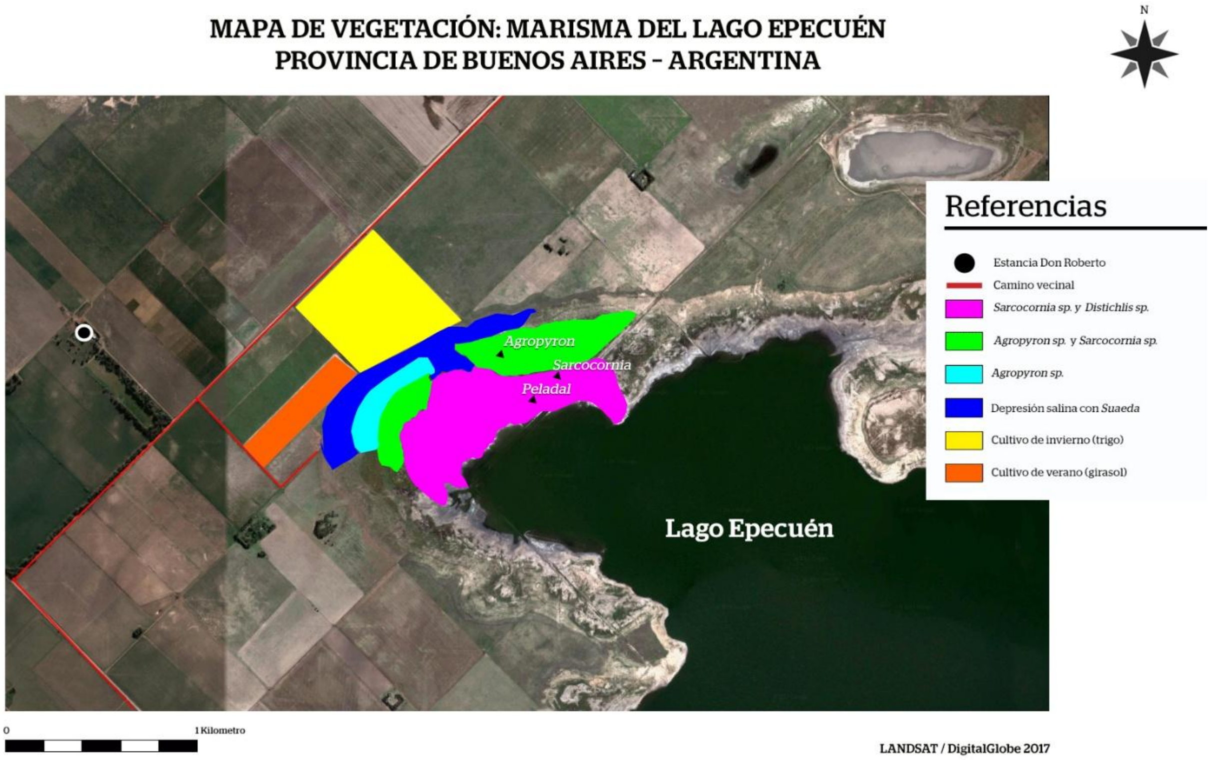

Figura 6: Marisma de la Laguna Epecuén y zonificación de la vegetación. (Elaboración Matias Bianciotto).

En las orillas de la laguna de Epecuén (Lat. S 37° 05' 25,4" Long. W 62° 59' 31,5"), los establecimientos agropecuarios "Don Roberto", de Roberto y César Rolandi, y en el de Horacio Bargar situado a orillas de la laguna del mismo nombre (Figura n° 7); todas de alta salinidad, se desarrolla cría de ganado en pastizales halófitos de *Salicornia neei, Agropyron cristatum y Distichlis sp.*. Con la colaboración del Ing. Jorge Carrizo (Asesor de los Establecimientos) y el INTA Carhué, fue posible relevar sistemas productivos actuales en base a forrajeras nativas e implantadas adaptadas a alta salinidad, en ambientes salinos extremos con influencia de lagunas con contenido alto de sales complejas, superiores al mar (más de 200 g/l).

El área comprende el sistema de lagunas denominadas Las Encadenadas que corresponde a una depresión regional en la que se desarrollaron lagunas en secuencia de sudoeste a noroeste, en su mayoría salobres. Los suelos arenosos y francos en zona de cultivos y montes bajos son profundos (más de 1 m de profundidad) depositado sobre un subsuelo de tosca de origen terciario; en las depresiones de marismas que rodean las lagunas, los suelos son limosos a arcillo-limosos con un horizonte salino de alta concentración de sales[23]. La laguna Epecuén recibe como afluente el arroyo Pigüé. En el suroeste quedan relictos del monte natural de Caldén (*Prosopis caldenia*), remanente de la provincia del Espinal, la diagonal árida de Argentina.

Las zonas salinizadas costeras del sistema lagunar de las Marismas, tienen suelos limosos a limo arcillosos, con pH 8.4 – 9 y conductividad de 14,3 - 53,2 mmhos/cm^2 (salinidad 9 – 34 g/l), se ordenan como: Marisma Baja con pastizales ralos (peladares) de Salicornia, Puccinellia y Distichlis.; Marisma Media con pasturas sembrada de *Agropyron* con *Salicornia* nativa; la salinidad disminuye a niveles entre 9 a 14,3 mmhos/cm^2 (5,7 – 9 g/l); Marisma Alta de Depresiones Salinas cubiertas con *Suaeda y Agropyron* con conductividad de 8,9 mmhos/cm^2 (Figura n.° 7). Los vacunos Aberdeen Angus que pastorean en estas praderas consumen aguas duras de surgencias, con 1140 mg/l de $CaCO_3$ y pH 8 (figura n° 7), muy adaptados a este tipo de aguas muy salinas. Estos animales se alimentan especialmente de *Agropyron y Salicornia*, durante los meses de escasez de pasturas de invierno, para luego darles una alimentación en base a avena y aguas normales de baja salinidad, para la terminación antes de enviarlos a faena. El ambiente salino linda con zonas de cultivos de cereales de invierno y verano, suelos arenosos y francos, y bosques de Caldén (*Prosopis caldenia*).

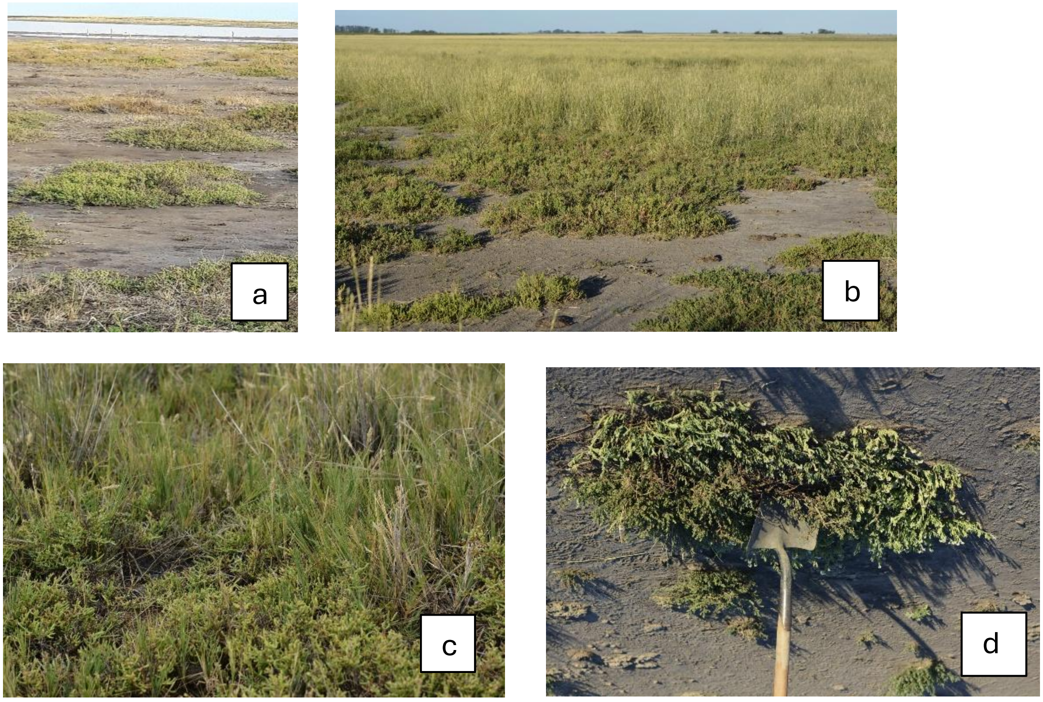

Figura 7: a, b, c, d: a) Marisma baja (Peladar) de *Salicornia neei y Distichlis*; b) y c) Marisma media de *Agropyron, Distichlis* y *Salicornia*; d) Marisma alta con depresiones salinas de *Suaeda, y Salicornia.*

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GLOSARIO

Acidificante: Sustancia que acidifica el medio en que se encuentra, provocando una disminución del pH.

Ácidos grasos esenciales: son el ácido linoleico, el ácido linolénico, y los ácidos grasos omega-3 y omega-6. El cuerpo no los produce por sí solo, por lo que se deben obtener a través de la dieta. Ácidos grasos omega-3 Ácido alfa-linolénico (ALA), Ácido eicosapentaenoico (EPA), Ácido docosahexaenoico (DHA). Ácidos grasos omega-6 Ácido gamma-linolénico (GLA), Ácido dihomo-gamma-linolénico (DGLA), Ácido araquidónico (AA).

Biomasa: Conjunto de la materia orgánica vegetal (hojas, tallo y raíces) y los materiales que proceden de su transformación natural o artificial. En el presente trabajo referido en general al follaje verde de las plantas cortado y pesado (kilogramos o gramos por metro Cuadrado o por hectárea.

cm^2: centímetros cuadrados (medida de superficie resultante de multiplicar largo por ancho de un predio o área).

cm^3: centímetros cúbicos; medida de volumen utilizada para dosificar líquidos (igual a milímetros).

Densidad de siembra o plantación: Número de semillas por metro cuadrado de superficie. O número de plantines por unidad de superficie.

Desmalezado: control (extracción mecánica, manual o eliminación con productos herbicidas) de plantas indeseables (malezas) que invaden el cultivo y compiten por nutrientes, luz y espacio con la especie cultivada.

Edáfico: Relativo a suelo o en relación directa con el tipo de suelo.

Fenología: Es la ciencia que estudia los cambios de los ciclos de los seres vivos en relación a los factores climáticos y cambios de estaciones (primavera – verano – otoño – invierno) a lo largo del ciclo de vida de la planta.

Flores hermafroditas: Son aquellas en donde encontramos órganos masculinos y femeninos en un mismo pie.

Hipoglucémico e hipolipidémico: efectos de disminución de azúcar y grasa en la sangre.

Hidratos de Carbono (Glúcidos): Compuestos orgánicos compuestos principalmente por carbono, hidrógeno y oxígeno. Sus principales funciones son como fuente de energía y estructura de la planta.

Inflorescencia: Inserción de las flores sobre las ramas (manzano) o la extremidad del tallo (tulipán). Pueden ser unifloras (una sola flor – magnolia) o pluriflora (varias flores en racimo: parrilla – cassis; en espiga: trigo).

ºC (grados centígrados): medida de temperatura en la escala Celsius **m^2**: metros cuadrados (medida de superficie = largo por ancho).

Marismas: zonas de encuentro del mar con la tierra, en especial en desembocaduras de ríos al mar. Son ambientes con alta salinidad en estos ecosistemas. También referidas como Salt Flats o depresiones salinas que pueden desarrollarse en lagunas salinas lejanas a las costas, o en altura en la cordillera.

Materia orgánica (Abono orgánico): Fertilizante natural proveniente de la degradación y mineralización de materiales orgánicos (estiércol, desechos de la cocina, pastos incorporados al suelo en estado verde o restos de vegetales en descomposición, etc.).

PH: medida de la acidez o alcalinidad de un líquido o solución acuosa. Las medidas de pH más ácidas son la inferiores a 7 (1 – 6), las más alcalinas son medidas iguales o superiores a 7 (7-10).

Pastizales halófitos: comunidades de pastos compuestas por plantas con alta adaptación a suelos salinos que admiten en el suelo más de 10 gramos por litro de sales.

Plantín: O plántula, es el estado del vegetal durante el período que va entre la germinación de la semilla al trasplante en su lugar definitivo, cuando emergen del suelo el tallo y primeras hojas verdaderas.

Poda: Práctica muy importante en producción frutícola. Consta de la eliminación por corte de ramas viejas o mal formadas, estimulando así el rebrote.

Kg/ha o g/m^2: kilogramos por hectárea (área de medida de 100m por 100m) o gramos por metro Cuadrado.

µm/cm (micromos por centímetro): medida de la salinidad del agua de Riego o del agua del suelo.

Rendimiento: Kilos o gramos de producto cosechado por metro cuadrado de superficie.

Suelo franco: suelo equilibrado en el contenido de arena, arcilla, limo y materia orgánica, en proporciones similares. Es el suelo ideal para cultivos de cualquier tipo, bien aireado, de fácil drenaje (circulación del agua desde la superficie hacia lo profundo del suelo), que facilita la penetración y desarrollo de las raíces.

Salinidad en g/l: (salinidad en gramos por litro) concentración de sales en gramos por litro referido a las aguas de Riego, aguas salinizadas o al agua de mar.

Suelo mal drenado: en general son suelos de cultivo con arcilla a poca profundidad, lo que los vuelve compactos en momentos de baja humedad durante épocas secas o de lluvias escasas. Esto impide la penetración de raíces hacia el subsuelo, además de producir estrangulamiento y muerte de raíces pequeñas al inicio del cultivo. Son suelos propensos a inundaciones (anegamiento) y muerte por asfixia (falta de oxígeno) de las plantas.

Transplante: Es el momento en que el plantín con buen desarrollado de raíz y con dos a cuatro hojas verdaderas, es llevado desde el almácigo a el lugar de cultivo definitivo.