THE BLUE ZONE OF SARDINIA: AN INTERGENERATIONAL EPIDEMIOLOGICAL STUDY ON NUTRITION AND ITS APPLICATION IN PUBLIC HEALTH

ANA CANELADA FERNÁNDEZ

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Since ancient times human beings have sought to prolong their lives in different ways. Up to now, the measures implemented in the field of public health have been the most effective manner by which to achieve said objective. This thesis uses this significant progress as a point of departure and seeks to provide a unifying vision of the traditions of some long-lived populations as an example applicable to present day society.

UNIVERSIDAD
DE MÁLAGA

Public Health and Psychiatry

School of Medicine

University of Malaga

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DOCTORAL THESIS

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Malaga, 2016

UNIVERSIDAD DE MÁLAGA

Departamento de Salud Pública y Psiquiatría

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HEREBY CERTIFIES

That the Doctoral Thesis submitted to the superior judgment of the Tribunal by **Ms. Ana Canelada Fernández** on the subject "The Blue Zone of Sardinia: an intergenerational epidemiological study of nutrition and its application to public health" was carried out under my direction, and is the expression of the author's technical and interpretative capacity, in such outstanding conditions that THEY make her worthy of the Degree of Doctor, provided the Tribunal designated for such purpose by the University of Malaga agrees thereto.

Malaga, 2nd October 2015

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My thanks to Joaquín Fernández Crehuet for having opened for me the doors of the School of Medicine of Malaga. It is a privilege to have been able to undertake this study in the Department of Public Health and Psychiatry, and for that reason hope that my contribution will be useful. I also wish to thank Mario Gutiérrez Bedmar and Antonio García Rodríguez, my thesis Directors, for their faith in my work and their patience regarding the inconvenience of distance required by my research.

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This thesis is dedicated to my daughter Eugenia, to my nephews Koray, Yunus and Egehan, to everyone I love and to Stella, who illuminated the path.

"What's done to children, they will do to society."

Karl Augustus Menninger
Psychiatrist (1893-1990)

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1. INTRODUCTION

1.1 *Blue Zone*, a new paradigm

Since ancient times human beings have sought to prolong their lives in many ways. Up to now, the methods promoted in the field of public health have been the most effective manner by which to achieve said objective. This thesis uses this important progress as a point of departure and seeks to provide a unifying vision of the traditions of some long-lived populations as an example that is applicable to present day society.

The first medical research on general population longevity began in the 1970's with the study of Okinawa. That was the first-time scientific evidence was provided of the existence of such long-lived populations. Validation of said evidence was possible thanks to new technical methods, which permitted verifying in a reliable manner the authenticity of historical population records. The study of Okinawa drew worldwide attention; its nutritional model and lifestyle were described in an informative book, *The Okinawa Program* (Willcox. BJ., 2001), known internationally. In 1999 Sardinia appeared as a place of exceptional male longevity at the *17th World Congress of Gerontology* held in Montpellier. Its discovery is the origin of the concept of *"Blue Zones"*, which is explained below.

From an academic point of view, achieving consensus regarding the causes of healthy aging in areas of extreme longevity is complex. It implies an approximation from many different scientific disciplines, whose reasoning is sometimes contradictory.

It will require more exhaustive multidisciplinary studies to delve into the possible determining factors of the phenomenon of population longevity. Agreement should be reached regarding the genetic, nutritional, psychological, demographic and life-style theories in order to enable pragmatic and feasible measures that could help improve public health measures.

This study seeks, first, to explain the current situation of *Blue Zones* as a health model at an international level, collating available materials. Secondly, the study deals with the *Blue Zone* of Sardinia, focusing on the region of Ogliastra and the village of Villagrande Strisaili, focal point of male longevity. Its nutritional model and lifestyle are analyzed, from the past to the present, with the new generations as the heirs of this valuable legacy and whose practical example can be taken as a model to be applied in public health.

1.1.1 The *Blue Zone* Concept

The concept of *Blue Zone* was introduced at the international level by the journalist Dan Buettner in his article "The Secrets of Living Longer" published by the *National Geographic* magazine in 2005. In the 1970's, the magazine had published research studies on long-lived populations that generated great curiosity amongst its readers, although subsequent scientific studies demonstrated that the data was not accurate. The article published by Dan Buettner created interest and the issue in which it appeared was the third best-selling in the magazine's history. The populations selected for the article had been widely researched and validated. They included Okinawa (Japan), Sardinia (Italy) and Loma Linda (USA). The article did not speak of *Blue Zones*, but just long-lived populations. Later, in 2008 National Geographic published Dan Buettner's book "*Blue*

Zones: Lessons For Living Longer From The People Who've Lived The Longest", in which a new zone was added, namely the Peninsula of Nicoya in Costa Rica. Lastly, in 2009 Ikaria (Greece) was validated, and was included in a second edition of the book published in 2012.

Blue Zone is a term coined by the demographer Michel Poulain and the physician Gianni Pes during the validation of the centenarians of Sardinia. The term was assigned to an area in the central part of the island where a group of exceptionally old persons had been located, which was marked in blue. Subsequently, it was first used in 2004 in an article published by the magazine Experimental *Gerontology* (Poulain M., et al., 2004). The term inspired Dan Buettner to use it in the title of his book.

Blue Zone is a new concept that refers to an area in which there are groups of long-lived individuals in adjacent villages with similar characteristics, in contrast with individual longevity, which is found in different parts of the developed world, in an isolated manner, and which studies on this topic associate with genetic components (Govindaraju D., et al., 2015), (Perls T., et al., 2002).

When we use the expression *"**Longevity Blue Zone"*** we are referring to longevity in connection with a population, which is known as *"Population Longevity"* in the field of research on the determinants of human longevity (Poulain M., et al., 2013).

For the moment, 4 *Blue Zones* have been validated worldwide:

1. The Island of Okinawa, in the southern part of Japan
2. The regions of Ogliastra and Barbagia in the province of Nuoro, in Sardinia
3. The Peninsula of Nicoya, in Costa Rica
4. The Island of Ikaria, in Greece

The concept of *Blue Zone* is based on the certification of the authenticity of the exceptional age of the oldest members of these populations.

At present the validation of a population whose longevity is above the average values observed in the rest of the world requires using historical records, such as birth and death registers, that prove in an exhaustive manner that the members of the population under study are long-lived. In the case of a *Blue Zone,* the validation of exceptional longevity in the population is first based on individual validation, and subsequently on a series of carefully selected indices that reliably reflect the noteworthy lifespan, or *"Population Longevity"* (Poulain M., et al., 2013) of the whole community.

Dan Buettner's book (2008), published again in 2012, analyses five *Blue Zones*; the fifth is Loma Linda, the epicenter of the Seventh Day Adventist Community in California. Michael Poulain, the demographer of the *Blue Zones*, decided not to include it in his academic studies because it did not satisfy the requirements that characterize the term *"Population Longevity".* However, its community model lifestyle may serve as an example of healthy aging and has been widely researched in the US.

1.1.2 Identification and validation of a *Blue Zone*

Sardinia, like Ikaria, was validated by Michel Poulain. Different certification methods were used for Okinawa and Nicoya, following the criteria of their respective demographers (Willcox DC., et al., 2008; Rosero-Bixby L., et al., 2013). The methodology used to certify Sardinia as a Blue *Zone* is explained below:

• *An area was defined* in accordance with the results obtained for the 377 municipalities of the island in previous research entitled Akea, *A Kent Annos*, (Deiana L., et al., 1999), 40 of which, located

in the provinces of Sassari and Nuoro had the greatest prevalence of centenarians.

- At the civil registry, the birth registers of persons born in the last two decades of the 19th century in all municipalities, that is from 1880 to 1900, and the death registers of the last two decades of the 20th century *were selected* to count the number of births and deaths.
- For the persons who *were identified* as having died at the age of 100 or more, their age was verified with the death records and the data was checked with the marginal notes made in the birth registers during the centenarian's life. Marriage and parish records were other important documents used to verify the information.
- The study *continued with the follow-up* of other centenarians who are still living, either in their place of birth or place of residence, by means of the "*anagrafe*" or population register. This is a permanent register in each town or village containing information on the characteristics and evolution of its population, the name of parents, date of birth, marriage, paternity, profession or change of domicile. This information was supplemented with data from the ISTAT (Italian National Institute of Statistics).
- The age of each centenarian was *validated* individually in accordance with the criterion used for long-lived individuals in general.
- The *Extreme Longevity Index* (ELI) (Poulain M., et al., 2004, 2013; Robine JM., 2007) *was used* to identify the areas of maximum population longevity. ELI was defined as the probability that a neonate would reach an age threshold *"x"* in any of the 377 municipalities on the island. In this case the threshold considered for ELI was 100. ELI was calculated as the ratio of the number of centenarians born between 1880 and 1900 and the total number of

births recorded during the same interval in each town or village. The difference of the ELI with respect to simply counting the prevalence of centenarians in a specific location consists in limiting the biases caused by migratory movements. ELI expresses the number of centenarians per 10,000 births and is equivalent to the probability that any person born in a specific town or village may reach the age of 100 there or in any other town or village. It was possible to apply this index in Sardinia because it includes exhaustive population records, such as marginal notes in the birth registers and in the "*anagrafe*" that each town or village regularly updates, making it possible to follow population movements.

- The Gaussian distribution, or smoothing function, *was applied* as a formula to delimit the area where the ELI reaches its highest value, making it possible to observe the spatial concentration of the centenarians as a *continuum* without the limits of the territorial division. An optimum scale was selected for the neighboring territories, in this case 15 km, which enabled establishing a balance between the size of the sample and the variability of the spatial distribution of the centenarians (Poulain M., et al.,2004, 2006, 2013). This method was also applied to divide the 377 municipalities of Sardinia into three different areas that describe a spatial gradient of population longevity: *Blue Zone* of maximum longevity, *BZ* of average longevity and *BZ* of non-existent longevity.

With the results of the validation process, it was possible to identify a mountainous area of Sardinia with a significantly larger proportion of centenarians born in the same location. This area was called a *Blue Zone* (Poulain et al., 2004, 2013).

As of that moment, the concept of *"Longevity Blue Zones"* started to develop, and it is currently defined as follows:

"Areas where the population is characterized by a significantly higher level of longevity in comparison with neighboring regions, provided this exceptional population longevity has been completely validated".

- Determinants of population longevity

Living to be 100 years old is currently considered a possible life expectancy. Gerontologists use the term longevity to refer to persons who live more than 90 years. However, researchers who study longevity usually consider centenarians as the model of reference. Other ages could mark this threshold in the future, as demographically being 100 years old is not in itself a significant value and in view of the fact that life expectancy is in constant evolution (Jeune B., et al., 1999), (Vaupel JW., et al., 1995), (Olshansky SJ., et al., 2005).

Before searching for the determining factors of the extreme longevity of a population, it is essential to validate each individual's age. Subsequently, longevity is verified in the population as a whole, after which the analysis of the determinants of said longevity can begin. At present the populations of the four *Blue Zones* are being studied by different groups of researchers, who are looking for the relevant points that explain the phenomenon (Poulain M., et al., 2013).

In order to find the determining factors of the longevity of a population, the first thing to do is to consider all the characteristics and behaviors that are common to the majority of the inhabitants of each one. The following are the ones that constantly appear in research work on *Blue Zones*:

- *Birth and residence*: the majority of the individuals studied were born and lived in the same place, experiencing the same conditions in early life.
- *Genetics:* they share the same genetic profile, increased due to geographic isolation.
- *Gender, female/male ratio*: the gender difference in life expectancy, or *Longevity Gender Gap,* favors the female sex in developed countries. This is partially due to the fact that men have a greater probability of suffering from cardiovascular disease, certain types of cancer, riskier behavior or accidents during their lifetime. In these countries the woman/man ratio is normally above 4; in other words, there are more than four centenarian women for each centenarian man. In the *Blue Zones,* life expectancy for both sexes mark a difference in connection with their respective countries, as they are more similar at very old ages, with a ratio that is close to 1. The exception is Okinawa, where the ratio is significantly greater in favor of women and is even higher than in the rest of Japan (Poulain M., et al., 2011; Rosero-Bixby L., et al., 2013).
- *Diet:* in all *Blue Zones* the population consumes its own food, or food produced locally: individuals usually have a family vegetable garden, raise animals, and hunt or fish. They also make good use of all available resources, and to a great extent constitute self-sufficient societies.
- *Physical activity:* in general, traditional occupations involved movement, with constant moderate activity.
- *Geographic and climate condition:* moderate climates that allow outdoor activities and optimum solar exposure, sloping land that favors physical activity, which has been considered a positive factor for Sardinia and Ikaria.

- *Lifestyle*: they share the same traditional lifestyles, maintain their customs and celebrations that support their self-esteem and identity.
- *Economic situation:* their stability is mainly based on a local economy of subsistence, with middle or low per capita income, in general lower than that of their respective countries.
- *Social gradient:* the negative effect on health due to social inequality, proposed by R. G. Evans, is not seen in any of the *Blue Zones.*

On the other hand, it was noted that all the *Blue Zones* studied began to develop economically late in comparison with their respective countries, due in part to their geographic isolation. This fact is reflected in lower per capita income, challenging Evans' social gradient theory, which considers that the longevity of a population increases in proportion to economic prosperity (Evans R.G., 1994). Social stratification in the *Blue Zones* is very limited, with a high level of solidarity and cooperation which mitigates the negative effects of social inequality (Rosero-Bixby L., et al., 2009), (Poulain M., et al., 2013). The individuals that are part of these societies possess a strong sense of collective responsibility and feel useful and integrated as they reach old age. These are persons who are aware of the importance of supporting the most vulnerable members of the community. All these societies have an extensive network geared at caring for older persons and children. In the *Blue Zones* elderly persons are well taken care of by family members, usually spouses and children, but also nephews, nieces and grandchildren, which gives rise to a great deal of exchange and interaction between the different generations.

1.1.3 Characteristics of each *Blue Zone*

To describe the individual characteristics of each *Blue Zone*, we will examine the work carried out by the local researchers who addressed the phenomenon from different perspectives, such as genetics, nutrition and lifestyle, amongst others.

- **OKINAWA (JAPAN)**

At an epidemiological level, Okinawa is the best documented *Blue Zone*. Okinawa belongs to an archipelago of 160 islands, called Ryukyu, located to the south-west of Japan and is one of Japan's 47 prefectures. For years it was at the top of the life expectancy ranking in a country like Japan, which has the highest average life expectancy in the world. The estimated population of Okinawa in 2013 was 1,416,587 inhabitants.

In 2008 Okinawa had thirty-five centenarians per 100,000 inhabitants. In 2013 other prefectures such as Nagano exceeded Okinawa in longevity, always with a clear female advantage. At present Japanese women live an average of 7 years more than men.

The research of Okinawa began in 1976, and the demographic methods used to validate the age of these long-lived individuals (Willcox DC., et al., 2008) are explained in Michel Poulain's article *"The Blue Zones: Areas of exceptional longevity around the world"*, 2013.

GEOGRAPHICAL CHARACTERISTICS	
(Information from 2013)	
Area (km^2)	2,271
Population	1,416,587
Density (population/km^2)	622
Mid-latitude	26º N
Altitude	Sea level
Gradient	Low
Proximity to the sea	Yes
Climate	Subtropical

Health and lifestyle indicators

Daily calorie intake (Kcal.)	~2,000
Obesity index (% BMI+30)	10-40
Religion	Shinto

Since 1976, "*The Okinawa Centenarian Study*" has investigated the factors of the extreme longevity of its inhabitants, which are the following:

- ***Genetics***: the HLA (*Human Leukocyte Antigen*) polymorphism DR1 was analyzed in 348 families of centenarians of Okinawa in 2006. The study of nonagenarians revealed a greater frequency of the HLA DR1 allele, analysis of which indicates a possible reduction of the risk of inflammatory, infectious, and autoimmune diseases. A subsequent analysis of 129 centenarians in contrast with a control group also revealed a high frequency of this polymorphism. The FOXO3A gene has also been associated to longevity in different populations and in Okinawa common variations (guanine base) of this gene were found associated to healthy aging

phenotypes. In addition, the inhabitants of Okinawa are genetically different from the Japanese, showing characteristics of a genetically isolated population. This isolation reduces the variables of its genetic pool (Bendjilali N., et al., 2014), which may favor the selection of the genes connected to longevity (Willcox DC., et al., 2006; 2008), (Willcox BJ., et al., 2006; 2008).

- ***Gender*:** the female/male ratio in longevous ages over 90 shows a significant advantage for the female gender, distancing itself from the other *Blue Zones.* The gender gap in respect to life expectancy in Okinawa is one of the highest of Japan, namely 8.23 years longer for women in 1975 (Willcox DC., et al., 2012). For the year 2000 Rosero-Bixby calculated that life expectancy from the age of 60 was 29.3 for a woman in Okinawa and 22.1 for a man, and that the probability of becoming a centenarian was 9.3 % and 2.1 % respectively. The female ratio was 4.4 (Rosero-Bixby L., et al., 2013). In 2005 the men of Okinawa were, in respect to women, twice as likely to die at any age due to the main causes of disease such as cancer and vascular problems (Willcox DC., et al., 2012).
- ***Diet*:** there are two factors in connection with diet:
    1. *Calorie restriction:* The low intake of calories and low body mass index of the inhabitants of Okinawa are, according to the experts, determining factors of their longevity (Willcox DC., et al., 2006; 2009), (Willcox BJ., et al., 2014). This hypothesis has generated a major controversy amongst researchers, who warn of the possible negative consequences for future generations (Le Bourg E., 2005, 2012).
    2. *A diet rich in phytonutrients*: Prior to World War II, purple sweet potatoes traditionally entailed 93% of the basic diet, according to the calculations made for the "*Okinawan*

Centenarian Study" (Willcox DC., et al., 2011), a much higher percentage than for the rest of Japan. Purple sweet potatoes are speculated to be a functional healthy food, rich in minerals and vitamins, that was studied by the island's research team (Willcox DC., et al., 2005). Other products that form part of the diet of Okinawa are green leafy vegetables, bitter melon (Cucurbitaceae), pumpkin, okra (mallow), soya and its fermented derivatives, marine algae, ginger and turmeric rhizomes, burdock and daikon, or oriental radish, and drinks such as green tea and jasmine to accompany meals, as well as millet liquor as a digestive. In respect to proteins of animal origin, they consume eggs, fish and meat, of which pork is the most esteemed. In their traditional cooking a large number of recipes call for pork meat and pork's fat, also used to conserve foods (Sho H., 2001)

Following World War II, the people of Okinawa modified their diet due to US and Japanese influence. At that time the population was exposed to both diets, namely the traditional one and the transitional one, which initially benefited their health due to the increase in nutrients. Little by little the traditional foods, such as sweet potatoes, were replaced by canned meat from the US and rice from Japan (Todoriki H., et al., 2004). Due to globalization, postwar generations were exposed to the westernization of their lifestyle, which may be associated to the decrease of longevity observed in Okinawa in 2010 with respect to the rest of Japan. This tendency began at the end of the 20th century and suggest complex processes and not only westernization of the diet.

- ***Environmental factors**:* Climate has been considered a determining cause of longevity on the island, as well as the surroundings and environmental conditions with a low level of pollution. The inhabitants of Okinawa enjoy outdoor life in a moderate climate and with their own plots of land suited for agricultural activities. According to the researchers, this would account for the probability of surviving between the ages of 70 and 100 by more than 40% (Robine JM., et al., 2012).
- ***Socio-cultural factors:*** Particularly noteworthy is the degree of social integration of the elderly (Willcox DC., et al., 2007) and the excellent quality of intergenerational relationships, a characteristic of all *Blue Zones*. There are multiple social activities with childhood friends, who help each other throughout their lives *(Moai)* (Willcox BJ., et al., 2013). Women transmit respect for ancestors and their values, the foundations of Shinto. Emphasis on venerating ancestors gives the community a sense of belonging and continuity with the past. The numerous festivities, or *"Umachi",* during the year consist of family reunions to honor ancestors, at which traditional food and drinks are served. Great importance is given to the food served, which is a compendium of the Polynesian, Chinese and Japanese cultures that have influenced the island and are considered a source of longevity. The dishes consist mainly of pork meat, sweet potatoes, spices, medicinal plants, algae and fish (Sho H., 2001).
- ***Lifestyle and physical activity:*** Every day the centenarians work in the family vegetable garden and do collective gymnastics in public parks. In addition, a study carried out by Goto (Goto A., et al., 2013) starting in 1987 and extending for a period of 12 years, with 724 individuals older than 65 in Ohgimi (Okinawa), showed that sleeping less than 6 hours and being socially isolated has a negative

influence on life expectancy. Most of the centenarians on the island have good sleeping habits, including naps, which have also been consider a factor of longevity (Uezu E., et al., 2000).

- ***Socioeconomic conditions and social gradient:*** Okinawa is the poorest prefecture in Japan, with the country's lowest per capita income. The main occupations on the island are fishing, agriculture and small businesses. In respect to the negative effect of the social gradient, Okinawa is an exception to Evans' theory (Evans R.G., et al., 1994). This is partially due to the fact that the island's inhabitants have a strong sense of collective identity and pride as a Polynesian ethnic group, which sets them apart from the rest of Japan. Despite their economic disadvantages, they have a social hierarchy that is more equalitarian than that of the other Japanese, and an efficient social and family support network which contributes to a significant reduction of stress (Cockerham W.C., et al., 2001).

➢ THE NICOYA PENINSULA (COSTA RICA)

The Nicoya Peninsula is located in the northeastern part of Costa Rica. It includes part of the province of Guanacaste and part of the province of Punta Arenas in the south. The cantons that stand out for their longevity are Carrillo, Santa Cruz, Nicoya, Hojancha and Nandayure, which belong to Guanacaste (see map) and in 2011 had a population of 161,000 inhabitants, 47% of which lived in urban areas, in cities of 25,000 inhabitants such as Nicoya, Santa Cruz and Philadelphia.

The male death rate in the Nicoya Peninsula is 20% lower than in the rest of the country. In 2013 men in Costa Rica had an average life expectancy of 77.3 years in comparison with 76 years in the US. The probability that a man from Nicoya become centenarian is 7 times greater than that of a Japanese man, and the former's life expectancy is 2.2. years greater. This fact is controversial from a demographic point of view, which considers that longevity increases with economic development, whereas Costa Rica continues to be a developing country. However, the longevity of the peninsula of Nicoya has been thoroughly validated by Rosero Bixby's research team (Rosero-Bixby L., et al., 2013). The increase of life expectancy is due to the social policies initiated in the decade of the 1950's in Costa Rica, culminating with the creation of a universal public health system in the 1970s. The entire process is documented in Rosero-Bixby's articles (Rosero-Bixby L., et al., 2005; Rosero-Bixby L., 1985, 2004).

GEOGRAPHICAL CHARACTERISTICS Information from the province of Guanacaste (2011)	
Area (km^2)	10,141
Population	326,953
Density (population/km^2)	32
Mid-latitude	10º N
Altitude	Medium-to-low
Gradient	Average
Proximity to the sea	Yes
Climate	Tropical

Health and lifestyle indicators

Daily calorie intake (Kcal.)	~2,400
Obesity intake (% BMI+30)	23.6
Religion	Christianity

The following factors of the longevous population of Nicoya have been studied:

- ***Genetics:*** The length of the telomeres of the inhabitants of the Nicoya Peninsula is greater than that of the population of Costa Rica (Rehkopf D., et al., 2013, 2014). The results of the CRELES study (Costa Rica: Longitudinal Study of Healthy Aging), in which different biomedical markers were considered, showed a significant difference in the height of the inhabitants of Nicoya with respect to the rest of the country, and which is higher than the average of Costa Rica. These results suggest that the inhabitants of Nicoya had better intrauterine and childhood growth and development because of better nutrition and lower incidence of infectious diseases. On the other hand, the biological markers showed that the inhabitants of

Nicoya of both sexes had lower levels of motor disability, of cognitive deterioration and stress. They also showed lower levels than the rest of the population for cardiovascular risks. The levels of the DHEAS hormone were significantly higher. This marker is closely associated to aging, so that its association with longer telomeres suggests a slower aging process in this population (Rosero-Bixby L., et al., 2012, 2013).

- ***Gender:*** According to the 2011 census, the so-called female/male *sex ratio* is 1.2 for ages over 90, compared with 1.5 for the rest of Costa Rica. The male advantage with respect to the rest of the country is due to extraordinary male survival and not to the female disadvantage. Starting at the age of 60, the life expectancy of a man on the Nicoya Peninsula is on average 24.3 years, a figure above the average of developed countries (Rosero-Bixby L., et al., 2013).
- ***Diet:*** According to R. Bixby, it is an "*ordinary diet*", typical of Central America, based on rice, beans and nixtamalized corn (chemical process applied to the grain consisting of heating it in an alkaline medium and subsequently letting the grain rest in the liquid mixture). This procedure enriches the corn with minerals, such as calcium.

  Large consumption of fruit: bananas, plantains, papayas, pineapples and pejibayes, a very popular indigenous fruit rich in vitamin C. The vegetables that are eaten the most are the following: pumpkin, yucca, squash, potatoes, avocadoes, palm hearts, tomatoes, and chili peppers. Coffee is a common drink, sweetened with sugar or Meliponini honey.

  Animal protein: the population of Nicoya differs from the rest of the country due to a greater consumption of calories and of animal protein: beef, pork, eggs, fowls, Turrialba cheese, fresh

curd and cottage cheese. The Nicoya Peninsula also stands out for the quality of the fish and shellfish. The inhabitants of Nicoya consume 3 grams more of protein that the average of the country, which is 70 grams per day. Their diet is characterized by a low glycemic index, which is one point lower than the national average of 76 percentage points. It has high fiber content, one gram more per day than the average, which is 23 grams. The fat intake of the inhabitants of Nicoya is equivalent to the rest of Costa Rica, although consumption of animal fat is higher, using pork fat for cooking. The body mass index is lower than in the rest of the country (Rosero-Bixby L., et al., 2013).

- ***Environmental factors*:** Nicoya is one of the driest areas of the country, with altitudes ranging from 100 to 500 meters. It is oriented towards the Pacific Ocean and has a more moderate climate, with two seasons and an average temperature ranging from 22 to 36 degrees centigrade. Its ecosystem, with dry forests and pastures, allows for beef cattle breeding, the most extended activity in the area (Rosero-Bixby L., et al., 2013). Another noteworthy element is the drinking water, which contains a high level of calcium and magnesium that can prevent heart disease and osteoporosis (Buettner D., 2008).
- ***Lifestyle and occupation*:** Less physical and cognitive deterioration was observed in the inhabitants of Nicoya, which is related to their outdoor activities during all their life. They are engaged in cattle farming and are called "sabaneros", (Rosero-Bixby L., 2008). The longevity of the inhabitants of Nicoya has been linked to their lack of stress and large amount of daily physical activity, as shown in the studies carried out in 2010 by Cassidy (Cassidy A., et al., 2010).

- ***Socioeconomic conditions and social gradient:*** In the Nicoya Peninsula there is a free and efficient system of public health and social security guaranteed by the government, which abolished the army in 1949 and established a policy of social equality and development. Starting at that time, the government focused its budgets on education and public health (Cadwell JC., 1986), (Rehkopf D., et al., 2010). The Nicoya Peninsula is isolated due to its geographic location, which has fostered, like in the other *Blue Zones*, strong social cohesion that is reflected in certain demographic indicators, such as the level of suicide, which is one of the lowest of Costa Rica (Granados-Bloise D., 1998). In Costa Rica the influence of the socioeconomic gradient or educational level is not observed after the age of 60, according to an epidemiological study carried out over a 17-year period (Rosero- Bixby L., et al., 2005), (Dow WH., et al. 2010).

➢ IKARIA (GREECE)

Ikaria is an island located in the Aegean Sea, with a population of about 8,000 inhabitants. It has one of the highest life expectancies of Greece, which in 2013 was 78 years of age for men and 84 for women.

More than 30% of the inhabitants of the Island of Ikaria reach a life expectancy of 90, in comparison with the rest of Greece, with 5%, whereas more than 1% of the population lives beyond that age. Average mortality due to natural causes is about 10 years above the world average, including Greece. Researchers administered a population survey to assess the levels of cardiovascular risk with the objective of discovering the secret of longevity in Ikaria (Stefanadis CI., 2011).

The study of the island of Ikaria is similar to epidemiological studies such as EPIC (*European Prospective Investigation into Cancer and Nutrition*) and HALE (*Healthy Ageing Longitudinal Study in Europe*). In 2009 the island had 8,312 inhabitants, of which a cohort of 1,430 persons was selected for the study, 343 men and 330 women aged 65 to 100, whereas the other 657 were under the age of 65 (Stefanadis CI., 2011). According to the University of Athens research team, the cohort studied shows a strong adherence to the Mediterranean diet (Chrysohoou C., et al., 2013) and low levels of hypertension (Panagiotakos DB., et al., 2011).

GEOGRAPHICAL CHARACTERISTICS (2011)	
Area (km^2)	255
Population	10,385
Density (population/km^2)	33
Mid-latituds	37º N
Altitude	Medium-to-high
Gradient	High
Proximity to the sea	Yes
Climate	Mediterranean

Health and lifestyle indicators

Daily calorie intake (kcal)	~2,000
Obesity index (% BMI+30)	12.5
Religion	Orthodox Christians

The following factors of longevity were analyzed:

- ***Genetics:*** The study of Ikaria, led by cardiologists from the University of Athens, did not research genetic factors. Nonetheless, it was noted that the parents of the most longevous cohort had died at a very old age for their times, namely 76 years of age for the father and 80 for the mother, which is closed to current life expectancy in Greece. This fact is significant, considering that at that time life expectancy was about 50/55 years of age, which suggests a hereditary component that has yet to be researched.

- ***Gender*:** The female/male ratio is more balanced than for the rest of Greece. According to the data collected in 2010 by the "*Ikaria Study*", it is 1.1, slightly more favorable for women over the age of 80, in other words 90 men for every 100 women. Here again, the advantage is due to greater male longevity and not to a disadvantage for women (Panagiotakos DB., et al., 2011).
- ***Diet:*** The inhabitants of Ikaria follow a version of the Mediterranean diet. It includes a wide variety of vegetables and edible native plants collected all year round, more than 100 varieties including dandelion, purslane, chicory, salsify, sorrel, arugula, redroot pigweed, chervil, borage, common mallow, cardoon, or nettle. The tradition is to boil these green leafy vegetables called "horta" before eating them, and then to drink the left-over vegetable stock during the day like an infusion, to which lemon, a common seasoning for food and drinks, is added. Herbal teas are used widely: sage, wild oregano, olive leaf, rosemary, marjoram, mint and mountain tea (Canelada A., field work 2009, 2010, 2012).

  Consumption of olive oil and olives is extended all over the island. The most common root vegetables are potatoes. Chickpeas and a local variety of black eye beans are the most common legumes. Seasonal vegetables are like those grown in other areas of the Mediterranean (Chrysohoou C., et al., 2013).

  Animal protein comes greatly from goat breeding, which is a fundamental part of the island's economy. Poultry, rabbit and pork meat are regularly consumed, in line with neighbors' Mediterranean countries. Milk and its derivatives mainly come from goats and sheep, such as feta cheese. The consumption of fish is significant along the coast and the population study shows that it has positive effects on the inhabitant's mental capacity,

with a low incidence of dementia and prevention of depression (Chrysohoou C., et al., 2009). There is an important number of long-lived individuals around Raches in the central-western part of the island. In these areas of the interior, the main activities are apiculture, viticulture, and stockbreeding. The quality of the honey is extraordinary, made from the ample Mediterranean flora and from trees such as the autochthonous pine. This variety of pine's honey is produced by the bees using the honeydew excreted by the aphids that reproduce in the tree (dark colored, with the taste of resin and balsamic and antiseptic medicinal properties (Canelada A., field work 2009, 2010, 2012). Consumption of homemade wine is standard, but consumption of Greek coffee is much greater: 339 ml/day versus 186 ml/day of wine, reason why the Athens team studied coffee as a factor of longevity (Siassos G., 2013).

- ***Environmental factors:*** The orography of the island of Ikaria is steep, crossed lengthwise by a mountain range formed exclusively of schist metamorphic rock. It has 8 springs of radioactive, salt and hyperthermal waters (49.5º C) that flow to the sea and are used for therapeutic-medicinal purposes. There is a spa in the city of Therma and natural wells in the sea for public use. Ikaria has a large volume of drinking water due to its tectonic structure, with abundant high-quality aquifers and natural springs. All municipalities have good water supplies, with many additional sources for irrigation. The island's plant biodiversity, with numerous indigenous plants, is protected by the Greek government due to its risk of extinction.
- ***Lifestyle****:* Most of the inhabitants have a traditional lifestyle and eat their meals with the family. Daily occupations involve physical activity, which increases due to the features of the terrain. The lifestyle could explain that even though some members of the

group studied have high risk factors (tobacco/alcohol) for cardiovascular disease and cancer, they are protected and do not show dysfunctions of the endothelium in old age (Panagiotakos DB., et al., 2011), (Oikonomou E., et al., 2011). Other noteworthy characteristics are the lack of stress and a tolerant and flexible attitude. The daily nap is one of their "secrets of longevity"

- ***Socioeconomic conditions:*** There is great cohesion and social commitment; solidarity is an idiosyncratic feature of the inhabitants of Ikaria. Their survival is based to a large extent on their altruism. An example of their extraordinary character is how they overcame the terrible events occurred there in the World War II, later on the assimilation into their society of the 13,000 communists exiled by the Greek government following the civil war and subsequent military dictatorship in Greece.

One half of the sample studied declared having a low level of income, and some stated they did not have a pension. In these cases, their needs were covered by the community, or that they lived with their families (Chrysohoou C., et al., 2009). A significant fact is that 3.3% of the men and 4.1% of the women continue to work voluntarily at old ages. This is illustrated by the example of a 95-year-old resident of Evdilos, who despite having had a leg amputated in World War II, diligently took care of two businesses he owned and proudly showed his library of classical books (Poulain M., Canelada A., interviews to the oldest inhabitants of the island during the certification of Ikaria as a *Blue Zone* in 2009 and follow-up in 2012). The influence of the social gradient is not detected here, there is not differentiation between social classes, it is almost non-existent. The solidarity between the inhabitants reduces their level of psychological stress and the risk of physical and mental disease, the incidence of depression in Ikaria is minimal (Panagiotakos DB., et al., 2011).

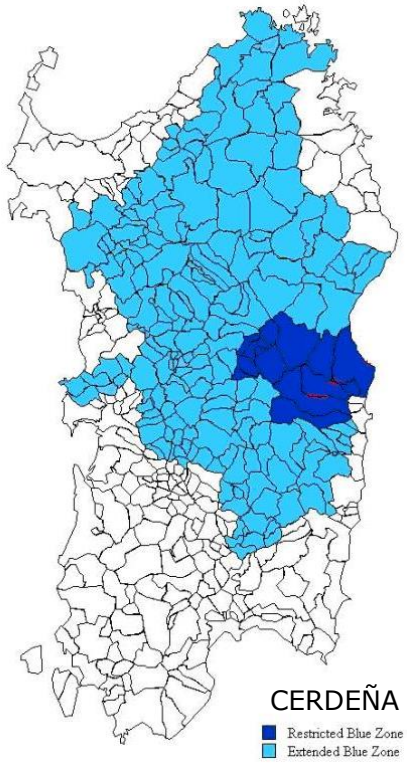
➢ SARDINIA (ITALY)

The *Blue Zone* of Sardinia is mainly located in the region of Ogliastra. The areas of longevity correspond to municipalities located around the mountains of Gennargentu, the highest peak reaching a height of 1,834 m. The epicenter of the area is Villagrande Strisaili in Ogliastra, from which a geographic gradient of longevity extends to other regions such as Barbagia and Nuoro and includes 14 municipalities. The validation of the centenarians of Sardinia reveals the exceptional male longevity of the area and importantly gender equality with respect to survival. This population has remained isolated for centuries, which has contributed to the stabilization of its genetic pool (Bonafé M., et al., 1999) and to the preservation of socio-cultural aspects during its entire history. In 2014 an increase of the population in the region of Ogliastra was observed in comparison with 2011, with a total of 57,642 registered inhabitants.

The validation of Sardinia as a *Blue Zone* was certified 100% by the demographer Michel Poulain.

The island of Sardinia is the origin of the concept. After the demographic work the research of the determinants of its longevity has focused on genetics and lifestyle.

GEOGRAPHICAL CHARACTERISTICS	
Information from the region of Ogliastra (2011)	
Area (km^2)	1,559
Population	57,349
Density (population/km^2)	31
Mid-latitude	39º N
Altitude	Medium-to-high
Gradient	High
Proximity to the sea	Yes
Climate	Mediterranean



Health and lifestyle indicators

Daily calorie intake (kcal) ~2,600

Obesity index (% BMI+30) 8.7

Religion Catholic Christianity

The factors of longevity observed include the following:

- ***Genetics:*** Considering the circumstances of their general isolation, the polymorphism of chromosome Y was analyzed to identify variables that could explain the prevalence of male longevity in Sardinia and the genetic structure of the Sardinian population (Passarino G., et al., 2001). Regulation of cytokine, their genetic polymorphisms, and the frequency of production of interleukin 10 (IL10), given its anti-inflammatory action and its association with

longevity in other areas of Italy (Pes GM., et al., 2004), were analyzed. The influence of HLA-DR alleles on the longevity of the area was also analyzed since the high frequency of the HDL-DR1 is thought to be associated with protection from infectious diseases. In the study of Sardinia researchers considered that these genes favored survival, but did not explain longevity (Lio D., et al., 2003). Neither of these markers have demonstrated, in terms of frequency, significant divergence in respect to the population of Sardinia in general, which may indicate that other factors such as nutrition and lifestyle may have intervened at an epigenetic level in the improvement of life expectancy.

- ***Gender:*** The female/male ratio for Villagrande Strisaili was calculated based on the percentage of nonagenarians of the cohort born between 1876 and 1912, which is 10.7% for men and 11.4 % for women. The equality of the ratio (1.06) is considered exceptional with respect to the rest of Italy. This exceptionality is due to a larger number of men reaching a higher life expectancy (Poulain M., et al., 2011) and not to the disadvantage of women which are also long lived.
- ***Diet:*** The role of traditional food is essential to understand this society. The diet is influenced by the local economy, based on sheep and goat breeding (Carbini L., 1998), which occupies 66% of the island's territory. Dairy products are its distinguishing feature (Geo nº 417, French edition, 2013).
- ***Environmental factors, occupation and lifestyle:*** The geographic characteristics are marked by the inclination of the terrain of the mountainous areas in which the longevous populations are located. One of the characteristics of the Gennargentu Mountains is the abundance of water from the springs located in the bordering villages and in the shelters for shepherds. Physical activity is linked

to the activity of transhumant grazing. Covering long distances every day, together with the average slopes of the area, are variables that have been considered as factors of longevity (Poulain M., Pes GM., Canelada A., field work in the archives of the Municipality of Villagrande, interviews with shepherds and their families in 2011, 2012,2013,2014) (Pes GM., et al., 2011).

- ***Socio-cultural factors and the socioeconomic gradient:***

Economic development began in Sardinia in the mid-20th century, largely because of the Italian government, going from extreme poverty to a relative material wellbeing with limited social stratification. The absence of a clear class gradient between the mountain populations, devoted to traditional activities, together with the lack of social competitiveness and of stress that characterizes this society, have created more favorable conditions for individual health compared to the populations living on the mainland (Poulain M., et al., 2013).

1.1.4 "Vitality Cities/Blue Zones Project ®"

D. Buettner's book "*Blue Zones*: *Lessons For Living Longer From The People Who've Lived The Longest*", published in 2008 by National Geographic, interested Americans and drew the curiosity of academics, such as the cardiologist L. Appel (Appe L., 2008), who in his article "*Dietary Patterns and Longevity: Expanding the Blue Zones*" expressed the wish that *Blue Zones* be common all over the world. D. Buettner's book attained great popularity, which led to the development of the first pilot project to recreate a *Blue Zone*. The location chosen for the project due to its demographic suitability was Albert Lea, in Minnesota, the state where Buettner lives. The project was sponsored by the AARP *(American Association of Retired Persons),* local authorities and received the support of the University of Minnesota. Very competent professionals specialized in the new concept of healthy city were also recruited.

The *Blue Zones* Project promotes health in a commercial format. The *Vitality Cities* use business and market logistics techniques to administer public health in the locations selected. In theory, the formula enables individuals to be responsible for their health and to manage it, interacting and using new media technology. The *Beach Cities* in California are an example of an easy transformation into *Vitality Cities*, since there is a Californian target population with high economic level and great awareness regarding health matters, which also attracts young entrepreneurs.
(Canelada A., field work in collaboration with the Beach Cities Health District 2012)

According to the sociologist D. Carter (Carter D., 2015), the "*Blue Zones Project"* uses many mechanisms typical of neoliberal policies: public-private association, and competitiveness between

participating communities to obtain public funds. This entails the decentralization of the health system, transferring competencies to the local level. It also benefits from the corporate sponsorship of public projects to promote its brand. The emphasis falls on the citizens to adopt healthy behaviors by means of different changes in the local environment.

At present the states that are participating in the *Blue Zones* project are Minnesota, California, Iowa, Hawaii, Texas and Florida, and the list keeps growing. For the time being the project is only being applied in the United States.

Dan Buettner selected 9 principles, extracted from his book *Bluezones: Lessons For Living Longer From The People Who Leaves The Longest*, to explain the longevity of this areas of the world. These are the model on which the *Vitality Cities project* is based on and are the result of integrating different characteristics of all the *Blue Zones* in a journalistic, subjective, informative style.

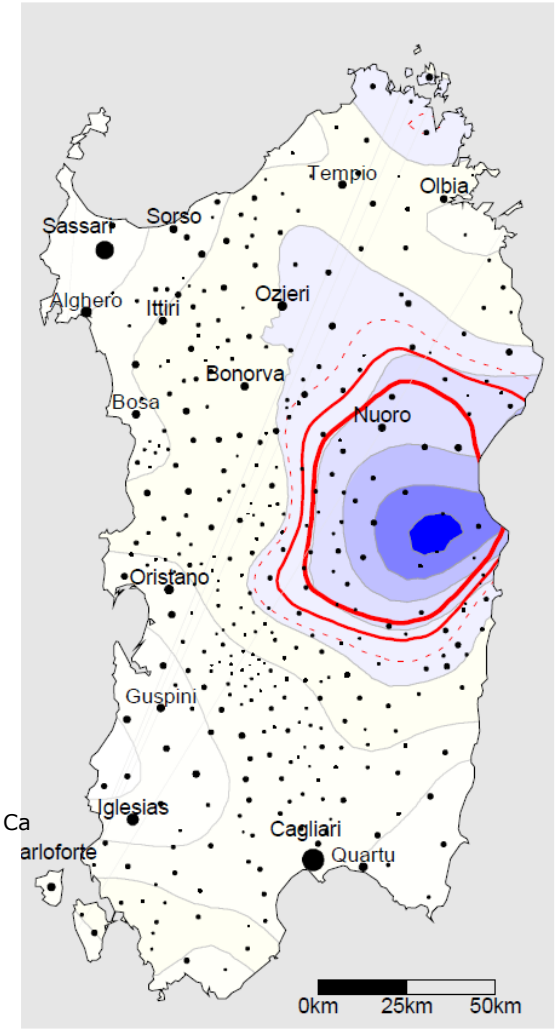
The origin and the relevance, according to the author, of these 9 principles in each one of the *Blue Zones*, are express in parenthesis as follows:

- *Move in a natural manner* ***(all Blue Zones)***
- *Reduce stress* ***(all Blue Zones)***
- *Have a purpose in life: "Ikigai"* ***(Okinawa)***
- *Reduce calorie intake: "Hara hachi bu", only eat until you are 80% full* ***(Okinawa)***
- *Eat a diet mainly of plant origin (95%): cereals, legumes, vegetables and fruit: "plant slant"* ***(all Blue Zones)***
- *Drink wine with all meals: "wine at five"* ***(Ikaria/Sardinia)***
- *Have religious beliefs and practices* ***(all Blue Zones)***
- *Prioritize the family and social cohesion* ***(all Blue Zones)***
- *Choose the right friends: "Moai"* ***(Okinawa)***

D. Buettner published another book with *National Geographic*, *"The Blue Zones Solution",* in which he describes the characteristics of the diet of each Blue Zone in accordance with his journalistic work and summarizes the experience of the *Blue Zones Project*® (Buettner D., 2015).

1.2 Sardinia, nutritional study of a *Blue Zone*

The identification of a point of exceptional longevity, or *Blue Zone*, in Ogliastra, a well delimited population in the mountains of Sardinia, led to this present study, which is the first historical revision carried out of the eating habits of the *Blue Zone* population of Sardinia. It is based on epidemiological studies of former hygienist physicians and of the main authors in each period **(Table A).**



The darkest blue area marks the *Blue Zone,* the epicenter of longevity in the region of Ogliastra.

Map (Poulain M; et al; 2004).

Until recently, the populations of the Sardinian *Blue Zone* depended to a large extent on stockbreeding (sheep and goats) and

their main economy consisted of transhumant grazing. Hence consumption of food of animal origin, particularly of dairy products, was proportionally much higher than in the rest of the island.

The nutrition transition in urbanized areas and in the lowlands of Sardinia began in the middle of the 1950s, driven by economic development. In the shepherding areas like Ogliastra region, which is a *Blue Zone*, this process began later owing to inhabitants' resistance to change, given that they belonged to a society organized around an efficient and stable pastoral economy.

Even at present a large part of the population of this area of the mountains, the center of which is Villagrande Strisaili, continues to exercise the same activity and eat the same traditional diet, based on local cereals, autochthonous legumes, mountain vegetables, stockbreeding and sheep and goat milk dairy products.

The following paragraphs contain a chronological description of the diet of longevous men and their families, distinguishing the population groups by occupation and gender. In addition, dietary changes during the nutrition transition are shown, and the most specific foods of their diet are listed.

Finally, a present-day study is provided, comparing the dietary habits of school children in Villagrande Strisaili with those of an urban location, Sassari, to verify whether the advantages observed in the past are still maintained in the new generations in this epicenter of longevity.

1.2.1 Pretransition history, from the end of the 19th century to the 1950s

Sardinia remained isolated, with a small population due to the convergence of several factors, including lack of sanitation, endemic malaria and lack of effective exploitation of its territory in previous centuries (Sanna E., 2006).

In the past, different foreign powers tried to colonize the island, including Spain, but never succeeded in penetrating beyond the coastal areas where the land was exploited under a feudal system. A considerable proportion of the native population was obliged to seek refuge in the central mountains, the *Blue Zone*, where they developed their own culture (Angioni G., 1982).

This mountain population considered "barbarian" by the Romans, which is the origin of the name Barbagia given to this interior part of the island, remained relatively independent and developed its own traditions and food resources, based mainly on stockbreeding, which have continued to the present. In contrast, the inhabitants of the plains and the coast continued the agricultural traditions of the Roman Empire, for which the island has been famous as a major supplier of cereals for the Italian peninsula (Garnsey P., 1988).

Little is known about the basic diet of Sardinia until the middle of the 19th century, except for dispersed information found in legal documents known as *Condaghes* drafted in the monasteries (Segreti A., 1992) or included in the report of the Spanish viceroys (Delitalia E., 1982). Although the first detailed description of the diet of the populations of Sardinia is found starting in the middle of the 19th century in the work of Angius (Angius S., 1842), it is only in the first half of the 20th century that nutritional reports have a standard

scientific basis for their analysis (Lissia S., 1903; Peretti G., 1943; Le Lannou M., 1941).

As mentioned by the French geographer Le Lannou (Le Lannou M., 1941), the traditional diet of Sardinia was scarcer in the farming areas, where there was extensive poverty amongst a large part of the population, with the absence of market exchanges. According to Peretti (Peretti G., 1943), the main discrepancy between the lowlands and the inhabitants of the mountains, who were essentially shepherds, was the larger consumption of foods of animal origin by the mountain inhabitants **(Table 1A, Table 2 and Figure 2).**

Up until the nutrition transition, the traditional economy favored to a large extent the consumption of local products. The main foods consisted of cereals, basically wheat and barley, as well as legumes, potatoes and dairy products in the grazing areas. See the comparison of the grazing area with the rest of Sardinia **(Table 1B)**.

Two foods of vital importance were widely consumed all over the island: sourdough-leavened bread and vegetable soup or *minestrone* made with green beans, fava beans and potatoes (Tessier S., et al., 2005). In the mountain areas of Ogliastra, the center of grazing, *minestrone* also included bacon (Angius V., 1842).

Prior to the nutrition transition, fresh fruit was generally consumed in small quantities. It is important to note that cultivating fruit trees did not become extensive until after World War II. Seasonal fruit, such as figs, pears and apples, were frequently dried so it could be consumed throughout the year.

Wild fruit such as prickly pears (Opuntia Ficus-indica) and arbutus (Arbutus unedo L.), endemic throughout the island, were consumed occasionally by transhumant shepherds, depending on

the season (Delitalia E., 1982). In addition, local medicinal plants were included in their daily diet. Knowledge regarding those plants was transmitted from fathers to sons, as was customary in many Mediterranean countries. Other nutrients in the diet were different types of mushrooms, such as the *fungi porcini,* collected during the season and greatly valued all over Italy. Honey was used extensively as a sweetener (Loi MC et al, 2004).

The consumption of chestnuts and walnuts was typical of the population of the mountains and provided substantial calorie intake as well as proteins, essential fatty acids and minerals during the winter months (Le Lannou M., 1941). **Figure 4** shows a comparison of average consumption in 10 European countries according to the DAFNE (Data Food Networking) database in the 1990s (Naska A., et al., 2006) and G. Peretti's data in 1943.

According to the reports that cover the period from the mid-19th to the mid-20th century, meat consumption of rural populations did not exceed 4 or 5 servings per month. However, the Carta Mantiglia notes how shepherds sacrificed at least one sheep every week. Furthermore, it is important to bear in mind that the meat used to prepare the traditional dishes, such as bacon and lard in *minestrone* and poultry stock and meat, was not thoroughly recorded in the surveys. Sometimes the surveys referred to the agricultural cadasters, which only recorded annual production and not a family's own production (Canelada A., bibliographical work, Library of the University of Sassari, 2014). The meat consumed by farmers came from pigs and poultry, whereas shepherds also consumed the meat of sheep and goats (Angius V., 1842), (Carta Mantiglia, 2000).

The consumption of dairy products, from both goats and sheep, was much higher in the mountains (Angius V., 1842). Instead

of the *pecorino* cured cheese, most of which was intended for sale, the population often consumed ricotta (cottage cheese), a derivative of pecorino made with sheep whey, curd and a fresh sour sheep or goat cheese called *casu axedu*, rich in *Lactobacilli*, also yoghurt in the summertime (Carta Mantiglia. 2000; Peretti G., 1943). The products from family vegetable gardens together with poultry, pigs, and hunting meat from the vast forests, completed the average food intake of families in the areas of pastoralism. Goats were raised close to the houses, a custom called *mannalita* which facilitated the daily consumption of milk for children. In the winter, the colostrum of sheep and goats was mainly consumed by children. The diet's habitual monotony was interrupted on major religious or civil festivities, most expected was the one celebrated in spring, around May, to welcome returning transhumant shepherds (Tore G, 1975).

Up until the nutrition transition, consumption of fish and shellfish in the mountain villages of the interior of Sardinia was quite low, due to the communication barriers between the coast and the mountains. The widespread lack of refrigerators also made it difficult to store them for consumption (Tessier S., 2004). Fish consumption was almost exclusively limited to the villages located along rivers, and those along the coast that had fishermen communities (Mondardini G., 1981), to wealthy persons in the main cities and to the monks in the monasteries (Cottino A., et al, 1985), (Segretti A., 1992).

Before the nutrition transition, wine consumption in Sardinia was below the Italian average during the same period (Brotzu G., 1938), with higher consumption along the coast. The island's typical wine is called *Cannonau* **(Table 1B).**

In the first quarter of the 20th century the calorie intake of the population in Sardinia improved, progressively approaching the levels of the other regions of Italy (Tibaroni J., 1928) **(Figure 1).**

- *Introduction to the life and surroundings of a shepherd*

The context in which centenarians and their families lived is described below. The longevous population that was studied was born between the end of the 19th and beginning of the 20th century in the regions of Barbagia and Ogliastra, south of the province of Nuoro.

This was a very stable society whose economy was based on stockbreeding. According to a study of the University of Cagliari, at the beginning of 1800 the inhabitants of the highlands devoted to shepherding had the island's most stable economy, whereas farmers were still living in conditions of feudal tenants. The former was the first to use money as an instrument of commercial exchange within rural guilds. Their products were always valued inside and outside the island, particularly the cured *pecorino* goat cheese, famous worldwide. In the 18th century, in grazing areas like Ogliastra there, there were 3.9 heads of sheep per person. The cattle, on the other hand, was in the north of the island, in the areas of Alghero and la Gallura (Anatra B., 1987).

The living standard in the grazing areas was good, although shepherds had to start learning the trade early, between the ages of 10 and 12. The first-born inherited the position and had the privilege of going to school and thus knew how to read and write, which guaranteed the well-being of the entire family. A great deal of importance was attached to the home and the family. Marriages were only held once the house was built, which enabled couples to maintain a good standard of living. Houses usually had two or three

floors, sometimes two kitchens and a special room for the oven, where the *pistoccu* bread and traditional cakes with nuts and almonds were made. Keeping the house in optimal conditions was important for the shepherd since his wife was alone with the children during the 6 months of transhumance. Children helped their mother with home chores, which were assigned based on gender. Boys helped in the vegetable garden and with the animals, and girls helped making the bread, cured meats (ham, sausages, bacon) and the preserves (Canelada A., interviews with shepherd's families and Antonio Cannas, historian of Villagrande Strisaili in 2010, 2015).

The shepherds would leave in October and come back in May. During the period of transhumance, they would form groups of around 7 men and used shelters made of stone and wood located at strategic points along their route, where they stopped to make *pecorino* cheese. The shelters were located near the multiple springs from the Gennargentu mountains. The shepherds also used the shelters to prepare their traditional dishes, like *minestrone* and *the pecora in cappotto.* They prepared the cured cheese that was sold with the lamb meat during the periods of reproduction and consumed any excess production (sheep meat and potatoes). The diet was supplemented with wild plants and fruits like prickly pears, arbutus unedu and other wild berries (Pes G., et al 2014). When they settled near the villages in the lowlands, they bartered to supply themselves with local produce, such as vegetables and fruit (Poulain M., Canelada A., interviews with centenarian shepherds and Antonio Cannas, historian of Villagrande, 2013).

Their basic diet began with breakfast, which sometimes included a glass of whey from preparing *casu axedu* or sour cheese, *pistoccu* bread crumbled in sheep or goat milk and coffee. Lunch was the most energetic meal, and consisted of vegetables, *fagioli* and

potato *minestrone* (seasoned with salted *casu axedu* and bacon), sheep meat with potatoes or Sardinian sausage. For dinner they had ricotta or cottage cheese and *pistoccu* bread moistened with the whey of the cottage cheese. During transhumance shepherds did not usually drink wine because it was difficult to transport. They drank water from springs, barley coffee, chicory coffee and even acorn coffee. The vegetables they ate included raw wild fennel, chicory, thistle, asparagus and dandelion. As part of popular pharmacopeia, they used plants like mallow for coughs, chamomile for upset stomachs, gentian, nettle, rosemary, sweet bay, sage, thyme, helichrysum and other Mediterranean herbs for different ailments. Land snails and wild mushrooms were also part of their transhumant diet. They ate more meat at celebrations or when animals had to be sacrificed (Carta Mantiglia 2000). During the breeding period, the rams were sold or consumed by the shepherds and their families, and *Pecora in cappotto*, or stewed ram, is considered the emblematic dish. Shepherds collaborated with their group to resolve unforeseen circumstances and take care of the flock, forming a very close community with its own rules, and numerous activities such as music, improvised poetry, singing and games.

The documents analyzed in the archives of Villagrande confirm the tradition of passing the profession of shepherd to the firstborn male, intituling him to go to school. This fact not only help the management of the family's economy but allows them to enjoy a richer intellectual life in the time of transhumance. (Poulain M., Canelada A., demographic research at Villagrande's town hall, interviews with shepherds and their families 2011, 2013,2015).

1.2.2 Nutritional quality according to occupation and family:

- *Comparison of the nutritional status of shepherds and farmers*

The population that lives in the central mountains of Sardinia, and in particular the *Blue Zone*, has a lifestyle that is different from the lifestyle of the rest of the island. It is important to bear in mind that agriculture focusing on wheat, dating back to the Roman Empire, is not compatible with the type of terrain of the mountains of central Sardinia. For that reason, its inhabitants maintained their traditional pre-Roman lifestyles until World War II (Le Lannou M., 1941). As a community that consisted essentially of transhumant shepherds (Salzman PC., 1991), for centuries they adopted nutritional models that differ from what is known nowadays as the Mediterranean Diet.

It is important to compare the dietary habits of the shepherds and of the farmers of the lowlands in view of the differences of the physical conditions found in the two populations.

In both groups carbohydrates from grains constitute the largest energetic input to the diet, which included very few vegetables and fruit (Peretti G, 1943), (Tessier S., 2005). According to Peretti's survey in 1938, the consumption of animal protein was 20% greater in the shepherd population compared to farmer population (Peretti G, 1943).

Foods of animal origin entailed an obligatory choice for Sardinian shepherds in the pretransition period due to the limitations inherent to transhumance, which implied a greater consumption of dairy products and cured meat instead of fresh meat. Despite the large consumption of dairy products amongst shepherds, the energy obtained from fat was moderate in proportion to other nutrients.

For the decade of the 1930s, the data show that the superior quality of the nutrients eaten by shepherds in comparison with farmers had a positive impact on the overall health of the *Blue Zone* population. This was reflected in the difference of the body parameters observed historically between the two groups, with greater muscular mass and more fatty tissue amongst the shepherds. The average height of men of the pastoral society was 3 cm greater in comparison with the males of the farmer families, whereas body weight was 7 kg greater amongst shepherds with respect to the farmers (Peretti G, 1943), **(Table 2 and Figures 2 and 3).**

- *Comparison of the nutritional status of wives of shepherds and of farmers*

The extreme longevity in the shepherding central areas of Sardinia, discovered at the of the twentieth century, exceptionally affects males. For this reason, it is important to examine the role of diet based on gender.

77% of the women of this region did not work outside the home and were able to devote more time to produce and prepare their food (Tessier S, et al, 2005).

The relation between men's and women's diets in Sardinia was mentioned in Peretti's work (Peretti G., 1943). He reported that women's diet was closely connected to their social origin, and with the occupation of the head of the family. According to this author, the nutritional status of women, together with other morphological indicators such as height, weight and muscular mass, was significantly better in the pastoral society than in the agricultural setting **(Table 2, and Figures 2 and 3).**

The same author concluded that there was greater nutritional quality in the average shepherd family diet with respect to the diet of farmer families. Moreover, he provided evidence of a greater prevalence of cavities amongst farmers' wives, which could indicate a calcium deficiency during pregnancy and breastfeeding related to their gender but also due to less accessibility to animal products. However, the wives of shepherds were better nourished and did not suffer these deficiencies.

1.2.3 Differences in the nutrition transition in Sardinia

The nutrition transition is defined as a sequence of dietary and nutritional patterns resulting from large shifts in the global structure of the diet, related to changes in economic, demographic health and social factors (Popkin BM., et al., 2004). Although in the first half of the last century Sardinia was considered an underdeveloped region compared with the rest of Italy, after World War II it slowly recovered and benefited from the impressive economic and social recovery of the mainland. In contrast with other regions of Italy, Sardinia experienced the transition later, around the middle of the 1950s (Tessier S., 2005) and in some interior areas such as the *Blue Zone* it is still ongoing. In 1952 the livelihood of about 45% of Sardinia's active population still depended on traditional agriculture, and particularly animal breeding, and only 28% on industry (in 1936, the percentages were 57% for traditional rural activity and 20% for industrial activity) **(Table 3 and Figure 4).**

Changes in the overall dietary structure of Sardinia

The changes in the overall Sardinian dietary structure were influenced by several socioeconomic factors:

- A rapid increase of average family income, due to the gradual return of emigrants with greater purchasing power.
- A progressive reduction of self-produced foods as result of the decrease of the population involved in agro-pastoral activities.
- The incorporation of women for the first time to the labor market, resulting in reduction of the time spent on culinary tasks.
- The pressure of the media, which promoted the processed products of mainland Italy, pushed the population to adopt a diet that differed from the autochthonous model (Carbini L., 1998).

The population living in urban areas and in the lowlands were the first to experience the effects of increased availability and choice of food. The main modifications in their daily diet during the decade of the 50s was overeating and replacing legumes and *minestrone* with foods of high calorie content*,* such as processed meats and commercial pasta imported from the mainland.

In general, during the nutrition transition there was a considerable increase in protein intake, an increase of fat intake from 13% to 25%, and a reduction of the intake of carbohydrates (Brotzu G., 1954).

The calorie intake of the Sardinian population descended in World War II and the post-war period, returning to previous levels in 1952, with a significant increase of the calorie intake at the end of the 1950s.

Because of the geographic isolation of the *Blue Zone,* the generations born at the end of the 19th century experienced prolonged exposure to the traditional diet, since they were between 60 and 80 years old when the nutrition transition began. Improvements in transport and communications, in the supply and conservation of foods, enabled the centenarian generation to reach the age of 100 following their traditions, benefiting also from the availability of new foods to balance the old diet during the nutrition transition **(Figures 4 and 5).**

Even though the *Blue Zone* population maintained its traditional lifestyle longer, changes were recorded, such as the increase of vegetable, olive oil and meat consumption, with a prevalence of poultry in respect to beef, as well as a reduction in the consumption of milk in favor of fresh cheese, cottage cheese and yoghurt (Tessier S., et al., 2005) (**Figure 5).**

1.2.4 Specific characteristics of the classic diet in Sardinia before the nutrition transition

- *High consumption of 50% whole grain cereals and sourdough-leavened bread*

One the fermented foods used daily in the traditional Sardinian diet is bread, which has formed part of the population's basic diet for centuries. On occasions, daily bread consumption prior to the nutrition transition exceeded 500 grams, so that the diet's fiber content was very high: 20 gr/100 (Peretti G, 1957). The flat, dehydrated bread called *pistoccu* was made at home and transported during the 6 months of transhumance. Traditionally, the bread was prepared using whole barley or wheat grains and potatoes (Murru-Corriga C., 1991). The flour obtained was mixed with microbial yeast passed on through generations, in laboratory tests, this sourdough bread showed a very significant content in *lactobacilli.* In the mountain areas of Sardinia, bread is still made in the traditional manner.

In Sardinia, cereal cultivation was traditionally characterized by an important production of barley, which was more appropriate for the highlands. Barley was mainly sowed in the marginal mountain terrains (Pino Branca A, 1926), a custom which continues at present, although it is grown mainly for animal feed. In the rest of Sardinia, barley production has diminished considerably (Attene G., et al., 1996).

- *High consumption of dairy products and fermented dairy products*

In the studies carried out by Tivaroni in 1921, it was estimated that consumption of dairy products was 79% higher in

Sardinia compared to the rest of Italy (Tivaroni J., 1928). In the areas of shepherding, there were mainly sheep and goats, instead of cattle, and the cheese included fermented varieties such as the sour cheese *casu axedu*, made with goat or sheep milk, with similar properties to yoghurt. This sour cheese was salted and smoked to be used to prepare *minestrone* (vegetable soup) during the six months of transhumance. Other dairy products included cured pecorino, curd of sheep milk and above all cottage cheese prepared with whey. This whey provided protein content to the diet since leftovers were used at dinnertime to moisten the barley and potato *pistoccu* bread. Goat milk, in turn, was consumed more in the family, and due to its qualities was considered more appropriate for the growth of children. Every family had its own goats, which were raised near the house. Every day, a shepherd took them to graze in the nearby mountains (Canelada A., interviews with shepherds and their families 2010, 2011, 2013, 2014, 2015), (Canelada A., interview with a centenarian (wife and daughter of shepherds) in Urzulei, 2013).

- *Low to moderate fat diet*

This study shows how until 1950 the diet of Sardinia could be considered low to moderate in fat. It has been estimated that the calorie intake derived from fat was between 15% and 20%, although there was a significant increase of the intake of lipids during the nutrition transition (Beasley JM., et al., 2013).

The fat used most by the population in the areas of shepherding was pork fat, which in transhumance was transported in the form of bacon and eaten with bread or added to the legume dishes. Olive oil was not consumed until infrastructures were improved, enabling transport to the highlands. In any case,

consumption in the lowlands was moderate due to the limited production.

- *Moderate consumption of meat*

Based on the reports that cover the period from the mid-19th century to the middle of the 20th, the rural population ate meat (intended as a piece of red meat) about four times per month, although the derivatives of pork and other smaller animals like poultry and their eggs were used as additional ingredient in the traditional dishes, rich in legumes, beans and potatoes.

As in neighboring Mediterranean countries, pork was a fundamental source of food for families all year long. The animals were raised near the family vegetable garden and provided a good source of protein and most important fat. The families used the pork to prepare cured meats, which were consumed throughout the year. Bacon, Sardinian sausages, ham, and salt-cured meats, derived from pork, formed part of the diet of a large segment of the island's interior population. Shepherds used the salt-cured meats as an important source of nutrients during the transhumance (Peretti G., 1943).

- *Moderate wine consumption*: In the agricultural cadaster of 1929 and in Fermi's studies in the 1930s the consumption of wine that is recorded for the *Blue Zone* is lower than in the rest of Sardinia, where consumption was lower than the Italian average. Because of transporting difficulties during transhumance, shepherds did not usually consume wine.

- *Micronutrients in the traditional diet:*

  High content:

  - Calcium and vitamin D: the content of calcium in the traditional Sardinian diet was very high due to the

consumption of milk and dairy derivates. Long hours of exposure to the sun contributed to the intake of vitamin D.

Low content:

- Sodium: below the average threshold
- Iodine: Sardinia continues to be the region of Italy with the lowest intake (Pastorelli AA., et al., 2015).
- Vitamins A, E, C: scarce intake of these antioxidants in the past due to low consumption of fresh fruit and vegetables. At present a low level of vitamin A is observed amongst the centenarians of Sardinia (Polidori MC., et al., 2007).

- *Calorie restriction in the traditional diet*

If we analyze the historical situation of the diet in Sardinia, since the end of the 19th century to the beginning of the 20th the calorie intake was low in some areas, and part of the population was in a precarious situation in respect to food supplies (Tivaroni J., 1928; Brotzu. G., 1954). Malnutrition mainly affected the people of the lowlands, but not those who lived in the mountains and were devoted to shepherding. The availability of food was always greater in the highlands since it was based on a very stable pastoral economy.

The calorie intake of the diet in Sardinia increased in the first quarter of the 20th century, progressively approaching the level of the average for mainland Italy **(Figure 1).**

1.2.5 Comparative study of the eating habits of children of the *Blue Zone* of Villagande

This study was preceded by another one carried out in 2008 by "Okkio alla *Salute*" entailing 2,341 school children in Sardinia between the ages of 6 and 12. Said study estimated that the prevalence of obesity and overweight was between 6.6% and 18% (ISTISAN, 2008). These values are below the national average for Italy and are much lower than the 30% registered for the preadolescent population of the south of Italy (ISTAT, 2007).

Inside Sardinia it was noted that the prevalence of overweight and the obesity index in the province of Ogliastra were the lowest ones registered for the entire island (Piras I., et al., 2008).

These reports motivated our research, which was carried out in 2010 in Villagrande, province of Ogliastra, in Sardinia's *Blue Zone*.

The research consisted of a comparative study of the eating habits and lifestyle of school children in the village of Villagrande (3,500 inhabitants), with a control group in an urban setting, namely the city of Sassari (129,000 inhabitants) located in the north of the island. The participating students were girls and boys between the ages of 10 and 15 enrolled in the primary and secondary schools in both locations **(Table 4).**

The hypothesis of the positive influence of the lifestyle and eating habits as determining factors of a good health and longer survival, like the one recorded in that community, was considered once again. One of the important elements of this study was to verify whether the healthy eating habits of previous generations persisted amongst the youngest generation, by means of interviews with parents and grandparents **(Appendix 1).**

The nutritional survey, carried out ten years ago in a limited number of families in the same village of Villagrande, revealed that eating habits and food consumption were influenced by the traditional lifestyle and efficient intergenerational transmission (Tessier S, 2005).

- *Structure of family eating habits in Sardinia*

To facilitate the interpretation of the results of the study of children **(Tables numbered 5 to 10)**, note should be made that in both Sardinia and Italy the structure of daily meals follows a fairly constant pattern. Breakfast is normally light and consists of a cup of expresso or cappuccino with milk, bread or biscuits and more recently, puff pastry filled with marmalade, cream or chocolate. Lunch is the main meal of the day and in general children eat at home with the family between 1:00 and 2:00 pm. The starter is usually pasta or rice, especially in northern Italy, and less in Sardinia. The main dish is usually meat or fish with vegetables or salad, sometimes adding cheese, followed by fresh fruit or sweet food for dessert. Like in other Mediterranean countries wine is consumed in moderate amounts (average of 1 glass), occasionally to accompany meals. Dinner is usually light (soup, salads, cheese, vegetables and fruit). However, in the rural areas, and particularly in a pastoral economy, dinner can be heavier. Appetizers are not habitual at everyday meals.

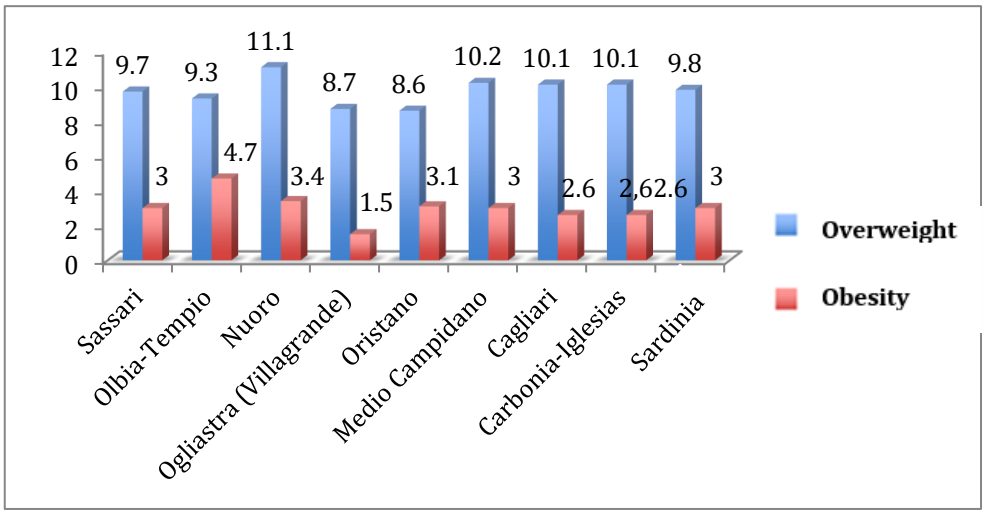
- *Introduction to the survey*

As an introduction to the survey, the distribution of overweight and obesity in the eight provinces of Sardinia is shown below, calculated in a total population of 8,125 18-year-old teenagers in 1998 for a study published by (Piras I., et al. 2006).

The total incidence of overweight and obesity in Sardinia is 9.8% and 3.0%, respectively. The average value of the body mass index for all of Sardinia is 21.8 kg/m², with the minimum value of 21.7 kg/m² in Ogliastra. The provinces with less overweight and obesity are Oristano and Ogliastra. Distribution of obesity shows a significant difference between Olbia-Tempio and Ogliastra ($P<0.05$).

The region which has registered the lowest index of obesity in teenagers is the province of Ogliastra. These data are relevant because they show an advantage for the region to which Villagrande belongs and which was the subject matter of our comparative study.

Differences of overweight and obesity in Sardinia (Piras I., et al 2006)



Justification

2. JUSTIFICATION

This is the first doctoral dissertation on *Blue Zones*. As member of the research team in Sardinia, I want to share the knowledge acquired up to now regarding the points that interest the public most, namely the nutrition and lifestyle of these long-lived populations as a healthy model.

The merit of collecting historical data lies in the fact that it is the first attempt to compare these valuable sources of information about Sardinia's traditional culture, strongly rooted in the interior of the island in comparison with the coasts, with the current situation.

The data obtained have been relevant to assess the importance of the nutritional factors and their historical evolution in connection with male longevity in the *Blue Zone*, as well as a positive influence for the family and for future generations.

All researchers have the responsibility to transmit the knowledge acquired that contributes to the common good and the improvement of social conditions. This contribution is a positive model for a life diet, in the original sense of diet in the Latin term. The prospect that this unique place may become a common place for future generations fully justifies this study.

Objectives

3. OBJECTIVES

1. To place the concept of *Blue Zone* within a specific framework, carrying out a historical revision of the nutritional characteristics of the centenarians of the *Blue Zone* of Sardinia during the 20th century to recreate their nutritional status at a young age and examine the evolution of their diet over time.

2. To describe the nutritional characteristics of the nutrition pretransition in Sardinia in relation to the longevous population of the *Blue Zone* comparing it to other less longevous population in the island, analyzing the differences according to occupation and gender.

3. To assess the late entry of the nutrition transition in the areas of shepherding with respect to the rest of Sardinia, and to consider the positive regulatory effect of nutrition transition in the specific age group of centenarians.

4. To discuss nutritional aspects considered as possible determinant factors of longevity in other long-lived populations around the world. Finally propose a critical analysis of the simplification of the nutritional model of the *Blue Zones* disseminated by the media worldwide.

5. To research the eating habits of the new generations in the emblematic *Blue Zone* of Villagrande Strisaili by means of a comparative study with a control group in the city of Sassari to show the differences of the nutritional status of both child populations.

6. To analyze the results of the survey and relate them with the historical data to extract more relevant points that enable establishing the characteristics that have influenced this *Blue Zone* population.

7. To assess the degree of intergenerational transmission of traditional knowledge and habits in the longevous population, to be considered as possible example for the prevention of obesity and other health concerns in the new generations.

Material and Methods

4. MATERIAL AND METHODS

4.1 Methods of the historical revision

The historical revision consisted of a structured search in Sardinia's main libraries, including the Universities of Sassari and Cagliari, for classic publications on traditional nutrition.

The research focused on texts written from the beginning of the 19th century until the decade of the 1950s.

The chapters chosen are the ones that contain descriptions of the eating habits in Sardinia. The initial selection was carried out by identifying the most relevant titles, then reading the texts that contained information on potentially relevant aspects of the Sardinian nutritional tradition.

The literature consulted contains obsolete scientific standards, particularly the oldest books, which is why the scoring method was adapted to more modern standards for the sake of a better understanding of the information, as explained later.

This study provides a general vision of the situation of the traditional diet of the *Blue Zone,* with its advantages and disadvantages and its evolution towards the transition diet.

The historical sources of information selected for this revision is shown below in **Tables A and B.**

Table A: Historical information on nutrition in Sardinia

Period	Description	Reference
Mid-19th century	One-time references on the quality of foods in the different municipalities of Sardinia	Angius V., 1842
End of 19th century	Nutritional habits of the Sardinian population until the end of the 19th century. First descriptions of the dietary differences between the lowlands, cereal monoculture, and the highlands, with high production of dairy products.	Tore G., 1975
1904	Eating habits in the north of Sardinia in the early years of the 20th century	Silla Lissia., 1904
1920s	Nutritional status of the Sardinian population in the decade of the 1920s and its comparison with the nutritional status of the rest of Italy	Tivaroni J., 1928
Early 1930s	Brief description of the health and nutritional status of the population in the 377 municipalities of Sardinia in the middle of the 1930s, with special emphasis on the problem of endemic malaria	Fermi C., 1934
End 1930s	Detailed analysis of the diet in the 1930s of shepherds and farmers, two occupational groups that live in the central area of Sardinia. First mention of gender differences	Peretti G., 1943
1930s	Essentially a geographic study that includes some references to the habits of shepherds and farmers all over the island	Le Lannou M., 1941
From WWII to 1954	A summary of the nutritional status of Sardinia after World War II until 1954	Brotzu G., 1954
1957	Nutritional status of the rural population of Sardinia during the postwar period of reconstruction	Peretti G., 1957
1949-1957	Nutritional status of the population of Sardinia from the postwar period to the beginning of the nutrition transition	AA.VV., 1957. Societá Editoriale Italiana.
NT* en las BZ** at the end of 1990	Comparison of the dietary habits of Sardinia, included a BZ** village on the island of Malta, at the end of the 20th century	Tessier S. Gerber M., 2005 Tessier S. Gerber M., 2005
NT* WWII to present	Evolution of the nutritional habits since the postwar period up to the 1990s	Carbini L., 1998

* TN: nutrition transition

** BZ: *Blue Zone*

An additional source of information on nutrition during the period under study is the *Agricultural Cadaster,* a national census on agricultural activities published until 1929.

Table B essentially shows local food productions in the traditional agro-pastoral societies and can be considered as an acceptable proxy to calculate the average consumption of each town or village's population.

The variables selected are related to the annual production of certain foods in each municipality of the island.

Table B: Information on the measurements used for the nutritional analysis of the agricultural cadaster of 1929 and of C. Fermi in 1934

Variables	Description	Source
Diet score	Originally expressed with adjectives and re-coded in ordinal number format from 1 to 5	C. Fermi 1934
Meat consumption	Indicated how many times the population ate meat per month	C. Fermi 1934
Wine consumption	Expressed in liters/person/year	C. Fermi 1934
Wheat production	Expressed in hectoliters/person/year*	Agricultural Cadaster 1929
Barley production	Expressed in hectoliters/person/year*	Agricultural Cadaster 1929
Nuts production	Expressed in kilos/person/year	Agricultural Cadaster 1929
Cheese production	Expressed in kilos/person/year	Agricultural Cadaster 1929

**The original data expressed in hectoliters or kilograms were divided by the total population of municipality.*

Analysis of the nutritional factors and eating habits prior to the nutrition transition

Table 1A of the results shows daily food consumption in the decade of the 30s for families of farmers and shepherds of rural areas (Peretti G., 1943).

Table 1B includes different nutritional data collected for a classic study of Sardinia in the first six months of 1930 by the Italian hygienist C. Fermi, published in 1934, and the data obtained from the agricultural cadaster. In accordance with this author's original description, all the variables were collected by means of a structured questionnaire that was filled out by health personnel in each village. In the original text, the quality of the diet of the population in each village was expressed with adjectives (from "very poor" to "excellent"). To perform the calculations, they were coded once again, using an ordinal number variable ranging from 1 to 5.

As usual in the decade of the 1930s, the criteria to calculate the score of the quality of the diet did not include current standards. The calorie intake or percentage of macro and micronutrients were not considered to calculate the score. On the other hand, like other contemporary surveys such as the one carried out G. Peretti, the score resulted from information about the diet that was both qualitative (type of protein) and quantitative (frequency and amount consumed). The quality of the diet was estimated based on the relative proportion of the animal protein intake. In respect to the average height and robustness of the male population, the data was obtained from existing military lists.

In **Table 2** G. Peretti registered the differences in the nutritional status, the body composition and the anthropometric profiles amongst farmer and shepherd families in 1938.

Table 3 compares the intake of nutrients in Sardinia with the average in Italy after World War II.

The results are also shown in figures.

- Figures represented in bars for calorie and nutrient intake before and after World War II. **Figures 1, 4, 5**
- Figures in the form of circles for the nutritional status and in bar format to compare body composition and the anthropometric profiles, according to occupation and gender amongst the population of shepherds and farmers. **Figures 2, 3**

4.2 Methods of the study of eating habits of the child population of a *Blue Zone*: Villagrande Strisaili

Sample of participants and questionnaire (Appendix 2)

A structured qualitative questionnaire was obtained by slightly modifying a previous questionnaire used in nutrition studies in Sardinia (ISTISAN, 2008), which was given to each school child included in the study to collect his/her personal data, eating habits and lifestyle, including physical activity for the children of Villagrande.

The survey was organized by means of a series of meetings between teachers, students and specialists in nutrition, at which a questionnaire on the frequency of eating different foods at the five daily meals (breakfast, mid-morning, lunch, afternoon snack and dinner) was administered, distinguishing student's sex. The questionnaire was filled out with the help of the students' parents in order to obtain demographic information, including the child's age and sex, place of residence, eating habits and the level of intergenerational integration in the case of Villagrande.

The experimental protocol, the questionnaires on nutrition and the informed consent form were presented to the local Ethics Committee for approval before the study began. Subsequently, all students selected in the study were given this form, which was returned with the parents' signature **(Appendix 1).**

The protocol was approved by the Provincial Board of Ogliastra on January 28th, 2010.

The questionnaire consists of 3 parts:

- **Part I**: includes the student's personal data
- **Part II:** includes a group of questions related to the number and type of meals.
- **Part III:** includes the frequency of consumption of different categories of foods.

Statistical analysis

The average value ± standard deviation of the main parameters derived from the analysis of the questionnaire was calculated and presented in a table format. The U Mann-Whitney test for continuous variables and Pearson's χ^2 test for the analysis of frequencies with SPSS 10.1 (SPSS Inc., Chicago, IL, USA) were used to compare the groups. The level of statistical significance of the differences was set at $p = 0.05$.

The results are shown in:

- **Tables**

Table 4: number of participants and range of ages

Tables 5, 6, 7, 8, 9, 10: show the results

- **Figures**

Figure 6: the comparative bar chart shows the frequency of consumption of the different food categories in the diet of the two child populations.

Results

5. RESULTS

5.1 Results of the historical analysis

Data before the Nutrition Transition, period prior to World War II

Analysis of Table 1 A

In 1903, statistics published by the General Health Directorate reported that meat consumption in Sardinia was 8.3 kg/year in comparison with the Italian average of 12.7 kg/person/year during the same period.

In 1926 average meat consumption had increased to 14 kg/person/year in Sardinia, in contrast with 16.2 kg/person/year in mainland Italy (Camis M., 1926).

According to the data reported by G. Peretti in 1938 and published in 1943, the amount of animal protein consumed by shepherd families in the area of Nuoro (Barbagia and Ogliastra) was significantly higher in comparison with farmers. The region of Barbagia, located at the northern limit of the region of Ogliastra, is a good point of reference with respect to the area of maximum longevity found in Villagrande, province of Ogliastra. The following data correspond to the area of Barbagia, considered as an area of shepherding, and refer to the average consumption of 28 farmer families and 17 shepherd families:

- *Proteins:* The quality of the diet was calculated according to the animal protein intake. The protein intake was 21% for shepherds and 18% for farmers, from which it is inferred that the shepherd diet was of greater quality.

- *Fats*: A distinction is made between fat of animal origin and of plant origin. The intake of animal fat represented 86.8% with respect to plant fat amongst shepherds and 74.8% amongst farmers. Despite the large intake of dairy products, the energy obtained from fats was low for both shepherds and farmers, 18% and 14% respectively. Olive oil consumption is not significant.
- *Carbohydrates*: The biggest content of the diet comes from carbohydrates; in other words, 61% amongst shepherds compared to 68 % amongst farmers.
- *Wine:* The average content of ethanol in the wine of Sardinia is 13.9º/100 ml. Given average consumption, the content of wine in total energy intake was insignificant amongst farmers (5%) as well as shepherds (4%).

Macronutrients in the diet of both groups

	Farmers	Shepherds
Protein	18%	21%
Carbohydrates	68%	61%
Fat	14%	18%

Table 1.A Daily food consumption for 28 farmer families and 17 shepherd families in the mountain area of Barbagia, before World War II

Proteins (gm*)*	**Farmers**	**Shepherds**
Animal	19.5 (16.8%)	34.6 (29.3%)
Plant	96.5 (83.2%)	83.7 (70.7%)
Total	116.0	118.3
Fats (gm)		
Animal	32.1 (74.8%)	46.6 (86.8%)
Plant (olive oil)	10.8 (25.2%)	7.1(13.2%)
Total	42.9	53.7
Carbohydrates (gm)	469.0	398.8
Energy (kcal)		
Without wine	2,756.1	2,608.8
With wine	2,905.2	2,719.6

Energy (kcal): During this period the average calorie intake for the whole population of Sardinia was 10,230 kJ (2,445 kcal) per person/day, slightly lower than the Italian average of 10,880 kJ (2,600 kcal) per person/day for the same period. However, the values recorded in the shepherding area are comparable to the average for Italy.

Calorie intake (Figure 1)

- **1929**

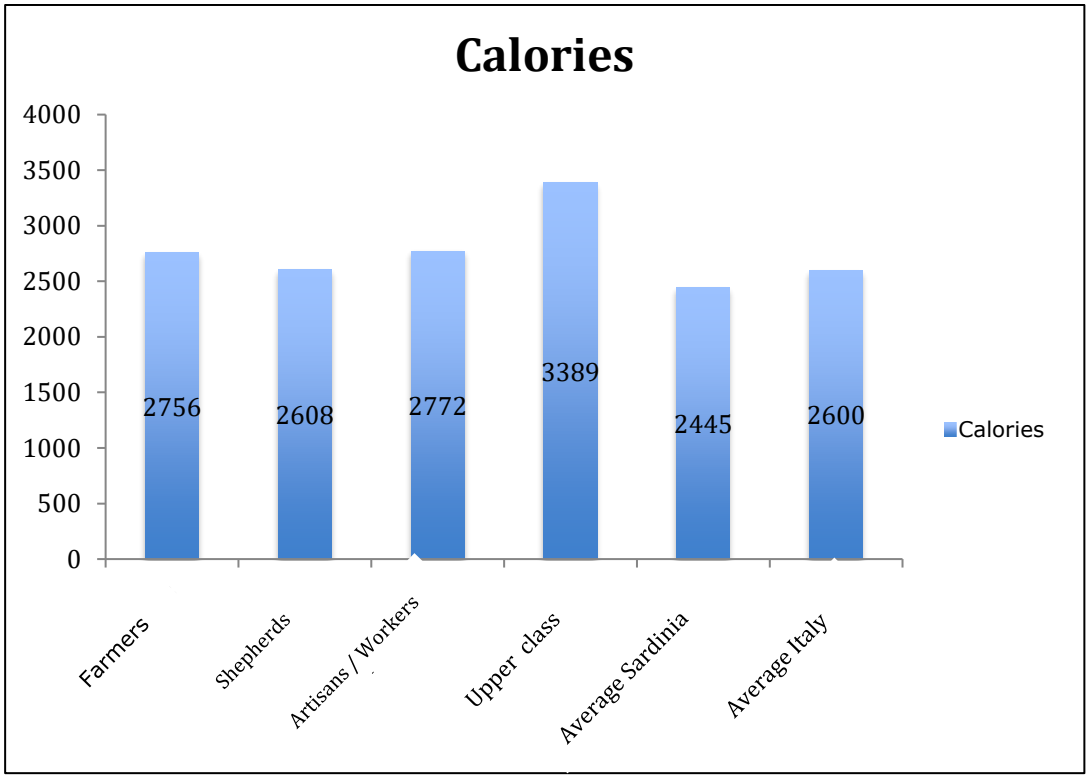
According to the historic data recorded by Tivaroni, the average calorie intake in Sardinia was 10,040 kJ (2,400 kcal/ person/day) for all the population of the island (Tivaroni J., 1928).

However, according to the records of the *Comissione per lo Studio dell' Alimentazione,* in the urban areas the calorie intake was higher than the average for the island, as seen in the city of Sassari, which is located in the north. In 1929, the calorie intake recorded varied from 11,720 kJ (2,802 kcal/person/day) for the working class to 13,150 kJ (3,144 kcal/person/day) for the upper classes (Brotzu G., 1954).

- **1938**

Brotzu recorded values amongst artisans that ranged from 9,810 kJ (2,344 kcal/person/day) to 13,390 kJ (3,201 kcal/person/day), with an average of (2,772 kcal/person/day). In the south, amongst the well-off population of Cagliari, the island's largest city, the values obtained ranged from 11,460 kJ (2,740 kcal/person/day) and 16,980 kJ (4,058 kcal/person/day), giving an average of 3,389 kcal/person/day. That same year the average calorie intake for the whole population of Sardinia was calculated to be 10,230 kJ (2,445 kcal/person/day), very close to the one recorded for Tivaroni in 1924 and slightly lower than the Italian average of 7% and 10,880 kJ (2,600 kcal/person/day) for the same period. From these data it is deduced that in the most important cities and in the areas of shepherding of Sardinia the calorie content was optimal, whereas in the rest of the island it was below the Italian average and there were deficiencies in respect to calorie intake.

Figure 1. Calorie intake of the urban population of Sardinia in comparison with the mountain population in 1938



Analysis of Table 1B

Data on food production: agricultural cadaster 1929 and C. Fermi 1934

- *Cereals:* Production of barley was considerably greater in the mountainous regions and in Ogliastra (*Blue Zone*). Note should be made that until the end of World War II, commercial exchanges between the different communities were limited due to lack of infrastructure (Angioni G., 1974), although certain produce such as wheat was valued as an object of exchange (Le Lannou M., 1941).
- *Average per capita meat consumption*: It was low (4-5 servings/month) for all of Sardinia, although the shepherd population in the highlands ate fresh meat more frequently.
- *Nuts:* Intake was much greater in the highlands, including Ogliastra (*Blue Zone),* and consisted of the mountain varieties, particularly acorns, chestnuts, walnuts, hazel, and almonds.
- *Cheese:* Consumption was greater in the shepherding society, bearing in mind that the quantities expressed in the agricultural cadaster only measure the average consumption for Sardinia of the excess *pecorino* cheese not exported. The varieties used by the mountain populations consisted of *pecorino* sub products with lower fat content, such as ricotta, curd and *casu axedu*, which were consumed daily (Tivaroni J., 1928).

Table 1B. Differences between the area of high longevity (*Blue Zone*) and the rest of Sardinia, nutrition variables

Table 1B. Agricultural Cadaster 1929 / C. Fermi 1934

Variables	Average consumption for the *Blue Zone*	Average consumption for the rest of Sardinia
Diet score (1-5)	2.6 ± 1.1	2.4 ± 0.8
Meat consumption (Intake/person/month)	5.09 ± 3.1	5.10 ± 3.7
Wine consumption (Liters/person/year)	79.3 ± 75.7	89.6 ± 62.4
Wheat consumption (Hectoliters/person/year)	1.06 ± 1.61	1.54 ± 1.79
Barley consumption (Hectoliters/person/year)	0.92 ± 0.75	0.52 ± 0.44
Nut consumption (Kilos/person/year)	0.27 ± 0.62	0.07 ± 0.11
Cheese consumption* (Kilos/person/year)	7.4 ± 4.6	5.2 ± 6.0

**In the original records the amounts were expressed in hectoliters (cereals), kilos and liters per person and year. The results were calculated dividing the amount by the total population of each municipality.*

***Milk and cheese**: In the decade of the 1920s Tivaroni estimated that consumption of dairy products in Sardinia, especially in the areas of shepherding, was 79% higher than the Italian average. The data of the cadaster reflect commercial production without considering the family production of dairy derivatives.

Analysis of Table 2

Differences in the nutritional status based on body composition and anthropometric profiles between 28 farmer families and 17 shepherd families, men and women of the region of Barbagia in 1938, as reported by G. Peretti in 1943.

Table 2 shows physical condition indicators of both groups and sexes. The nutritional status, muscle mass and adipose tissue is compared, depending on both occupation and gender.

Anthropometric parameters and body composition for men

- *Height:* higher in shepherd men, 3 cm more compared to farmers
- *Weight:* 7 kg more in shepherds. In the 1930s shepherds already showed clear indicators of having a more nutritious diet.
- *Muscle mass:* greater in shepherds
- *Body fat:* greater in shepherds

Anthropometric parameters and body composition for women

- *Nutritional status*: shepherds' wives' status is similar to that of men shepherds ($p = 0.555$) and is thus considerably better than that of farmers' wives ($p = 0.013$).
- *Physical condition*: body height and muscle mass are also higher in women living in shepherds' families.
- *Body fat:* the wives of shepherds had more adipose tissue than wives of farmers, which implied an energy balance above zero attributable to the pastoral environment (Peretti G., 1943).

From these data it is concluded that the physical condition of shepherds' wives was better than that of farmers' wives **(Figures 2 and 3).**

Table 2. Comparison of shepherds and farmers in respect to nutritional status, body composition and anthropometric profiles

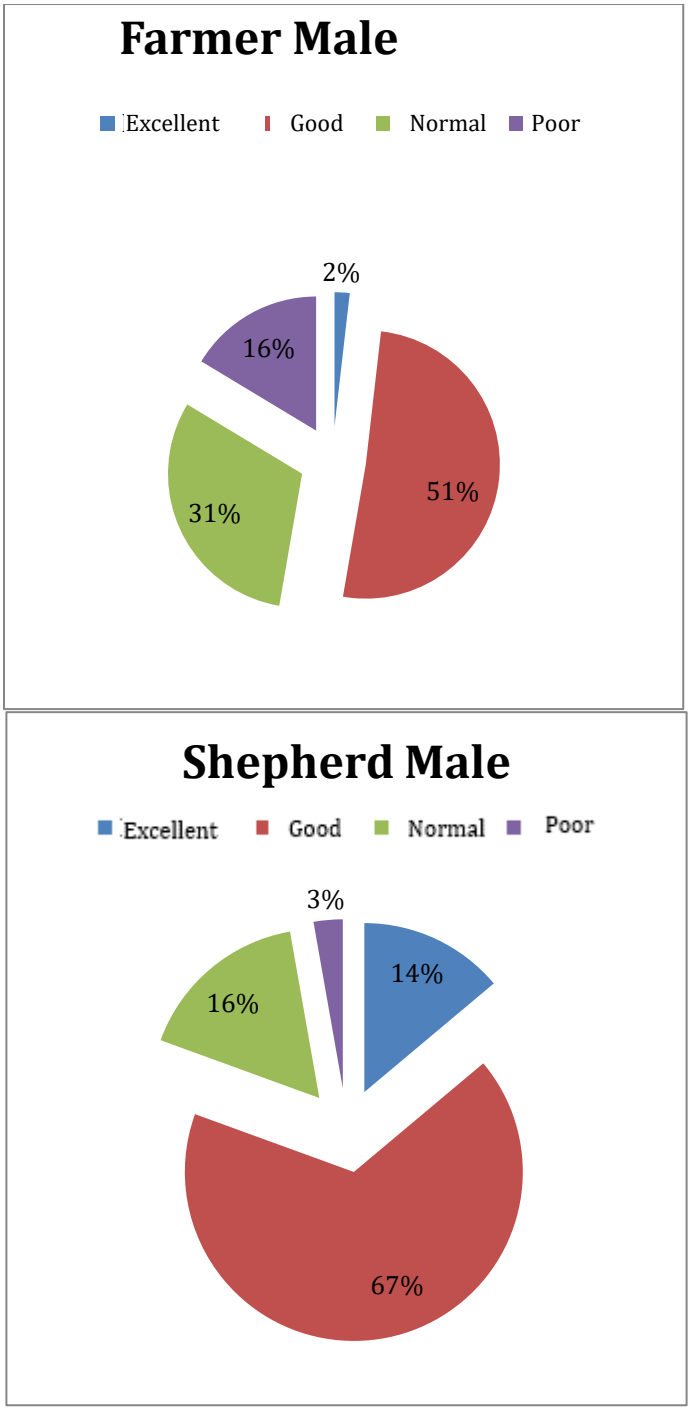
Nutritional Status [1]	**Farmers**		**Shepherds**	
	Male	**Female**	**Male**	**Female**
Excellent	1 (1.82%)	7 (14.29%)	5 (13.89%)	5 (12.82%)
Good	28 (50.91%)	12 (24.49%)	24 (66.66%)	21 (53.84%)
Normal	17 (30.91%)	15 (30.61%)	6 (16.67%)	10 (25.64%)
Poor	9 (16.36%)	15 (30.61%)	1 (2.78%)	3 (7.7%)
Muscle mass [2]				
Excellent	4 (7.27%)	2 (4.08%)	8 (22.22%)	2 (5.13%)
Good	34 (61.82%)	14 (28.57%)	26 (72.22%)	22 (56.41%)
Normal	17 (30.91%)	30 (61.23%)	2 (5.56%)	15 (38.46%)
Poor	0 (0.0%)	3 (6.12%)	0 (0.0%)	0 (0.0%)
Body fat [3]				
0	5.46%	6.12%	0.0%	0.0%
1	3.63%	10.2%	0.0%	2.56%
2	38.19%	28.57%	19.45%	28.22%
3	49.09%	36.74%	69.44%	35.89%
4	3.63%	18.37%	11.11%	23.07%
5	0.0%	0.0%	0.0%	10.26%

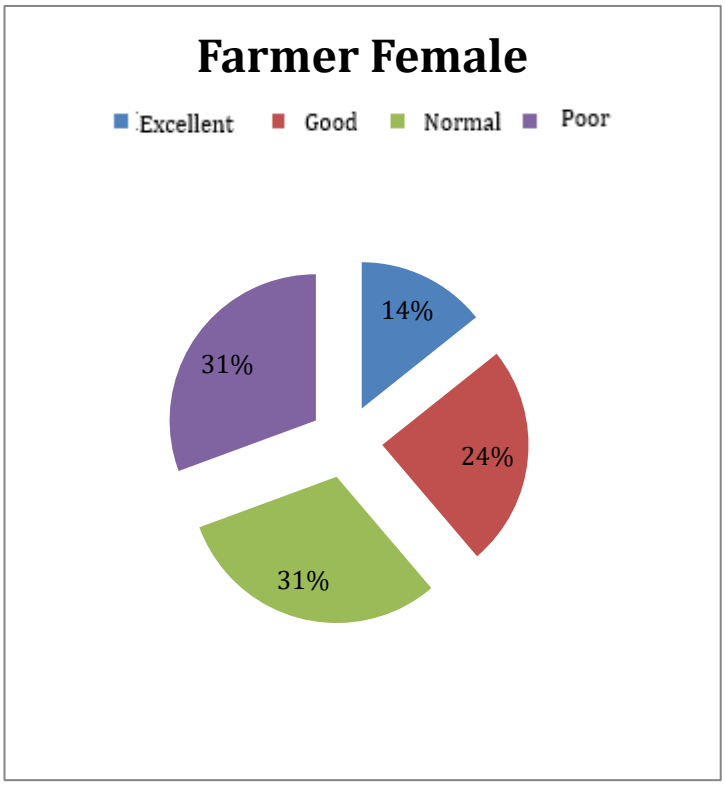
[1] Male farmers vs male shepherds, χ^2=11.2, p-value: 0.011; Male shepherds vs wives of shepherds, χ^2=2.08, p-value: 0.555; Male farmers vs wives of farmers, χ^2=12.2, p-value: 0.007; Wives of farmers vs wives of shepherds, χ^2=10.8, p-value: 0.013;

[2] Male farmers vs male shepherds, χ^2=10.8, p-value: 0.013; Male shepherds vs wives of shepherds, χ^2=13.8, p-value: 0.003 Male farmers vs wives of farmers, χ^2=15.3, p-value: 0.002.
Wives of farmers vs wives of shepherds, χ^2=8.75, p-value: 0.033.

[3] Male farmers vs male shepherds, χ^2=22.3, p-value: 0.0001; Male shepherds vs wives of shepherds, χ^2=25.7, p-value: 0.0001 Male farmers vs wives of farmers, χ^2=19.1, p-value: 0.002.
Wives of farmers vs wives of shepherds, χ^2=19.3, p-value: 0.002.

Figure 2. Nutritional status according to occupation and gender




Farmer Female
Excellent
Good
Normal
Poor
14%
24%
31%
31%

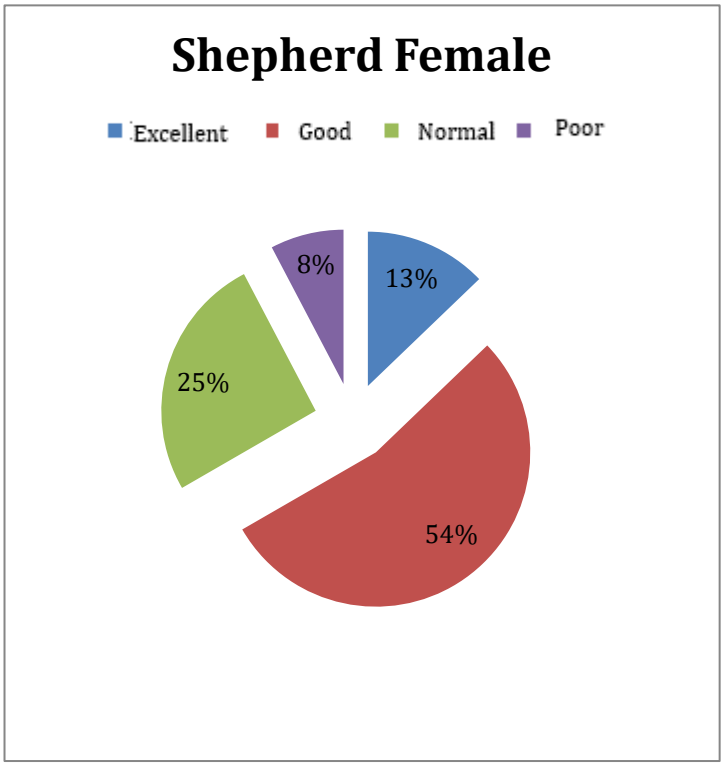

Shepherd Female
Excellent
Good
Normal
Poor
13%
54%
25%
8%

Figure 3.1 Comparison of muscle mass according to occupation and gender

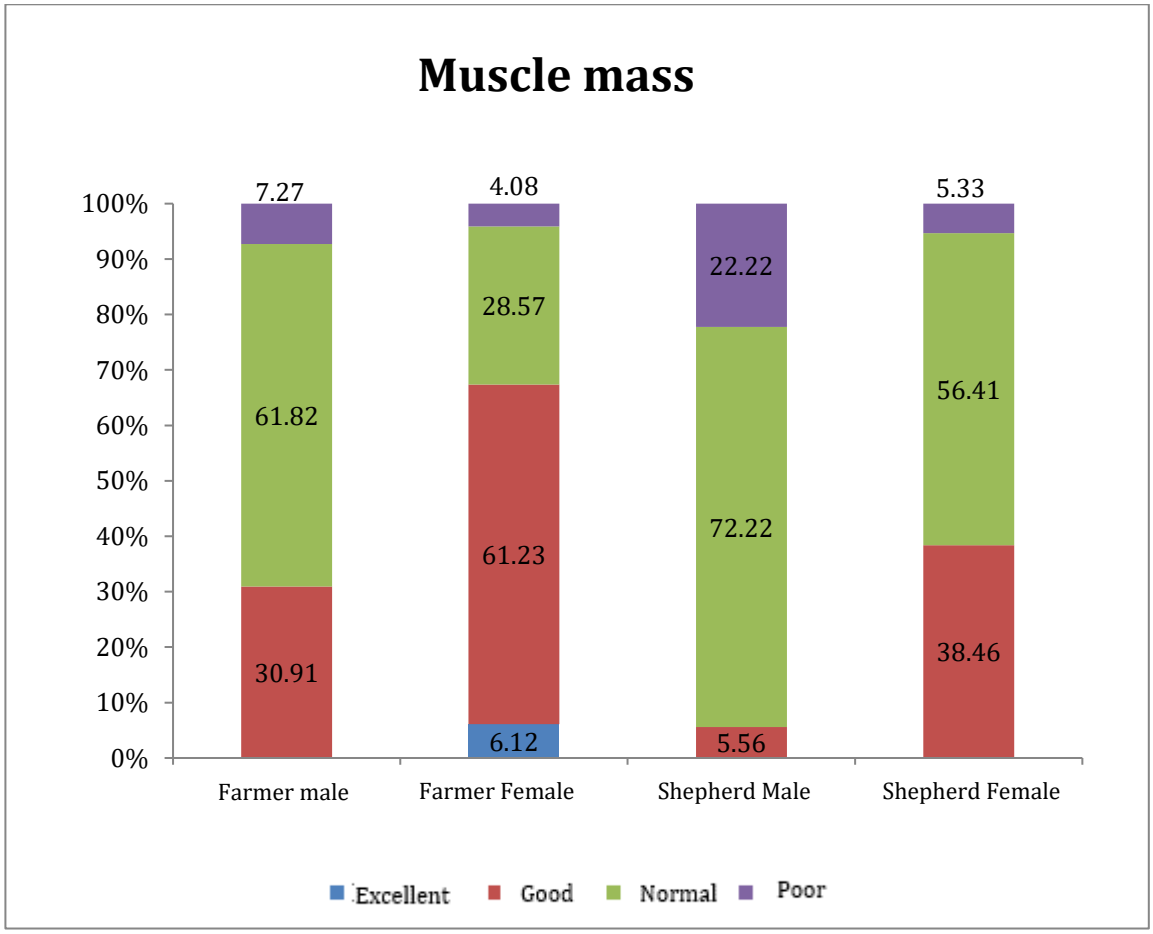
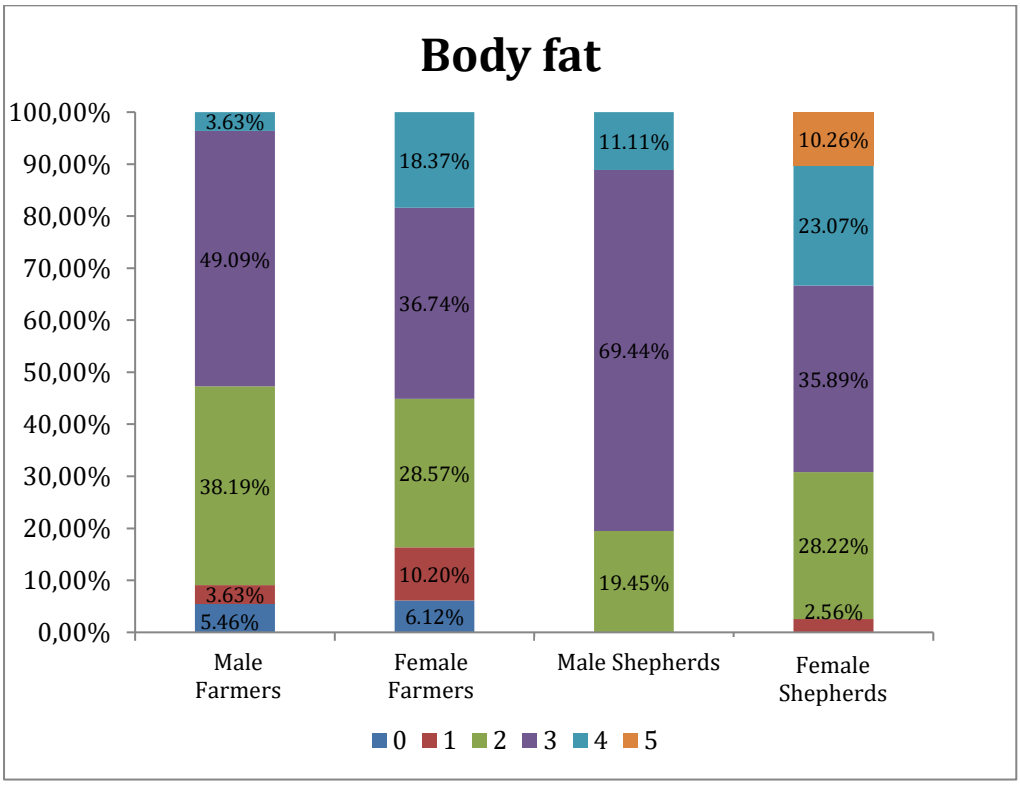


Figure 3.2 Comparison of body fat according to occupation and gender



0=very poor 1=poor 2=normal 3=good 4=very good 5=excellent

The nutrition transition in Sardinia

Analysis of Table 3

The Nutrition Transition (NT) began in Sardinia in 1950, but only in the coastal regions, and started to be noted in the areas of shepherding 10 years later.

The percentages of **Table 3** are calculated with respect to the Italian average.

During the NT protein intake increased all over Sardinia, although on the island it was less than the Italian average. One of the main characteristics of NT is the increased consumption of beef and refined flour.

1. **Meat:** consumption of meat was 77% of the Italian average, although it is estimated that in the "*Longevity Blue Zone*" the higher figures were due to the regular consumption of sheep and goat meat.
2. **Fish**: fresh or salt-cured; was not a product of usual consumption in the areas of shepherding, and in the rest of the island it was only consumed by the upper classes (Cottino A., et al., 1985).
3. **Refined flour**: consumption was low all over Sardinia, 57% of the Italian average.
4. **Wine**: wine consumption was 56% with respect to the average in Italy. A previous ecological study on the lifestyle in Sardinia's *Blue Zone* observed that the average intake of red wine was lower in this area than in the rest of Sardinia, and that the spatial distribution of wine consumption in the island's municipalities did not represent a direct relation with longevity (Pes G., et al., 2011).

5. **Liquor**: consumption was above the Italian average due to the tradition of making liquors from medicinal plants and forest berries, such as myrtle liquor.

In 1947 total energy consumption per capita had diminished with respect to the years before the war, ranging from 7,530 kJ and 8,370 kJ (1,800 kcal/person/day to 2,000 kcal/person/day), reflecting the food insecurity immediately after the war (Brotzu G., 1954). In 1952 energy consumption recovered its pre-war levels with 10,040 kJ (2,400 kcal/person/day). In 1959 it rose again above 11,030 kJ and reached 16,380 kJ (2,637 kcal/person/day to 3,915 kcal/person/day).

Table 3. Intake of nutrients in Sardinia and Italy in 1952 (AA.VV., 1957)

Foods	Sardinia*	Italy	%
Wine (l/per capita)	28.81	51.70	56
Liquors (l/per capita)	0.43	0.20	215
Meat (kg/per capita)	16.58	21.40	77
Beef (kg/per capita)	0.77	5.50	14
Varieties of beef (kg/per capita)	3.61	5.52	65
Pork (kg/per capita)	4.78	7.60	63
Sheep/Goat (kg/per capita)	6.83	2.01	340
Horse (kg/per capita)	0.59	0.76	77
Cold meats, bacon (kg/per capita)	1.42	3.30	43
Salted fish (kg/per capita)	0.84	2.40	35
Chocolate, cookies, sweet food (kg/per capita)	1.21	2.10	57

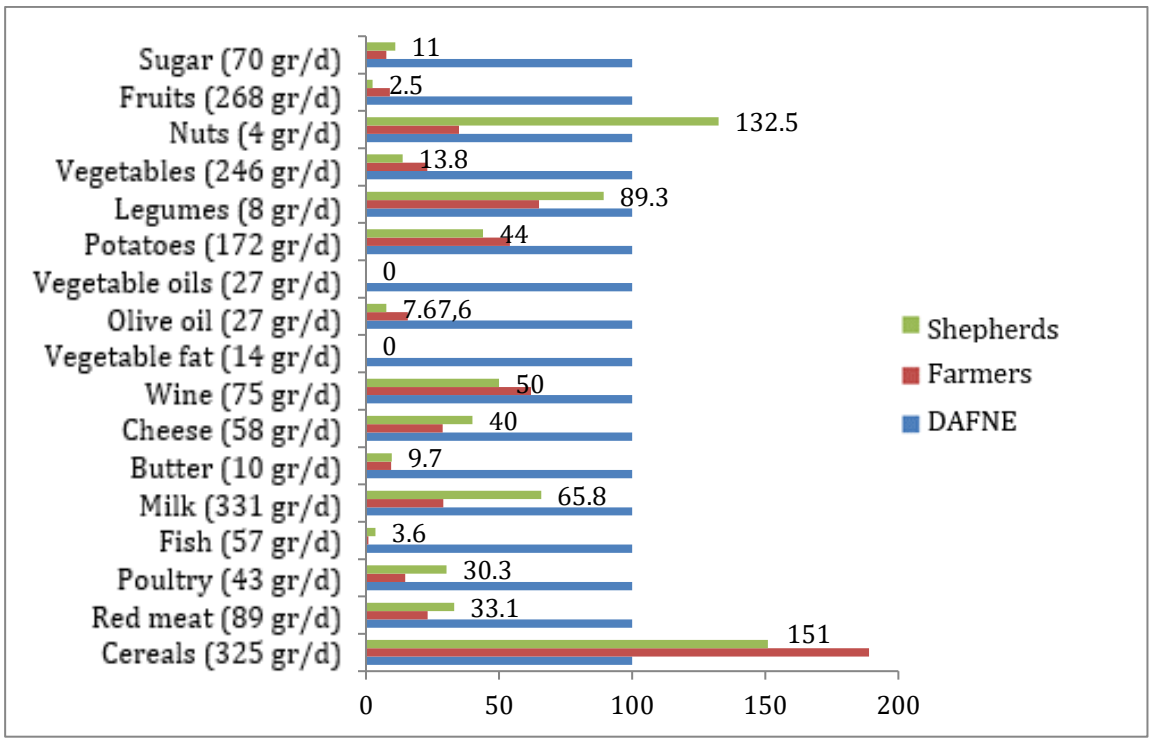
** In this table the percentages are expressed with respect to the Italian average. The amounts consumed are expressed as the difference between the quantity produced + the quantity imported (during said period) + the initial stock less the quantity exported and the final stock.*

Analysis of Figure 4

In this figure, the data on food consumption in Sardinia during the pretransition period which are recorded in the agricultural cadaster and were provided by Peretti (G. Peretti, 1943) are compared with average food consumption (blue) in 10 European countries (included 4 Mediterranean countries) considered by DAFNE: (*Data Food Net Working*) for the decade of the 90s (Nasca A., et al., 2006).

The figure shows a large consumption of cereals and nuts for the mountainous areas of Sardinia and the nutritional differences with respect to the European average at the end of the 20th century, period in which the centenarians were already experimenting the transition diet, as shown by M. Gerber and S. Tessier's data in 2005. Since DAFNE did not include animal fat in its study, we were unable to include it in ours, although it was essential for the pretransition period.

Figure 4. Comparison of average consumption data of DAFNE in the 1990s (Data Food Net Working) with the data of G.Peretti 1943



In the pretransition period there is large consumption of cereals and fruit in respect to the European average in the 1990s. The high level of nut consumption would largely compensate the lack of fruit and vegetables during the pretransition period.

Analysis of Figure 5

In the study carried out by the epidemiologists M Gerber and S Tessier (Tessier S., et al., 2005) in Villagrande in 2001 on the dietary changes that occurred as a result of Sardinia's nutrition transition, the questionnaire used revealed the following changes in the diet of the population of 70-year-olds that had been subject to the nutrition transition:

- *Increase* of the consumption of:

fresh fruit and vegetables (generalized + 60%),
olive oil (+ 56%)
beef (+ 55%)
fish (+ 50%)
chicken (+60%)
pasta (+20%)

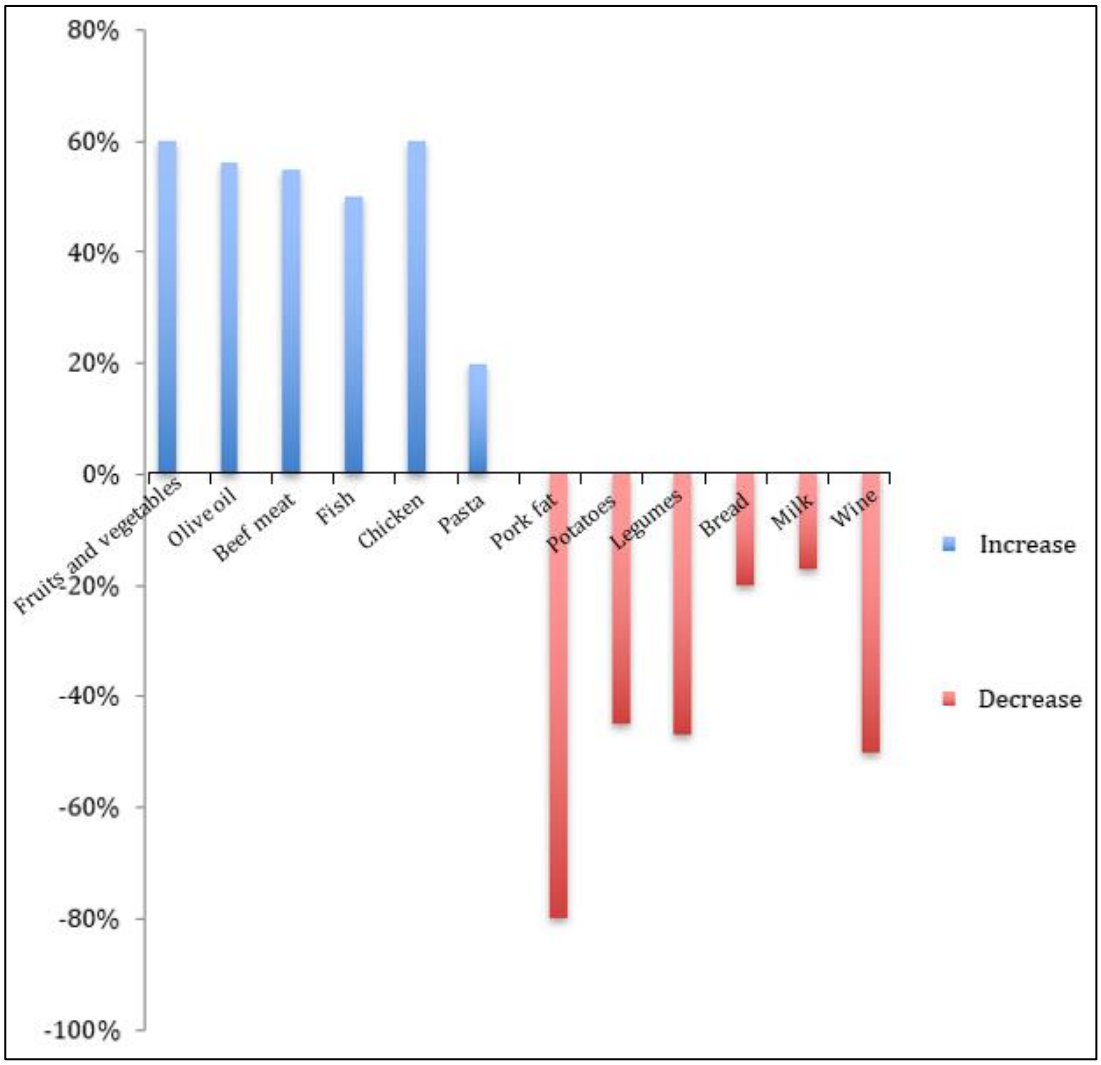
- *Decrease* of the consumption of:

lard (-80%)
potatoes (-45%)
legumes (- 42%)
bread (-20%)
milk (-17%)
wine (-50%)

In summary: there is a decrease of pork fat in favor of olive oil for cooking, although the former is still consumed in the form of homemade cold meats. More vegetables are eaten and less legumes are used in the preparation of *minestrone* soup, and bread consumption is reduced. The excess of carbohydrates observed in the past is thus balanced. Meat variety increases, combining the standard use of pork and rabbit with chicken and beef. Wine consumption is reduced, particularly amongst women. The increase

in beef intake could be associated to the population's perception that its consumption was a symbol of a higher purchasing power and social development. However, the most noteworthy and positive element was the incorporation of fish, olive oil, fruit and vegetables to the diet.

Figure 5. Evolution of food consumption in Villagrande since the nutrition transition according to the data provided by Tessier in 2005



5.2 Results of the comparative study of two child populations: Villagrande (BZ) and Sassari

Analysis of Table 4

236 questionnaires were analyzed, comprising 116 children (59 boys and 57 girls) of Villagrande (rural *Blue Zone* area*)* and 120 children (control group comprising 60 boys and 60 girls) of Sassari (urban area). The age of the students at the beginning of the survey is shown in **Table 4**.

Table 4. Values of Villagrande and Sassari

Location	Variable	Boys	Girls	Total
Villagrande	No. (%)	59 (50.9%)	57 (49.1%)	116
	Age	11.8 ± 1.3	11.9 ± 1.1	11.8 ± 1.2
Sassari	No. (%)	60 (50%)	60 (50%)	120
	Age	10.7 ± 2.4	10.2 ± 1.0	11.1 ± 1.3

Descriptive analysis and interpretation of the questionnaires and the tables

The children of the rural areas were shown to have a more frequent healthy diet model than the children of the urban areas: (89% vs 74% had breakfast, p = 0.004); the total consumption of vegetables at least once a week was greater in the rural environment (94% vs 54%, p<0.01). Fruit showed similar quantities and were consumed at least once a week in both groups (97% vs. 94%) as well as legumes (79% vs 71%). Cheese, Sardinian pecorino sheep milk, was more consumed in the rural area than in the urban one, several times per week (86% vs 73%). Fish was consumed more frequently in the rural area, 81%, in contrast with the urban area, 65%, (p<0.001). In addition, lighter lunches including vegetables and fruit were more frequently chosen by girls in the rural environment (41% vs 11%) compared to those who preferred a more complete meal (30% vs 68%, p <0.001).

Consumption of soft drinks was habitual in both cohorts, although it was greater in the urban area.

Breakfast (Table 5)

To the question "Do you have breakfast in the morning?" 103 of a total of 116 (89%) students from Villagrande answered yes. In the rural setting 76% of the boys and 96% of the girls had dairy products every day, accompanied with biscuits (boys 54.2%, girls 49.1%), or cereals (boys 30.5%, girls 44.4%).

In the urban group only 89 of totals of 120 students (74%) had breakfast at home. **Table 5** shows the frequency of food consumption by category for students of both sexes. In the urban environment the two most consumed foods were milk (60.7% boys,

52.4% girls) and sweet food (42.9% boys and 0% girls). In both rural and urban setting, the most consumed product was milk, accompanied by cereals or biscuits, although the girls completely abstained from eating processed baked goods. Only a small percentage did not have an adequate breakfast, not consuming the appropriate nutrients in accordance with healthy European standards (Colic B., et al, 2003).

Mid-morning and afternoon appetizers/snacks (Table 6 and 8)

The number of children shown in the tables indicates that some of them consume different groups of foods.

95% of the students of the rural environment ate a snack mid-morning: 97% boys vs 93% girls **(Table 6).** 80% of the students of the rural area also had a snack mid-afternoon, the frequency of which was slightly lower in comparison with the mid-morning sandwich. There were no gender differences **(Table 8).** Sandwiches were the preferred food for 74% of the boys and 64% of the girls for the morning snack. In contrast 20% of the boys and 28% of the girls consumed fruit. For the afternoon snack, fruit consumption was considerable: 36.8% for the girls and 30.5 % for the boys.

In the urban zone consumption of the morning snack was 70% for both sexes **(Table 6)**. The favorite food for boys and girls were sandwiches, followed by chips, whereas fruit did not have relevance in the morning. The afternoon snack in urban areas was consumed by 75% of the children, without any difference by sex. Fruit was consumed by 14.3% of the boys compared to 19% of the girls.

Main meals (Tables 7 and 9)

All the school children of Villagrande Strisaili had lunch and dinner at home; in contrast, 100% of the school children in the urban area had lunch at the school cafeteria.

The structure of lunch and dinner is shown in **Tables 7 and 9** respectively.

For lunch in the rural area a part of the girls preferred a lighter lunch, up to 45% have only the first course, with vegetables and fruit 38,6%. While 22,8% of the girls take a first and second course and 26,3% a complete meal including fruit. For the boys 37.2% preferred only a first course, accompanied by vegetables and fruit. And more than 50% had the complete lunch including fruit, or first and second course.

For lunch at the urban school, 60.7% of the boys preferred the complete meal, whereas 76.2% of the girls preferred having only the first or second course, without salad and without fruit.

At dinner in Villagrande students had the following: 32.2% of boys had the first and second course, and 18.6% had the complete meal, the rest first or second of which 23.7% with consumption of fruit and vegetables. As for the girls 31.5 % had the first course, 15,7% only second course with 29,8% of them including vegetables and fruit, 28% had the first and second course, and 22.8% had the complete dinner including fruit and vegetables.

At dinner in Sassari 7.1% of the boys and 33.3% of the girls had the first and second course, and 53.6% of the boys and 28.6% of the girls had a complete course.

The consumption of fruit and vegetables, both at lunch and dinner, was greater in the rural area of Villagrande.

The most important element to highlight is that in the rural area meals are homemade, whereas in the urban area a large percentage consisted of processed food.

Food preferences in rural and urban areas (Table 10, Figure 6)

Table 10 shows the estimated food preferences with the weekly frequency of consumption, irrespective of sex.

Meat: total consumption was greater amongst boys who lived in the rural areas compared to those that lived in the urban area (100% vs 94%). 91% of the students of Villagrande indicated a considerable consumption of sausages, ham (mostly homemade) and other products derived from pork, at least once or more per week. In 34% of rural samples students consumed meat almost daily and only 9% completely abstained, percentage which is similar to urban area.

Cheese: 86% of children in Villagrande indicated that they consumed dairy products made of sheep and goat milk more than once a week vs 73% in Sassari. The statistical difference was significant.

Fish: the frequency of consumption was greater in the rural sample (81% Villagrande vs. 65% Sassari, $p < 0.001$); this was a positive change, since in the past fish consumption in the rural area was scarce (Gargiulo L., et al., 2004).

Vegetables: in Villagrande the frequency of consumption, at least once a week, was considerably higher in the rural area, (94% vs. 54%, $p < 0.001$).

Fruit and legumes: the results of the rural and urban cohorts are similar: at least once a week 97% vs. 94% and 79% vs. 71% respectively.

Consumption of precooked food: it was more significant in the urban area, where 45% consumed precooked food at least twice a week compared to Villagrande, where it was consumed by 22% of the children. There are differences in comparison with the urban environment, considering that 46% of the children of Villagrande never consumed them.

There were no differences between the rural and urban cohorts in respect to the minimum consumption of *alcoholic beverages.*

On the other hand, consumption of *soft drinks* can be considered significant in both groups. Only a minority (13% in Villagrande and 2% in Sassari) completely abstained, whereas 95% of them drank soft drinks at least once a week, and 27% every day.

Table 5. Frequency of food at breakfast

Foods	**Villagrande (rural)**		**Sassari (urban)**	
	Boys= 59	Girls= 57	Boys= 60	Girls=60
Milk	45 (76.3%)**b	55 (96.5%)**a	36 (60.7%)	31 (52.4%)
Cereals	18 (30.5%)	23 (40.4%)	17 (28.6%)	17 (28.6%)
Chocolate	8 (13.6%)	6 (10.5%)	2 (3.6%)	6 (9.5%)
Cookies	32 (54.2%)**a	28 (49.1%)	13 (21.4%)**b	26 (42.9%)
Coffee	3 (5.1%)**a	8 (14.0%)	13 (21.4%)	6 (9.5%)
Coffee with milk	3 (5.1%)	7 (12.3%)	13 (21.4%)	0 (0.0%)
Tea	9 (15.3%)	4 (7.0%)	15 (25.0%)	9 (14.3%)
Pizza/pasta	1 (1.7%)	0 (0.0%)	4 (7.1%)	6 (9.5%)
Juice /fruit	15 (25.4%)	9 (15.8%)**a	9 (14.3%)**b	29 (47.6%)
Sandwich	3 (5.1%)	5 (8.8%)	0 (0.0%)	3 (4.8%)
Sweet food	2 (3.4%)**a	4 (7.0%)	26 (42.9%)**b	0 (0.0%)
Crispbread/butter /marmalade	5 (8.5%)	2 (3.5%)	6 (10.7%)	3 (4.8%)
Bread and chocolate spread	12 (20.3%)**a	17 (29.8%)	0 (0.0%)	0 (0.0%)
Others	6 (10.2%)	2 (3.5%)	2 (3.6%)	0 (0.0%)

* p<0.01; ** p<0.001; *a*, rural vs. urban; *b*, boys vs. girls

Table 6. Frequency of food mid-morning

Foods	Villagrande (rural)		Sassari (urban)	
	Boys= 59	Girls= 57	Boys= 60	Girls=60
Sandwich	44 (74.5%)	37 (64.9%)	43 (71.4%)	51 (85.7%)
Snack	7 (11.8%)	10 (17.5%)	15 (25.0%)	11 (19.0%)
Pizza	3 (5%)	0 (0%)	0 (0%)	9 (14.3%)
Coffee with milk /coffee	4 (6.7%)	1 (1.7%)	0 (0%)	0 (0%)
Sweet food	4 (6.7%)	2 (3.5%)	4 (7.1%)	0 (0%)
Fruit	12 (20.3%)**a	16 (28.0%)	2 (3.6%)	0 (0%)
Others	9 (15.2%)	11 (19.2%)	6 (10.7%)	0 (0%)

p<0.01; ** p<0.001; *a*, rural vs. urban; *b*, Boys vs. Girls

Table 7. Frequency of food at lunch

Foods	**Villagrande (rural)**		**Sassari (urban)**	
	Boys= 59	Girls= 57	Boys=60	Girls=60
First course	22 (37.2%) **a	26 (45.0%)**b	13 (21.4%)	0 (0.0%)
Second course	9 (15.2%) **a	10 (17.5%)**b	0 (0.0%)	0 (0.0%)
First and second course	9 (15.2%)	13 (22.8%)	13 (21.4%)	11 (19.0%)
Fruit and vegetables	17 (28.8%)**a	22 (38.6%)**b	9 (14.3%)	0 (0.0%)
Sandwich	4 (6.8%)	0 (0%)	0 (0.0%)	0 (0.0%)
Complete meal (1st, 2nd course and fruit)	21 (35.6%) **a	15 (26.3%)**b	36 (60.7%)	46 (76.2%)
Pizza	2 (30.4%)	4 (7.0%)	2 (3.6%)	0 (0.0%)
Others	1 (3.4%)	1 (1.7%)	0 (0.0%)	0 (0.0%)

* p<0.01; ** p<0.001; *a*, rural vs. urban; *b*, boys vs. girls

Table 8. Frequency of food for the afternoon snack

Foods	**Villagrande (rural)**		**Sassari (urban)**	
	Boys= 59	Girls= 57	Boys= 60	Girls= 60
Sandwich	12 (23%) **b	5 (8.7%) **b	30 (50.0%)	23 (38.1%)
Chips	11 (18.6%) **a	14 (24.5%)**b	19 (32.1%)	26 (42.9%)
Pizza	4 (6.7%)	2 (3.5%)	2 (3.6%)	3 (4.8%)
Coffee/ coffee with milk	4 (6.7%)	6 (10.5%)	9 (14.3%)	3 (4.8%)
Sweet food	21 (35.6%) **a	17 (29.8%)	6 (10.7%)	11 (19.0%)
Fruit	18 (30.5%) **a	21 (36.8%)**b	9 (14.3%)	11 (19.0%)

* p<0.01; ** p<0.001; *a*, rural vs. urban; *b*, boys vs girls

Table 9. Frequency of food at dinner

Foods	Villagrande (rural)		Sassari (urban)	
	Boys= 59	Girls= 57	Boys= 60	Girls= 60
First course	13 (22.0%)	18 (31.5%)	19 (32.1%)	17 (28.6%)
Second course	12 (20.3%) **a	9 (15.7%)	4 (7.1%)	11 (19.0%)
1st and 2nd course	19 (32.2%) **a	16 (28.0%)	4 (7.1%)	20 (33.3%)
Fruit/vegetables	14 (23.7%) **a	17 (29.8%) **b	6 (10.7%)	3 (4.8%)
Sandwich	3 (5.1%)	0 (0.0%)	4 (7.1%)	0 (0.0%)
Full meal (1st, 2nd course and fruit)	11 (18.6%) **a	13 (22.8%)	32 (53.6%)	17 (28.6%)
Pizza	18 (30.5%) **a	8 (14.0%)	6 (10.7%)	0 (0.0%)
Others	2 (3.4%)	3 (5.2%)	0 (0.0%)	0 (0.0%)

* p<0.01; ** p<0.001; *a,* rural vs. urban; *b*, male children vs. female children

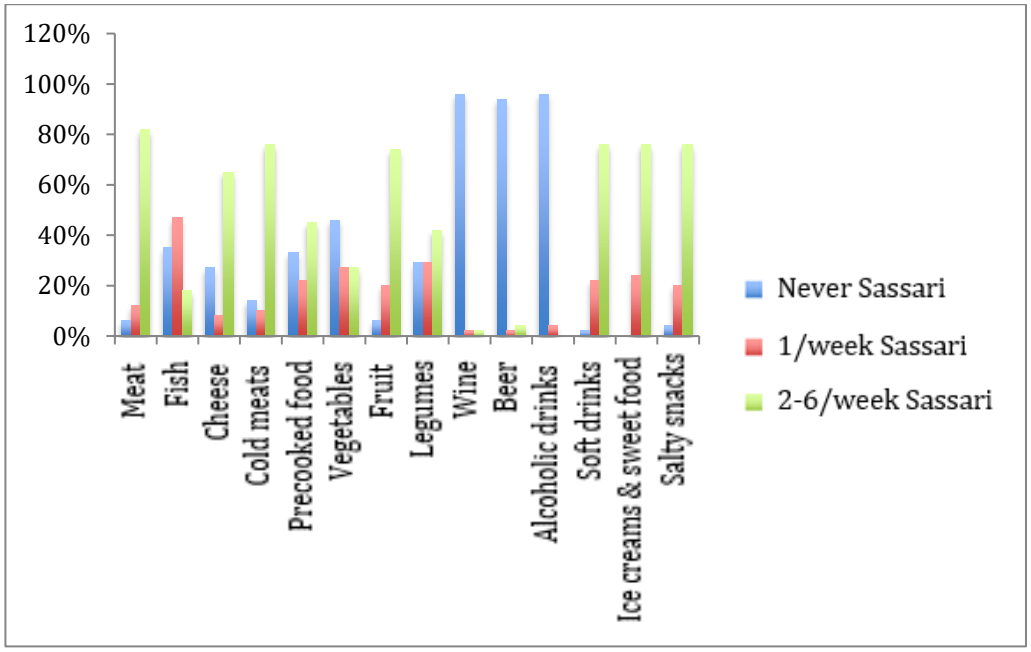
Table 10. Frequency of food in the child diet

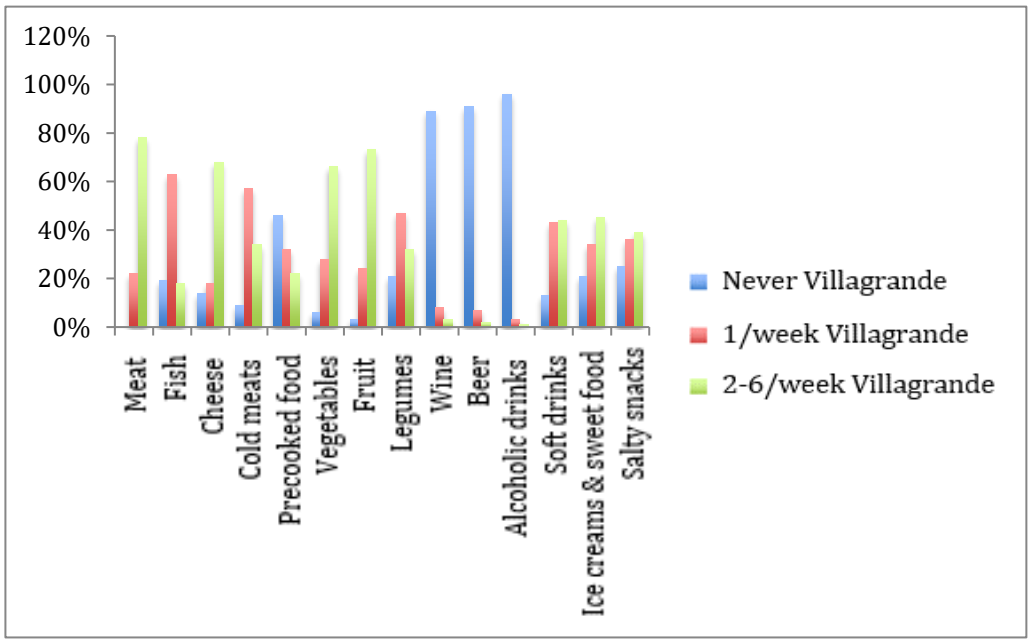
Foods	Villagrande (rural)			Sassari (urban)		
	Never	1/ week	2-6 / weeks	Never	1/ week	2-6 / weeks
Meat	0%	22%	78%	6%	12%	82%
Fish	19%	63%	18%	35%	47%	18%
Cheese	14%	18%	68%	27%	8%	65%
Cold meats	9%	57%	34%	14%	10%	76%
Precooked food	46%	32%	22%	33%	22%	45%
Vegetables	6%	28%	66%	46%	27%	27%
Fruit	3%	24%	73%	6%	20%	74%
Legumes	21%	47%	32%	29%	29%	42%
Wine	89%	8%	3%	96%	2%	2%
Beer	91%	7%	2%	94%	2%	4%
Alcoholic beverages	96%	3%	1%	96%	4%	0%
Soft drinks	13%	43%	44%	2%	22%	76%
Ice creams and sweet food	21%	34%	45%	0%	24%	76%
Salty snacks	25%	36%	39%	4%	20%	76%

Rural vs. Urban $p<0.001$

Figure 6. Frequency of food in the child diet in an urban area (Sassari) and a rural area (Villagrande)

According to food frequency data of Table 10





Discussion

6. DISCUSSION

Advantages and disadvantages of the diet in the Blue Zone pastoral environment during the pretransition period

The classic diet in the pastoral zones, where the largest number of centenarians is located, has three main products, namely dairy products, bread and lard and bacon.

Dairy products

Consumption of cottage cheese, or *ricotta,* and sheep and goat milk whey, which are rich in water-soluble globular proteins, was a very efficient, low-fat source of nutrients. Together with the shepherd's daily physical activity, it resulted in an energy balance close to zero. The multiple nutrients of goat milk whey include cystine, which is essential for glutathione synthesis, a fundamental endogenous antioxidant produced by the cells. The transhumant shepherds interviewed by our team showed excellent body parameters in respect to musculature and bone mass at an elderly age (Pes., et al., 2014). Goat milk and its derivatives were, and still are, greatly valued by the inhabitants of the pastoralism areas and their families. In comparison with bovine dairy products, goat milk has a higher nutritional value and is more similar to human milk than cow milk (Hanlein GFW., 2004). The fat globules of goat milk, due to their smaller size and larger surface area, are more easily digested by the intestinal lipase. A diet based on goat milk helps improve the metabolism of lipids, favoring particularly the decrease of triglycerides. During the digestion of goat dairy products, there is an increase of biliary secretion of cholesterol, mobilizing its deposits and lowering its level in plasma, which gives rise to a

hypocholesterolemia effect that protects against cardiovascular diseases (López-Aliaga I., et al., 2010). Goat milk also has a high level of short and medium chain saturated fatty acids (Alférez MJ., et al., 2001), such as butyric acid (C4: 0), caproic or hexanoic acid (C6: 0), caprylic or octanoic acid (C8: 0), and capric or decanoic acid (C10: 0), which have a protective effect in respect to carcinogenesis of the colon (Hinnebusch BF., et al., 2002). The high carnitine content allows for a more optimal use of fatty acids inside the mitochondria, limiting the creation of substrates that promote lipid peroxidation (Díaz-Castro J., et al., 2012), improving the cell's general metabolism (Penn D., et al., 1987). In addition, goat milk is also rich in zinc and selenium, which are essential for the optimal activity of the immunological system and promote healthy aging (Mocchegiani E., et al., 2007). The combination of calcium and phosphorous in the goat milk may have preserved the population of the *Blue Zone* from the loss of bone mass and resulting risk of fractures in old age. The diet was rich in calcium; the intake of this nutrient has a very important impact on health, particularly in reducing the incidence of osteoporosis (Angeles-Agdeppa I., et al., 2010). Its consumption may also be associated with the higher levels of vitamin D observed in the inhabitants of the area and with a lower frequency of bone fractures amongst the centenarians of the *Blue Zone* (Errigo A., et al., 2000) of Sardinia. In addition, the lactobacillus paracasei probiotic is particularly frequent in certain varieties of Sardinian cheese; regulating the rate of transcription of inflammatory genes decreasing it (Bäuerl C., et al., 2013) and countering the aging process.

Sourdough bread

Sourdough bread is of much greater quality than the bread that is consumed at present. The traditional barley bread can reduce the levels of glucose in the blood. The analysis of its postprandial effect shows a 25% reduction in the insulin response; it can preserve the functions of the cells that secrete insulin, preventing obesity and diabetes (Maioli M., et al., 2008). The active compounds of sourdough, rich in microbial ferments, have a positive influence on intestinal flora, performing an antagonistic action with respect to potentially pathogenic bacteria. Moreover, the microorganisms that exist in this food produce systemic effects by means of anti-inflammatory mechanisms that modulate the negative effects of an excess of cereals considered proinflammatory. The combination of bread and milk whey is a characteristic of the shepherd's diet, which reveals popular wisdom in combining foods for maximum benefits (Pes G., et al.,2014).

These two products of extraordinary quality had only one disadvantage: their consumption was excessive. However, physical activity had a regulating role that safeguarded shepherds' health (Pes G., et al., 2014).

Fat consumption

Lard formed part of shepherds' daily diets. Although its consumption has gone down, it is still used. The total content of fat in shepherds' diet was always moderate, constant, and well used energetically.

A diet high in saturated fats is officially considered harmful for health. Most studies warn of the risk of cardiovascular disease and some types of cancer (Chan DS., et al., 2011). This poses a controversy in connection with the results obtained in the *Blue*

Zones, where the fat used the most is that of pork, both in the past (Sardinia) and at present (Costa Rica and Okinawa), apart from Ikaria, which uses more olive oil, although pork meat is also part of its traditional diet. The CRELES study of Costa Rica (Rosero-Bixby L., 2007, 2013) noted that the fat consumed most was lard, and that the individuals who ate more saturated and monounsaturated fats in comparison with polyunsaturated fat showed the lowest rate of dementia (Aragón M., 2012).

The same phenomenon is observed in Okinawa, where lard is also used for cooking and preserving food. Recent studies on cognitive capacity and the metabolic syndrome in this population suggest the hypothesis that high cholesterol in the elderly may be an adaptive mechanism to protect them from the negative effect of aging on cognitive capacity. Cholesterol is essential to maintain myelin, which surrounds and isolates the nervous cells and is used to build their synapses. The function of myelin decreases over time and its destruction is associated with dementia and Alzheimer's. In consequence, low levels of cholesterol may cause myelin to be less vulnerable, provoking its disfunction in old age (Katsumata Y., et al., 2011).

In the case of Sardinia, the characteristics of the fat consumed are similar to those of Iberian pork (Ruiz G., et al., 2006). These are autochthonous breeds that feed on chestnuts, acorns, and the leftovers of the family vegetable garden. Due to high levels of oleic acid, this animal fat can be considered beneficial for human nutrition; it is minimally processed and is a good source of energy and micronutrients. In addition, a significant part of the essential animal fats is, by definition and behavior, monounsaturated (Pérez-Palacios T., et al., 2008). Animal fat, and specifically that of pork, is more stable, less sensitive to peroxidation and supports a

temperature similar to the one of olive oil, which is why it has been used in many traditional cultures for conserving and cooking food. It contains vitamins A, D, E and K (Barendse W., 2014).

Shepherds used it as an essential base of their nutrition. During the days of transhumance and until they reached a shelter, daily food consisted exclusively of milk, bread and bacon supplemented with the wild products collected in their way (Peretti G., 1943; Le Lannou M., 1941), (Canelada A., Poulain M., Pes GM., interviews with shepherds and their families - 2009-2015).

The other nutrients

Meat consumption: There was moderate beef consumption until the beginning of the nutrition transition, including the area of Ogliastra in this estimation. Shepherds, who attached more value to sheep as a source of income from wool and cheese, consumed the excess meat from male animals or from animals sacrificed for other reasons, so that it was difficult for hygienists in those days to make a real assessment of total meat consumption.

Diets with low cow meat consumption have been described in other areas of longevity such as Okinawa, where pork is used in many traditional dishes (Miyagi S., et al., 2003). In Ikaria inhabitants prefer goat meat (Panagiotacos DB., et al., 2011) and in both regions breeding of smaller animals and poultry was always encouraged for family consumption.

In the longevous area of the Nicoya Peninsula in Costa Rica, pork is also appreciated by the population, together with fowl meat (Rosero-Bixby L., et al., 2013). Beef is also consumed since stockbreeding forms part of the local economy.

In 1938 the amount of meat consumed by the shepherds and their families, 84.8g/day, was significantly greater than the

consumption of other groups in their surroundings. It is important to bear in mind the difficulty of calculating family production of poultry, goats and pigs for private consumption that was not recorded in the agricultural cadaster (main source of statistics at that time). The data collected in the decade of the 1930s indicate that the shepherds of the mountainous areas showed clear indicators of a diet richer in nutrients: greater muscular mass and more adipose tissue. Peretti considered the quality of the diet to be "very good" when it included animal proteins, and he estimated that within a normal range, the body mass index of shepherds, 23.5 kg / m², was greater that of farmers, 21.5 kg / m².

In the article published in 2014 by Valter Longo of USC Davis School of Gerontology, which was widely cited by the media, V.Longo and his team (Levine E., et al., 2014) suggested that a low intake of animal protein reduced IGF-1 levels and mortality in persons between the ages of 50 and 65. The opposite effect, reduction of mortality, was observed in persons aged 65 and over that increase the consumption of animal protein. Many medical studies dealing with nutrition and gerontology address the correct content of protein in old age and points to assess the most efficient nutrients to detain sarcopenia and osteopenia, common at this stage of life (Gaffney-Stomberg E., et al., 2009). Animal protein is considered to be the most efficient, and in this category, attention has been paid to milk whey due to its assimilation and capacity to preserve and even increase muscle mass (Katsanos CS., et al., 2008). This means that the diet of Sardinian shepherds, despite moderate red meat consumption, did not entail a deficit of animal protein, thanks to the great variety of milk products and the content of whey consumed daily, both at breakfast (from sour cheese) and at dinner from ricotta cottage cheese with which bread was moistened.

The paradoxical aspects of shepherds' diet

The most relevant are the monotony of the diet, scarcity of fresh vegetables and fruit, an excess of carbohydrates in the form of bread, which can have a proinflammatory effect, and the use of pork fat as the main fat intake. The most significant aspect is the high consumption of sheep and goat dairy products and high calcium intake. Studies on cow's milk points that excess of calcium, arising from high intake of bovine dairy products, has been related to poor absorption of other micronutrients such as iron. However, studies of goat milk products carried out by a research team of the University of Granada School of Pharmacy show better digestibility and absorption of nutrients in laboratory animals fed with goat milk in comparison with those fed with cow milk (Barrionuevo M., et al., 2002; López- Aliaga I., et al., 2009).

Vitamins: During the period of transhumance shepherds had a low content of fresh food. In the study of centenarians carried out in different provinces in Italy (Polidori MC., et al., 2007), those in Sardinia showed equivalent results in levels of vitamins E, C and SOD, but slightly lower levels of vitamin A in comparison with the rest of centenarians.

We can summarize by saying that before the nutrition transition, the association of better body parameters and physical condition of shepherds with a situation of better nutrition, was mainly due to a monotonous but nutritious rich diet, both in quality and quantity, although it was not balanced in respect to certain nutrients.

The presence of other factors such as physical activity, low levels of stress and strong community support may have acted as factors to regulate their good health.

Nutritional advantages of shepherds' families with respect to farmers' families

As described in the introduction and the results, the nutritional status of shepherds' wives was similar to that of shepherds' and better than that of farmer families. They had a higher index of adipose tissue in comparison with the wives of farmers, which benefitted their fertility and hormonal system; they had less physical activity than shepherds and showed an energy balance above zero, even though they had more stress due to the responsibility of being alone to care for the family during the 6 to 9 months of transhumance.

The wives of farmers performed very hard farming work and did not have as much nutritious content as shepherds' wives, from which Peretti inferred that the diet of shepherds and their families was much better (Peretti S., 1943). In terms of health and physical condition, shepherds' wives benefitted from being close to surroundings rich in additional food resources. Healthier nutrition for fertile women may have positive consequences, since good intrauterine conditions are related to the mother's nutritional status. Furthermore, the risks of malnourishment in a pregnant woman for her children have been observed, entailing the development of non-transmissible diseases in subsequent generations (Collins JL., et al, 2009).

Controversial aspects of factors of longevity in the diet

- *Wine consumption*

Drinking a limited amount of red wine has been proposed as one of the factors that intervene in longevity in the *Blue Zones,* using the example of Ikaria and Sardinia (Buettner D., 2008), since it has been associated with a lower risk of cardiovascular disease due to its content of resveratrol and other natural polyphenols (Corder R., et al., 2006). The data obtained in laboratory studies show that resveratrol can have adverse effects on the neurogenesis of the hippocampus and on the cognitive function in mice (Park HR., et al., 2012). In addition, it does not have the capacity to extend their life in conditions of oxidative stress (Da Luz PL., et al., 2012). In human trials with elderly men, supplementation with resveratrol blunted the positive effect of physical training in blood pressure, plasma lipid profile and maximal oxygen consumption (Gliemmann L., et al., 2013). Different consideration deserves wine, its complexity and synergy of multiple components, a moderate consumption in the contest of a healthy diet may be beneficial. (Artero A., et al., 2015)

However, during the nutrition transition, wine consumption on the island was 56% lower than the Italian average, and in the studies carried out by Tessier in Villagrande in 2001, an even greater decrease of wine consumption was observed in the female population. In the shepherding higher areas of Ogliastra, there is less tradition of winemaking and wine production is limited. This activity is more common in other areas of Barbagia and Ogliastra lower lands.

The hypothesis of wine as a determining factor of longevity is thus not pertinent to the *Blue Zone* of Sardinia.

- *Calorie restriction*

Several experimental studies with laboratory animals indicated that calorie restriction together with optimal nutrition, or CRON, played a beneficial role in longevity (McCay CM., et al., 1935), (Fontana L., et al., 2010). Some authors still sustain that CRON is an effective nutritional strategy to prolong life in human beings. In the studies of longevous populations, some researchers have highlighted the reduced consumption of calories, below official recommendations, as a possible explanation of the large number of centenarians in Okinawa (Willcox DC., et al., 2009), (Gavrilova NS., et al., 2011). This finding has been questioned by other experts in the subject, who have pointed to the potential danger of promoting a calorie restriction diet based solely on studies of longevous populations (Le Bourg E., 2005, 2012), stressing that postwar generations may have suffered a negative epigenetic effect due to the calorie restriction in mothers, manifesting itself in the obesity observed at present in the new generations in Okinawa. In Sardinia, the historical data of the first quarter of the 20th century (Pereti G., 1943; Tivaroni J., 1928; Brotzu G., 1954) show that calorie consumption in the diet had increased, progressively reaching the level of other Italian regions.

Hence, one can deduce that the role of calorie restriction is not sufficiently relevant to be considered a determining factor of longevity in Sardinia **(Table 1A and Figure 1).**

The nutritional transition, link between generations

During the transition certain aspects of the diet on the island improved, with greater availability of food, an increase in the consumption of fruit, vegetables, olive oil, meat and fish.

The nutrition transition contributed to a gradual process of adaptation to the diet of the mainland and to the use of imported products, although less than on other islands of the Mediterranean (Tessier S., et al., 2005). The population that lived in urban areas and the lowlands was the first to have a greater variety of food. The greatest change for these areas was a generalized tendency to eat more than usual and to substitute the *minestrone,* legumes with lard and salted cheese, for food imported from the Italian mainland, such as pasta, which differed from Sardinian pasta; the intake of carbohydrates from traditional products, such as bread, potatoes and legumes was compensated by an increase in the diet of fresh fruit and vegetables. The use of olive oil was progressively incorporated, substituting consumption of lard. On the other hand, consumption of red meat increased as a sign of a better economic status (AA. VV., 1957), (Carbini L., 1998). However, in the 1950s in Sardinia consumption of red meat, especially beef, was still below the Italian average **(Table 3).** In the interior, the phenomenon of the nutrition transition occurred later than in the rest of the island (Tessier S., et al., 2005), and in consequence the population continued consuming the traditional diet longer. In 2001 **(Figure 5)** Tessier and Gerber carried out a study amongst the female population of Villagrande to check the degree of intergenerational transmission of the culinary habits of the area. One half of the cohort interviewed was 70 years old and had experienced the nutrition transition. In the questionnaires they revealed that they had included new products in their diet, such as fish, influenced by the

new generations, and that goat milk was substituted with newer products such as commercial yoghurt.

One of the factors considered to be of greatest importance in the longevity of this *Blue Zone* is the persistence of good habits and optimal levels of nutrition, inherited from the local tradition (Pes GM., 2014) and supplemented by the nutrition transition, which has a regulating effect on the classic diet. Research links the phenomenon with a long intergenerational transmission of the traditional forms of life, together with a wise integration of the transition processes, which provide greater balance in the diet of the people of Villagrande and entail a major vital stimulus for the elderly. The inclusion of new products in the traditional diet improves other aspects such as the sensorial one, with an increase of different tastes, and the family aspect, as it promotes generational exchange. The nutrition transition facilitates access to regular consumption of fish, thanks in part to conservation techniques and improvement in transport that allow the supply of fresh products.

Relevant aspects of the comparative nutritional study of children

The nutritional study of the children of Villagrande was carried out because of the great interest generated by the exceptional health situation of the province's most longevous persons. In addition, it was noted that the province of Ogliastra has the lowest rate of adolescent overweight and obesity in all of Sardinia.

In general terms, the children and adolescents of Villagrande show a more adequate nutritional status than those living in urban areas. The most noteworthy element of the results **(Tables numbered from 5 to 10)** is the integration of the nutrition transition in the traditional diet of Villagrande, promoted by an

efficient generational exchange of culinary knowledge and healthy lifestyle habits. This exchange is possible thanks to the admiration and respect that the elderly inspires amongst the new generations. Note should be made that the multiple positive influences of the elderly on children include initiation in the consumption of traditional food such as dairy products, artisan bread and homemade cold meats, which are prepared by the family as a part of the traditional meals. They do not contain preservatives or other chemical products, only salt and spices like pepper. Pork derivatives are used in many ways: blood, for example, is mixed with local nuts and used to prepare typical winter sweet food.

Tasks, including care of the family vegetable garden, are shared by all members of the family, with children helping their parents and grandparents with the work. All of this leads to a better choice of food and to a healthy routine in which *all meals are prepared at home*. In addition, most of the students of the rural area habitually used olive oil, which became a part of the diet of the highlands after the nutrition transition, substituting lard (Canelada A., interviews at the comprehensive school of Villagrande 2014/2015). One of the key elements of the better nutritional status of the children in Villagrande is based on the structure of the family meals, which follows the Mediterranean model, in which lunch is more important than dinner (Pes., et al., 2015). In Tessier's comparative study of the islands of Malta and Sardinia, using Villagrande as a model he concluded that the incidence of overweight and obesity observed on the island of Malta but not in Sardinia could be due not only to imported foods but also to the adoption of the Anglo-Saxon meal structure system, in which dinner is the main meal (Tessier S., et al., 2005).

As the results show **(Tables numbered 5 to 10),** the boys and girls of Villagrande have lunch at home. Their choice of dishes differs from one another: girls choose lighter lunches with salad and vegetables, which on occasions they have instead of the second course, as shown in the results of **(Table 7),** having more complete dinners in the evening **(Table 9).** This would be related to their culinary culture: within the wide range of dishes that the mother sets on the table, all the members of the family, including on occasions the grandparents, know how to choose the dishes that are most appropriate for their needs. In general, the boys have more physical activity and calorie expenditure than the girls due to extracurricular activities such as football; all villages have a football pitch (Canelada A., interviews and questionnaire administered by Gisela Rubiu, Director of the school of Villagrande 2014). They also help with daily household chores, such as milking the goats, whose milk is still part of the breakfast of many children in Villagrande **(Table 5).** They help in making ricotta and curd, and as shown in the tables of results, dairy product consumption is greater than amongst the children of Sassari **(Table 10).** The girls participate in recreational activities such as a walk in the surrounding natural areas and help their mothers with the culinary tasks including the arduous preparation of *culurgiones*, Ogliastra typical pasta made of potatoes and *pecorino* cheese. Sardinian dancing, an activity in which many young people engage, is not only a healthy physical activity but also entails significant socio-cultural exchange, bearing in mind that Sardinia's folkloric groups are recognized all over Europe.

Observations regarding obesity and overweight in Europe

School children are more exposed to social change factors such as the nutrition transition. Estimations indicate that 5% to 30% of schoolchildren in most European countries have overweight/obesity, a phenomenon which is increasing (World Health Organization 2000). *Nonetheless, this study indicates that in Villagrande the nutrition transition has had very positive effects on the population: long-lived elders and non-obese children.* This suggests the possibility that perhaps the transition is not the sole cause of obesity, which could also be due to lack of knowledge and loss of the culinary traditions, making it more difficult to choose appropriate foods. In the last 50 years there has been a progressive change of eating habits in the industrialized world (James WPT., 2008), (Hawkes C., 2006), abandoning traditional diets in favor of a stereotyped diet like the *Standard American Diet (SAD),* which is detrimental due to its influence and capacity of expansion. In Europe measures promoted by organizations such as FENS (*Federation of European Nutrition)* are being taken in this respect, with the objective of establishing a consensus regarding the values that exist in each European country in the field of nutrition, with special emphasis on the ones applicable to children and adolescents (Branca F., et al. 2007). Comparative epidemiological studies have documented the drastic changes in dietary habits of the European population (Livingstone B., 2000). Particularly an important increase of overweight and obesity has been detected amongst adolescents and pre-adolescents in Italy (Celi F., et al., 2003), with the progressive abandonment of healthy eating models (Cavallo F., et al, 2008).

Childhood is a critical time for individual development and learning healthy eating and lifestyle habits which could prevent obesity in adults (World Health Organization 2000; 2002), (Freedman DS., et al. 2005). Numerous studies suggest that incorrect nutrition in childhood may be associated with metabolic and cardiovascular diseases in adults (Flegal KM. 2005; Kaplan KM. 1986). Child obesity and overweight are related to greater consumption of precooked and processed products, with energy content but low nutrition density, including refined carbohydrates, low quality meat derivatives, hydrogenated vegetable oils, excess of sugar and salt and a reduction of quality fruit, vegetable and protein consumption, which are essential for children's growth. To a large extent, the unhealthy eating habits of adults are acquired in childhood, which is why it is important to correct these trends starting at early ages at home and in school (Dietz WH. 1998).

One of the first European initiatives in this sense is the one carried out in Denmark in the context of the so-called *New Nordic Diet* (Andersen R., et al., 2015; Adamsson V., et al., 2011) and the Danish OPUS (*Optimal well-being, development and health for Danish children through a healthy New Nordic Diet)*. The following principles are the basis of the New Nordic Diet: autochthonous gastronomical potential, sustainability and Nordic identity. The study was carried out during 2 3-month periods with 834 Danish children between the ages of 8 and 11 who were given the possibility of substituting their usual lunch box food for hot lunches which included the following NND foods: roots, potatoes, cabbage, legumes, aromatic herbs, walnuts and nuts, fish and their derivatives, top quality meat and sustainable game meat, wholegrain cereals (rye), eggs, cheese, mushrooms, marine algae, most of it from ecological sources (75%) and without additives. This intervention promotes

initiating children in their culinary culture, which is more complex and richer, with increased intake of fish, vegetables and vitamin D, and a decrease of the intake of sandwiches, trans and saturated fat. The calorie intake is the same, but the nutrient density is greater. According to this study, school is an excellent place to promote public health interventions with children, as habits learned at this age have the biggest health prevention potential.

The nutrition transition is the logical consequence of progress in society and offers greater possibilities of choice than in the past. At the same time as the nutrition transition, which has been underway for several decades in industrialized countries, there is a change in the manner of preparing and manipulating food, the so-called culinary transition (Caraher M., et al., 2004). This implies the loss of skills to prepare food with an increase of precooked and packaged food which requires no culinary ability. Both the nutrition and culinary transitions are influenced by complex motives that entail social, economic and environmental factors at the local and global level. Changes in the global system of food production, together with the incorporation of women in the labor market, have diminished the possibilities and the time available to prepare traditional homemade meals, thus giving an advantage to the food industry. Demanding quality together with clear and verified information of the products in the market is the responsibility of institutions and individuals, and at the same time provide consumers with instruments that will connect them in an efficient manner with said industry. This transformation of the culinary culture is inevitable due to environmental, social and economic evolution, but should not entail a disadvantage in citizens' capacity to choose healthy foods and enjoy the culinary arts, which is known as "food sovereignty" (Kornelson S., 2009; Short F., 2013; Lyon P., et al., 2003).

The loss of culinary skills and knowledge has a negative impact on health. According to Jaffe and Kornelson, this trend will continue and the distance between the producer and consumer will grow, even affecting the most basic needs (Jaffe J., et al., 2006; Kornelson S., 2009), producing a detriment for citizens' health, for the quality of the environment and the sustainability of local economies. Other authors observe that the availability of precooked food has caused traditional cooking (transformation of raw materials into a complete dish that integrates the local culture) to be perceived as something which is not necessary (Lang T., et al., 2001; Lyon P., et al., 2003).

According to Caraher and Lang, children and adolescents are the most affected, since by losing the capacity to learn to cook at home they are not equipped with appropriate resources to decide correctly regarding conscious consumption in an increasingly complex industrial food environment. This disconnection from the traditional methods of transforming food foments low self-esteem amongst adolescents, which impedes even more the correct choice of healthy foods (Engler- Stringer R., 2009; Broughton MA., et al., 2006).

Follow-up in 2015 of the study of eating habits of the children population of Villagrande Strisaili

In 2010 the children of Villagrande had the advantage of living in a traditional environment that had assimilated the nutrition transition in a positive manner and in which the culinary transition had not yet arrived. The study of the lifestyle of the centenarians and the questionnaire on children's eating habits (Pes G., et al., 2015) have had an impact in the media, which has boosted

awareness amongst the inhabitants and local authorities **(Appendix 4**) of the importance of maintaining their traditions and regional cuisine.

A follow-up of the eating habits of children was carried out, a questioner administers to the staff working in the school kitchen. (Canelada A., 2015). It was observed that the school menus were well balanced and well designed by nutritionists of the regional administration. Social changes occurred in the last 5 years, incorporation of women in the labor market, resulting in more children having lunch in the school cafeteria, which prepares 200 meals daily for pupils and teachers. Following the good habits of their culinary traditions, the regional health authorities have designed a menu that includes local recipes and products. The menus are programmed monthly according to the season of the year. The nutritional values are balanced, the amounts are calculated based on students' ages. In their interviews, the four cooks employed full time by the school valued the school's initiative to give students one fruit for their morning snack to avoid the consumption of processed baked goods and to open students' appetite for lunch. Note was made of the local products stored in the school kitchen's pantry, including local vegetables, pasta and cheese. The cooks devote the necessary time to preparing the dishes. The epidemiologists Tessier and Gerber highlighted that the new generations of women in Villagrande devoted the same amount of time as their mothers in preparing lunch (Tessier Sophie., Gerber Mariette., 2005). The annex contains two examples of a weekly menu at the school of Villagrande in November 2015, differentiating between primary and secondary school children **(Appendix 3).**

Limitations

7. LIMITATIONS

The limitations of the historical study are proper of research work that analyses nutritional data ranging from the 19th to the mid-20th century. The literature in English, French and Italian that was reviewed does not use the same standards employed at present in scientific studies of nutrition. In some cases, an adaptation was made, assigning a numerical value to assessments of the physical and nutritional status of the population used by the first hygienists. Following a thorough analysis of numerous texts, relevant data was extracted, endorsing the validity of the study.

In respect to the comparative study of the child population, the choice of the size of the sample was conditioned by the fact that it was carried out in Villagrande, with 3,500 inhabitants and primary and secondary school children, estimated to represent 5 to 7% of the population. Hence the sample does not have the necessary statistical size to allow for a more in-depth analysis of more specific nutritional aspects between the two cohorts, since the questionnaire format does not consider the calories consumed in both populations.

The children's physical activity was only considered in Villagrande, given that the interviews to the families were carried out as part of field work on the lifestyle of the entire population of the village. For this reason, comparative tables with respect to Sassari are not provided.

Conclusions

8. CONCLUSIONS

1. Placing the *Blue Zones* concept in a specific academic framework was a necessary introduction to guide this work since the longevity population studies are not broadly known.

2. Healthy aging is the characteristic trait of Sardinia's pastoral society. Taking Sardinian shepherd society as a model, it is possible to conclude that in their pretransition history they took maximum advantage of available natural resources and were perfectly well adapted to their environment. All the family benefited from this optimum nutritional situation. The male longevity of Sardinian *Blue Zone* is exceptional, and it is not in detriment of female longevity, which also proves the effectiveness of their family model.

3. The efficient integration of the transition diet in their traditional diet favored the rapid improvement of the nutritional status of the future centenarians of this *Blue Zone,* giving a significant stimulus to their health in this critical period of life when the body begins its process of degeneration. The perfect conjunction of innate and acquired enabled them to attain an exceptional age.

4. An essentially vegetarian diet, consumption of red wine and calorie restriction are NOT determining factors of longevity in Sardinia. A multidisciplinary study is needed to clarify these controversial points regarding *Blue Zones* and their postulates as reflected in the media.

5. It is possible to conclude that the nutrition status of the students of Villagrande was more balanced and of greater quality

than that of their fellow students in urban areas, which would explain the lower rate of overweight and obesity.

6. The relevant point that stems from the comparison of generations in Villagrande Strisali is the continuity of traditional habits: eating at home, consuming local products and the respect for traditions that are transmitted by adults. Children benefit from a traditional structure that has demonstrated being efficient for previous generations. The success of this transmission of values is a positive model to recreate in a present-day context.

7. Population longevity offers the opportunity to carry out studies, like the one presented in this thesis, to assess aspects of current policies in the field of public health and nutrition. The feasibility of an evolutionary model, based on circular local economy, respecting the idiosyncrasy of each location could be considered. In addition, the present study highlights the importance of regulating the diet in childhood and in the elders as these two groups are the most vulnerable of our society and should be protected from imbalance diets as those promoted by mass media.

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Appendices

10. APPENDICES

1. PARENTAL PERMISSION TO ANSWER THE QUESTIONNAIRE

CONSENSO INFORMATO PER LA PARTECIPAZIONE AL PROGETTO:

"Educazione alimentare. Conoscenze nutrizionali ed intergenerazionali"

Approvato in data 28/01/2010 con delibera della Giunta Provinciale dell'Ogliastra del 22/12/2009

Questo modulo deve essere approvato e firmato dal genitore dell'alunno o da chi ne fa le veci.

Io sottoscritto ..... genitore dell'alunno.....

autorizzo mio figlio/a a partecipare allo studio dal titolo *"Educazione alimentare. Conoscenze nutrizionali ed intergenerazionali"* promosso dall'Istituto Comprensivo di Villagrande Strisaili in collaborazione con l'Università di Sassari e la ASL n°4 di Lanusei e che si svolgerà presso la l'Istituto Comprensivo di Villagrande Strisaili.

Dichiaro di aver ricevuto una copia del consenso da conservare, e di averne compreso le finalità adeguatamente illustrate dai promotori dello studio.

(barrare la casella)

❑ autorizzo, per gli scopi previsti da questo progetto il trattamento dei dati personali che riguardano mio figlio, in formato cartaceo ed elettronico, nel rispetto delle normative vigenti, ai sensi, del Decreto Lgs. 196/2003 sulla privacy.

❑ autorizzo inoltre a fornire i dati sull'indagine intergenerazionale mirata a conoscere e studiare la trasmissione delle conoscenze nutrizionali tra le varie generazioni

Firma leggibile del Genitore o di chi ne fa le veci

.....

Data: ...../...../2010

2. QUESTIONNAIRE ON EATING HABITS OF CHILDREN IN SARDINIA

In this questionnaire, you are asked to answer questions about your diet and lifestyle.

Part 1 Personal Information
1. Age:
2. Gender: o Male o Female
3. Weight:
4. Height:
Part 2 Eating Habits
5. Do you have breakfast in the morning? o Yes o No
6. Where do you have breakfast? o At home o In a bar
7. If you do not have breakfast, why is that? o I do not have time. o I am not hungry.
8. What do you usually have? (Mark the food that you have for breakfast.) o Milk o Cereals

- Barley
- Chocolate
- Biscuits
- Coffee
- Coffee with milk
- Tea
- Pizza
- Juice
- Sandwich
- Sweet food
- Rusk/butter/marmalade
- Bread with chocolate spread
- Other

9. Do you have a snack mid-morning?

- Yes
- No

- **What snack do you usually have?**
- Sandwich
- Snacks
- Pizza
- Coffee with milk/ coffee
- Sweet food (processed baked goods or similar)
- Fruit
- Other

10. Where do you usually have lunch?

- At home
- At the cafeteria
- At a bar
- Along the way

11. What do you usually have for lunch?

- First course ("Primo")
- Second course ("Segundo")
- First and second course

○ Fruit/ vegetables ○ Sandwich ○ Full meal (First course, second course and fruit) ○ Potato chips ○ Other
○ **What do you usually have for your afternoon snack?** ○ Sandwich ○ Snacks ○ Pizza ○ Coffee with milk/ Coffee ○ Sweet food (processed baked goods or similar) ○ Fruit ○ Potato chips ○ Other
12. Where do you usually have dinner? ○ At home ○ At the cafeteria ○ At a bar
○ **What do you usually have for dinner?** ○ Sandwich ○ Pizza ○ Coffee with milk/coffee ○ Sweet food (processed baked goods or similar) ○ Fruit ○ Other
13. Do you drink coffee? ○ No ○ Yes (….cups a day) ○ Sugar (…. spoonful)
○ **Do you drink tea?** ○ No ○ Yes (….. cups a day)

○ Cold tea (…. glasses a day) ○ Sugar (…. spoonful)
Part 3 Frequency of foods
14. How often do you eat meat? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
15. How often do you eat fish? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
16. How often do you eat cheese? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
17. How often do you eat cold meats? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
18. How often do you eat fast food? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week

○ More than 7 times per week
19. How often do you eat vegetables? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
20. How often do you eat fruit? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
21. How often do you eat legumes? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
22. How often do you drink wine? ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
23. How often do you drink sweet drinks? (Juice, Sprite, Fanta) ○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
24. How often do you eat ice cream and pastries?

○ Never ○ 1-2 times per week ○ From 3 to 5 times per week ○ From 6 to 7 times per week ○ More than 7 times per week
25. How much water do you drink every day? ○ Less than half a liter ○ Between one half liter and one liter and a half ○ More than one liter and a half
26. What type of dressing/seasoning do you use? ○ Olive oil ○ Seed oil ○ Butter ○ Margarine ○ Mayonnaise
27. Do you add salt to dishes? ○ Never ○ Sometimes ○ Always

3. EXAMPLE OF A WEEKLY WINTER MENU IN 2015

AZIENDA USL N.4 LANUSEI (for nutrition)

VILLAGRANDE SCHOOL CAFETERIA

First week of November for Primary School

Days	Menus	Amounts
MONDAY	*Malloreddus alla campidanese* (Local pasta 80 gm + Sardinian sausage, pecorino and onion)	…… ……..
	Cheese (Bel Paese)	50 gm
	Stir-fry vegetables (zucchini 100 gm + oil 5 gr)	……
	Bread	80 gm
	Fruit (winter melon)	150 gm
TUESDAY	Baked lasagna	……
	Beef escalope with lemon	50 gm
	Salad (vegetables 100 gr + oil 5 gr)	…….
	Bread	80 gm
	Fruit (tangerine)	120 gm
WEDNESDAY	Vegetable *Minestrone* (vegetables 200 gm+ pasta 20 gm + oil 5 gm)	…… ……..
	Roasted chicken	80 gm
	Baked potato (potatoes 200 gm + oil 10gm)	……..
	Bread	80 gm
	Fruit (apple)	120 gm
THURSDAY	Rice with *porcini* mushrooms (local)	……..
	Baked meatballs	……..
	Baked vegetables (vegetables 100 gm + oil 10 gm)	……..
	Bread	80 gm
	Fruit (orange)	120 gm
FRIDAY	Pasta with tuna and tomato sauce (pasta 80 gm)	……
	Baked fish filets (swordfish 70 gm + oil 5 gm	……
	Fresh salad (vegetables 100 gm + oil 10 gm)	…… ……
	Bread	80 gm
	Fruit (pear)	120 gm

Second week of November for Secondary School

Days	Menus	Amounts
MONDAY	Legume and cereal soup Milanese style Turkey escalope's (turkey 80 gm+ egg 10 gm + breadcrumbs 25 gm + oil 10 gm) Baked potato (potatoes 200 gm + oil 10 gm) Bread Fruit (plantain)	…… …… …….. 100 gm 150 gm
TUESDAY	Pasta with meat ragout (pasta 100 gm + parmesan 7 gm + meat ragout) Boiled egg with fresh tomato (tomato 150 gm + oil 5 gm Bread Fruit (tangerine)	…… …….. …… …….. 100 gm 150 gm
WEDNESDAY	*Culurgiones al sugo* (local artisan pasta made with potato, pecorino cheese) (*Culurgiones* 150 gr + parmesan 5 gm + basil and tomato sauce) Meat stew (beef 90 gm + oil 5 gm + spices) Mixed salad (vegetables 200 gm + oil 5 gm) Bread Fruit (apple)	…… …… …….. …… …… …… 100 gm 150 gm
THURSDAY	Rice with parmesan or pecorino cheese (Rice 80 gm + oil 10 gm + parmesan 7 gm) Herbed trout (Trout fillet 130 gm + oil 5 gm + spices) Vegetables cooked with garlic and parsley (vegetables 200 gm + oil 10 gm) Bread Fruit (orange)	…… …….. …… …… …… …… 100 gm 150 gm
FRIDAY	Pasta with broccoli (pasta 100 gm+ broccoli 150 gm + oil 5 gm + pecorino cheese 7 gm) Grilled steaks (pork or horse) Fresh vegetables (cucumber 150 gm + oil 5 gr) Bread Fruit (pear)	…… …… …….. 90gm …… 100 gm 150 gm

4. News in the press about the initiative of the Villagrande Strisaili school, University of SASSARI, and local health authorities (ASL)

24 | L'UNIONE SARDA — PROVINCIA OGLIASTRA — martedì 16 marzo 2010

Villagrande. Un progetto accomuna istituto comprensivo, Provincia, Asl e Università

Il pistoccu alla riscossa sugli snack

La scuola insegna ai ragazzi regole della sana alimentazione

Nel paese dei centenari si insegna il culto della buona tavola. Mangiar sano per prevenire le malattie: un ingrediente dell'elisir di lunga vita.

Nel paese dei cinque centenari viventi, la scuola intende promuovere la cultura della sana alimentazione made in Ogliastra, fattore principe della longevità. E Villagrande annuncia la rivalsa del pistoccu sulle merendine dai nomi accattivanti. Il progetto pilota si intitola Studio delle abitudini alimentari e dello stile di vita di una popolazione scolastica dell'Ogliastra', è finanziato dalla Provincia e viene portato avanti dall'Istituto comprensivo di Villagrande, guidato da Gisella Rubiu, in collaborazione con la Asl 4 e con la Scuola di specializzazione in Scienza dell'alimentazione dell' Università di Sassari.

«La ricerca - spiega Gisella Rubiu - ha già avviato i primi passi. Si propone di studiare le abitudini alimentari e la trasmissione intergenerazionale delle conoscenze nutrizionali su un campione di 100 allievi delle classi quarta e quinta elementare e della prima e seconda media, in modo da assicurare continuità all'esperimento».

Gianni Pes e Francesco Tolu, i ricercatori dell'Università sassarese che collaborano al progetto, hanno già condotto in Ogliastra importanti ricerche sullo stretto legame che lega l'alimentazione tradizionale alla longevità. «La promozione di uno stile di vita sano - sostengono gli estensori del progetto - rappresenta una delle priorità nelle strategie di educazione alla salute. Per promuovere questo stile di vita occorre incentivare un'alimentazione equilibrata sin dall'età infantile, quale garanzia per la salute in età adulta e un minore rischio di sviluppare malattie cardio metaboliche».

L'indagine epidemiologica, condotta in collaborazione con Gisella Meloni, diabetologa della Asl di Lanusei, verterà sulle abitudini alimentari degli studenti che parteciperanno allo studio e sulle loro conoscenze in tema di alimentazione oltre che sul loro stile di vita per valutare i rischi di sviluppare patologie cardiovascolari, obesità e diabete. È noto altresì che proprio durante questa fase si possa instaurare uno scorretto stile di vita (consumo di alcool, fumo e sedentarietà) che favorisce la comparsa di patologie da malnutrizione. Anche il rendimento scolastico dipende in misura non trascurabile da un corretto stile alimentare che deve essere quindi appreso il più precocemente possibile. «L'alimentazione - conclude Gisella Rubiu - fa parte del patrimonio culturale della società. Le abitudini legate all'alimentazione vengono trasmesse a livello intergenerazionale con modalità che sono parte integrante della nostra identità sociale».

NINO MELIS

The pistoccu to rescue children from snacks and the school teaches the children the rules of healthy eating.

In the land of the centenarians, the cult of good food. To eat healthy and prevent disease: an ingredient in the elixir of life. In the village of five living centenarians, the school intends to promote the culture of healthy nutrition made in Ogliastra, one of the main factor of longevity. Villagrande Strisaili announces the revenge of the pistoccu on snacks with captivating names. The pilot project is entitled "Study of the Eating Habits and Lifestyle of a School Population of Ogliastra"', it is carried out in the Comprehensive Institute of Villagrande in collaboration with the Department of Food Science of the University of Sassari. It will analized intergenerational transmission of nutritional knowledge on a sample of 100 pupils of the fourth and fifth grade.

The promotion of a healthy lifestyle - represents one of the priorities in health education strategies, this incentives in childhood, are a guarantee for health in adulthood and a lower risk of developing cardio metabolic diseases. It is also known that during this phase an incorrect lifestyle can be established (consumption of alcohol, smoking and a sedentary lifestyle) which favors the onset of malnutrition pathologies.

Academic performance also depends to a considerable extent on the correct eating style which must therefore be learned as early as possible.. Habits related to food are transmitted intergenerationally in ways that are part of our social identity ".