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A Tuna Vendor. She Holds in Her Hand Tunas Which Sell for One Cent. The Tip of the Maguey (Agave) Leaf With Which They Are Eaten is Shown.

THE TUNA AS A FOOD FOR MAN

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The Tuna as a Food for Man

CONTENTS

	Page
Introduction	9
The Common Name	10
Cultivation of the Nopal	12
The Tuna Markets	13
General Description of the Fruits	16
The Epidermis	17
The Rind	17
The Pulp	18
The Seed	19
The Refuse	19
Harvesting the Tuna	20
Harvesting for Immediate Consumption	20
Gathering Cultivated Forms	21
Gathering Wild Forms	21
Gathering for the Market	22
Comparison of Different Methods of Harvesting	22
Keeping Qualities of Tunas	23
Tuna Products	24
The Machinery Used in Making Tuna Products	26
Miel de Tuna	28
Melcocha	29
Queso de Tuna	30
Colonche	31
Relation of Tunas to Finished Product	32
Dried Tunas	33
Methods of Analysis	35
Composition of Tunas	39
Protein	40
Albuminoids	41
Amids	41
Acidity	42
Sugars	43
Alcohol Precipitate	47
Ash in Alcohol Precipitate	48
Starch	49
Ash	49
The Species and Varieties of Tunas Studied	51

Illustrations

COVER PAGE.—A tuna vendor. She holds in her hand tunas which sell for one cent. The tip of the maguey (Agave) leaf with which they are eaten is shown.

PLATE I.—Tuna Camuesa (*Opuntia larreyi* Weber). Reduced to one-half lineal dimensions.

PLATE II.—Harvesting tuna cardona.

Figure 1. Gathering tunas for immediate consumption.

Figure 2. Peeling tunas for immediate consumption.

PLATE III.—Tuna seed, and a scene upon the tuna market at San Luis Potosi, Mexico.

Figure 1. General view of a tuna market.

Figure 2. Seeds of edible tunas, natural size.

Fig. 1. No. 8142, Tuna naranjada.

Fig. 2. No. 8036, Tuna cuija.

Fig. 3. No. 8037, Tuna ranchera.

Fig. 4. No. 8038, Tuna palamita.

Fig. 5. No. 8039, Tuna mansa morada.

Fig. 6. No. 8135, Tuna joconoxtle.

Fig. 7. No. 8134, Tuna vinatera.

Fig. 8. No. 8136, Tuna chavena.

Fig. 9. No. 8141, Tuna pachona.

Fig. 10. No. 8050, Tuna teca, tuna blanca teca.

Fig. 11. No. 8051, Tuna cardona (*Opuntia streptacantha*.)

Fig. 12. No. 8150, Tuna durasnilla colorada.

Fig. 13. No. 8143, Tuna durasnilla blanca.

Fig. 14. No. 8146, Tuna blanca.

Fig. 15. No. Tuna camuesa (*Opuntia larreyi* Web. type, from Englemann herbarium).

Fig. 16. No. 8140, Tuna camuesa (*Opuntia larreyi*).

Fig. 17. No. 8065b, Tuna taponna (*Opuntia robusta* Wendl).

Fig. 18. No. 8065a, Tuna taponna (*Opuntia robusta* Wendl).

PLATE IV.—Dry tunas (Tunas pasadas).

Figure 1. Peeling tunas for drying Montesa, Mexico.

Figure 2. Drying tunas in the sun, Montesa, Mexico.

PLATE V.—The nopal and a tuna machine.

Figure 1. A seeder dissected.

Figure 2. Nopal agua-mieilla, Dublan, Mexico.

PLATE VI.—A "Queso de tuna" factory, Los Campos, Zacatecas, Mexico.

Figure 1. Exterior of factory showing furnace and flues.

Figure 2. Interior of the factory, showing seeders, evaporation kettles, etc.

PLATE VII.—In prickly pear thickets.

Figure 1. A temporary camp in a tuna thicket at harvest time, State of Zacatecas, Mexico.

Figure 2. First crop of tunas in the second year from two to three-joint cuttings. (Nopal manso morado). San Luis Potosi, Mexico, August 20, 1906.



"TUNA CAMUESA"

(Illustration $\frac{5}{8}$ actual size. SEE PAGE 56)

Preface

The bulletin presented herewith represents three lines of investigation—a study of the uses of the tuna (too nah), a study of the chemical composition of the tuna, and a study of the tuna products as manufactured by the primitive peoples of the Republic of Mexico. The authors have joined these three lines of work in one report, which is here presented under the caption "The Tuna as Food for Man." The bulletin has involved a large amount of labor in its preparation, and is a good example of the benefits to be derived by co-operation between field and laboratory workers whose special lines of investigation are diverse. The field knowledge combined with laboratory investigations always has a tendency to give economic bearing to the treatment. In this case a knowledge of the economic practises in Mexico has furnished the point of view from which the more scientific laboratory investigations have been broached.

There is presented in the paper actual economic practises, which are of interest not only to portions of the United States but to some of our insular possessions as well, botanical data necessary to the recognition of different species and varieties, and a large amount of chemical information of unusual interest. The botanical notes have been abridged as much as possible consistent with a clear presentation. In many cases they have been omitted almost entirely, but in all such cases they will be found more fully presented in Bulletin No. 60 of the New Mexico Station.

Interest in cacti in general, from both a food and a forage standpoint, has been greatly stimulated by popular writers during the past two or three years, and investigations of the nature presented herein have been sorely needed. There are but few edible tunas grown in this country, however, and these are mostly found in small, usually varietal collections of the warmer regions. In order to get an adequate idea of the

importance of the subject, and in order to secure a basis for future investigations in the development of forms better adapted to our use, it has been necessary to treat the subject from the broad point of view of the continent rather than the United States. As will be seen, a few valuable tunas are now grown within our borders. The forms, however, are comparatively few in number while the Mexican species are very numerous. Many of the latter have very desirable characteristics which if combined with species now grown here would make a very superior fruit. The data presented in this bulletin, while intended mainly as an account of the tuna as it exists today in the United States and Mexico, forms an important foundation for future investigations in the development of more desirable forms, a work which is now in progress.

The title of the writing contains the word tuna which is the Spanish for the fruit of the prickly pear plant or that section of the botanical genus *Opuntia* which bears flat jointed stems. The fruit of one *Opuntia* with cylindrical joints is also included in the bulletin for reasons stated in the text. There are many other cactus fruits that should be investigated as the tunas are here. Some work has already been done upon them and will be continued as time permits. The term pitalla (pe-tah-ya) is used by the Mexicans for a very large and heterogeneous group of cactus fruits belonging to such botanical genera as *Cereus*, *Echinocereus*, *Echinocactus*, *Pilocereus*, etc. In another publication it is proposed to treat these pitallas as the tunas are treated here.

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Agriculturist.

U. S. Department of Agriculture.
Washington, D. C., May 22, 1907.

Introduction

The prickly pear of the American and Australian, the Indian fig of the Englishman, the Barbary fig of the Frenchman, the tuna of the Spanish American, and the higos chumbos of the Spaniard is a fruit concerning which there are more varied beliefs, contradictory opinions, and grades of appreciation than concerning any known to us. The plant and its fruits are subjected to both praise and abuse. While the Mexican prays that there may be no rain when the plants are in bloom that the fruit may set well and produce a good crop of tunas, the legislative assemblies in some of the Australian colonies pass laws looking toward their eradication. While the Australian governments spend much money to eradicate the "weed", some ranchmen find that it can be fed to stock with profit. While the Southern Texan was imploring the Government in the early nineties to conduct investigations looking to the eradication of prickly pear, shrewd cattlemen and ingenious machinists were devising means whereby it could be divested of its objectionable characteristics at small expense and turned to a profitable use. While the Minister of Agriculture of India pronounced against its use in unqualified terms, it was found in this country that it could play a profitable role in both beef and dairy production in at least one section of the United States. While the South African is said to revile its presence, the poorest inhabitants of the Island of Sicily are said to largely subsist on its fruit for three or four months each year. The average American traveling in Mexico can see no value whatever in the tremendous stretches of prickly pear upon the Plateau, but the native peon grows these plants and similar ones in his orchards and gives them fully as careful attention as any plants which he attempts to cultivate.

Enthusiastic magazine writers would revolutionize conditions in the arid regions by the establishment of plantations of prickly pear without spines, thus converting the most arid deserts into populous, prosperous communities. Experience teaches, however, that the spineless varieties of cultivation are not hardy under natural desert conditions; that all of the valuable spineless species which produce either fruit or forage

in economic quantities require considerable precipitation at some time during the year; and that economic species are not known which thrive under a maximum temperature of less than 10°F. One exception to this may be noted in the case of *Opuntia arborescens* of Colorado; but the amount of stock feed produced by this species is comparatively small and its distribution limited.

Conservative judgment based upon observation and experiment, on the other hand, would pronounce many species of prickly pear to be decidedly susceptible to cultivation and highly productive of both fruit and forage under proper conditions of temperature and moisture. It is also true that there are species which thrive under moderate extremes of heat; that, as a rule, they are adapted to conditions of periodical rainfall and thrive where the distribution of moisture is too irregular and uncertain for commonly cultivated crops; that the spines and spicules have been practically successfully eliminated from the plant body in valuable species but not from the fruit; that all of the so-called spineless forms concerning which we have definite knowledge are less hardy, especially toward drouth conditions, than spiny natives; that it is quite probable that by persistent breeding and selection the spines and spicules may be more completely removed and the plant bred to withstand a greater degree of cold; that the plants can be fed together with more concentrated foods with profit; that the fruit is now, in its spiny condition, an important and highly prized ingredient in the diet of the poorer classes of Mexico and Sicily especially; and that highly prized products are prepared from the fruits; that the group is of sufficient economic promise to merit thorough investigation.

The Common Name

The common names which are used in this bulletin have been selected with the utmost care. They are based upon a careful investigation of all of the important prickly pear regions of the United States and Mexico. Unless otherwise indicated, it is believed that they are accurate. In each instance, unless the name is questioned in the text, it has been

verified many times. The orthography of the common names has, in nearly every case, been verified by educated Mexican gentlemen as well as by our own ideas based upon their derivation. We are much indebted to Sr. Enrique L. Guerra for suggestions and corrections of our list of popular names as well as for much valuable information upon all phases of the subject.

The popular names are, as a rule, quite the same in one locality, but there may be great variation when one compares names of species in different localities. Some well marked species, however, have apparently the same name wherever found. The names *cardona*, *tacona*, *camueso* and *amarillo* are, so far as our experience goes, invariable; but, as stated, they are very characteristic species which even the least observant can not well mistake. It is entirely different with the yellow or green fruited forms (including the tame or cultivated ones). These have a multitude of names by which they are known. Some of them may and probably do represent good specific distinctions. On this point we can not yet be certain, as our experience with the different forms has not been extensive enough. Some of them are spiny, others almost perfectly spineless and even in some cases apparently without spicules on either fruit or joint. In general aspect they are all very much alike and the names applied to the different forms do not appear to be at all uniform. To illustrate; some of the names used for the greenish-white fruited forms are as follows: *Nopal blanca*, *nopal teca*, *nopal paloaltena*, *nopal fafayuca*, *nopal Mexicana*, *nopal Americana*, *nopal Castilla blanca*, while *nopal lisa* is commonly used, but the latter name is applied to any thornless form. They all appear to be closely related to one form of our southwestern "mission pear", although with us this is nearly always a thorny form, while the greenish-yellow fruited forms of Mexico may exhibit any degree of spininess.

It must be understood that any list of common names of Mexican tunas can only be of tentative value after all, for there may be even less uniformity in popular names than in this country. In one locality, however, the name used for one species or variety is reasonably constant. The commercial

spirit has no influence here in a change of names, but the use of any name has come about by general custom.

As with many other natural and agricultural subjects, it is the native peon who is the court of final resort upon the names of plants. The ranchman when asked regarding the matter will almost invariably put the question to one of his more intelligent servants. The names used here have been obtained mainly from the peons and have subsequently been verified and examined by educated and intelligent ranchmen.

Cultivation of the Nopal

There are in Mexico many varieties of prickly pear which are found only in cultivation. This is especially true of the spineless forms in general. Others are native and may or may not be cultivated. Of the first group the peon may speak collectively as *mansas* or tame forms, but he has names for all of the varieties which are grown in his orchards as well as for the wild ones of the mountains.

To say that any of the forms are cultivated as we think of cultivation in this country, however, is a gross error. They are rarely ever cultivated. Cuttings are put into the ground and surrounded by a fence to protect them from animal depredations. Aside from this they get little or no cultivation.

A plantation is always started from cuttings, consequently it is an easy matter to maintain uniformity in the quality of the stock. Inasmuch as it is always an object to get tunas as soon as possible—the stock-feed side of the crop being always a secondary consideration—cuttings of three joints are planted when possible. A cutting consisting of two and one-half joints is common. When planted in this way it is said that a crop of tunas is produced the third year, while it takes five years to get one from one-joint cuttings.

Plantations are not confined to the *mansas*. On the contrary, the wild forms will often be found in the orchards under protection and are even planted without protection in the hills. Such forms as the *cardona* are admirably adapted to this purpose, for animals can not molest it much. The thickets of this species east of San Luis Potosi have been

greatly extended by planting cuttings in unoccupied areas. Several acres were planted there last year in this manner. How much of this has been done in the past is difficult to say for it is not always easy to tell the difference between areas which have been planted and those which have not. Quite likely many of the thickets found in the hills have been in a measure, established by the influence of man, some of them unwittingly, for the method of collecting the fruit scatters joints about, many of which strike root and grow. Some of the thickets in the vicinity of Alonzo, Mexico, are being slowly extended by this method of collecting the fruit.

The Tuna Markets

A very distinctive feature of the markets of the different cities of the highland region of Mexico is the space or booths assigned to the sale of tunas. The business is generally carried on by the poorer population in the most simple and primitive way. Not that the poor are the only ones who eat them, but they are eaten more extensively by the poorer class than any other. Plate III, Fig. 1, gives a good idea of the appearance of the tuna markets.

During the greater part of the season purchasers come to these booths, separated entirely by the size of the individual awnings or length and number of the benches and stools, where they may purchase one or more varieties of fresh tunas at a very low price. The purchaser is supplied with a stool, upon which he can sit, and a knife with which to peel the tunas. During the height of the season, when the fruit is cheapest, women appear on the markets each morning with huge baskets of them ready peeled, which they place in earthen saucers, and dispose of for one cent each (cover page). Each purchaser is furnished with a tip of maguey leaf or a thorn of the mesquite with which to eat the pulps, or, in a few instances, we have seen modern wooden toothpicks served with them.

By far the greater amount of fruit is sold unpeeled. This is especially true during the season when fruits are not abundant, for less waste attends it. Sometimes the purchaser

peels the fruit himself and at others he eats it as the vendor or his attendant peels it for him.

The process of peeling is practically the same as described beyond, the knife being run across the top and down one side to the base, when the pulp may be picked out easily. When fully ripe much of the rind of some species is consumed with the pulp. When this is done the tuna is taken between the thumb and forefinger of the left hand and the rind cut off with a sort of whittling motion of the knife, each stroke taking off the epidermis and a portion of the rind. In reality, not over one-half of the rind is ever eaten. In peeling the larger *mansa* (cultivated) forms, both ends are usually cut off and an incision made through the rind lengthwise between these two cut surfaces, when the remainder of the outside is removed by being pushed back with thumb and forefinger of each hand.

To remove the spicules, so that the fruit can be more easily handled, the vendors employ several simple devices. Sometimes the tunas are rolled around upon the sand by the aid of a bundle of small twigs or a bunch of weeds. At other times they are removed with a wisp of grass or brush made of maguey fibers. Often they are stirred in a pail of water. Any of these processes will remove the spicules fairly well if the fruit is thoroughly ripe. It should be remembered that there are no prickly pears without spicules. Even the so-called thornless ones, which have been developed in the Mediterranean region and eight or ten of which have been apparently produced in Mexico, all have some spicules upon the fruit, although the spines have been quite effectually bred off the plant body. Also, in nearly all cases, there are produced upon the fruits hair-like, fugacious spines, most of which drop off or are easily removed when the fruit is ripe. The spicules are the most serious obstacle to the use of this fruit.

As stated above, it is the pulp which is usually eaten; less often some rind is also consumed with it. It is well known that the pulp itself is very seedy, and on this account objectionable to the average American, although the Mexican swallows seeds and all with apparent indifference. Both the pulp and rind of *cardona* and *durasnilla* are eaten late in the sea-

son. In the latter fruit the pulp is not easily separable from the rind, but in the former it is.

The price of tunas upon the market varies greatly with the season. During the past year the cheapest were found at San Luis Potosi, where the cardona is sold as low as 15 to 20 for one cent* and the large mansas as low as 6 for a cent. In Guadalajara where tunas are rare, 3 to 5 cardonas for one cent and one amarilla, naranjada, or other mansa for the same price was the rule. During the month of August cardona was selling at San Luis Potosi for about 45 to 50 cents per crate of a thousand tunas wholesale; at the same time they were sold upon the market at the rate of 14 for a cent. It is said that one man can pick about three crates a day.

An attempt was made to determine how much of this fruit is eaten by the average peon in a day, but with no satisfactory results. We have repeatedly seen men eat 25 to 50 without stopping, and have had peons tell us that they eat on an average of about 100 per day. We believe, however, that where the diet is made up largely of tunas and they are conveniently at hand, upward of 200 per day are consumed by one individual. We have had intelligent and conservative ranchmen estimate to us that a man will easily consume many more than this of tuna cardonas per day when in the hills where practically no other food is available. This represents very often in the largest measure both food and drink, but it seems like a very heavy ration when one considers that the seeds as well as the pulp are swallowed. It has been our experience that one not accustomed to the fruit can eat 60 to 80 tuna cardonas and not swallow the seed. We have done this on one or two occasions in about two hours time.

It must be remembered that the pulp of 40 to 50 tunas (cardona) forms quite a bulky meal; the seeds are, of course, not digested. It is claimed that only a few of the species can be eaten in large quantities without danger. There is said to be no danger at all from eating any number of tuna cardonas, unless it be immediately after a heavy meal consisting largely

* Unless distinctly specified to the contrary, the prices quoted are in Mexican currency. U. S. equivalents can be obtained approximately by dividing by 2.

of meat. On the contrary, it is claimed that the mansas must be partaken of sparingly on account of their interference with digestion when eaten too freely. A peon is quite careful in eating tuna tapona because he believes it produces intense constipation. They claim that death has resulted in some cases from eating too much of this fruit.

The excreta, both solid and liquid, are decidedly colored when the red tunas, especially tapona, are eaten. So far as we have been able to learn, however, tuna cardona is the universal favorite and apparently results in no injury whatever, even when partaken of very freely. The natives' explanation of the injurious effects of the mansas is that they are too rich.

Where there are so many tunas consumed there is, of course, a large quantity of rind, and in the manufacture of "queso" and other products the quantity of seed taken out is quite large. Upon one ranch visited the by-products were fed to hogs. Upon the markets at San Luis Potosi during the month of August, the rinds were selling at the rate of ten cents to twelve cents per basket of about 50 pounds. They were consumed largely by dairy cattle, and were also fed to burros and hogs.

General Description of the Fruits

The fruits of prickly pear vary in size, shape and color, depending upon the species and conditions under which they are grown. They are from one to three inches in diameter and are usually pear or fig-shaped, but in some species they are nearly spherical. They will weigh from an ounce to a half pound or more, and vary when ripe from a yellowish-green to a dark purple color.

All varieties have minute spicules arranged in bunches over their surface, there being about one bunch to every square inch of surface in the best varieties, but in most species they are more numerous than this. The fruits of nearly all of the species have large spines also, which correspond to those of the plant body, but they are much more delicate and usually drop off before the fruits are thoroughly ripe. A cross section through the fruit shows it to be covered with a thin skin

TABLE NO. II.—COMPOSITION OF PULP

Collector's Number	Date of Analysis	Locality	Scientific Name	Common Name	Number per Pound	Average Weight in Grams					PERCENTAGE COMPOSITION OF EDIBLE PORTION																		
						Per cent. Rind	Per cent. Seed	Per cent. Refuse	Per cent. Edible	Total Solids	Soluble Solids	Specific Gravity of Juice	Total Solids in Juice	Total Proteids *	(N × 6.25) Aluminoids	(N × 4.55) Amids	Water Soluble Proteids (N × 4.55)	Acids Expressed as H ₂ SO ₄	POLARIZATIONS			Increase by Polarization	Decrease by Reduction	Total Sugars as Dextrose (Millin)	Ash in Soluble Solids	Alkalinity of Ash as K ₂ CO ₃	Alcohol Precipitate		
																			Direct	Invert	Temperature								
No. 2	'05	San Antonio, Texas	<i>Opuntia lindheimeri</i>	Prickly pear, Nopal	6.30	71.63	66.32	5.41	71.73	38.27	7.78	1.033	7.98	.201	.068	.143	.156	.700	+ 3	- 4	30° C	-.53	.00	7.18	.17	.027			
3	'06	"	"	"	18.12	33.00	67.00	7.80	74.80	33.30	1.928	4.8	.284	.48	.88	.88	1.18	+ 5	- 7	26° C	.15	.41	5.24	.42	.276	.394			
4	'06	"	"	"	13.78	32.96	58.00	6.71	66.71	33.29	7.80	7.37	1.030	7.27	.284	.88	.88	+ 0.0	+ 0.0	24° C	.00	.00	1.41						
5	'06	"	"	"	21.57	31.00	61.90	6.19	68.09	31.91	7.13				.459			+ 0.0	+ 0.0		.00	.00							
6	'06	"	"	"	17.07	36.54	66.90	9.57	76.47	23.33	5.33							2.15	+ 1.2	+ 3.3	33° C	.08	1.04	9.07					
Average of all Texas Samples.					15.37	35.43	64.02	7.54	71.56	38.44	6.74	7.47	7.03	.356	.068	.143	.220	1.228	-.067	-.367	27° C	.23	.14	2.94	.30	.152	.394		
8051	8-11-'05	Alonzo, Mexico	<i>Opuntia streptacantha</i>	Tuna cardona	10.34	42.83	58.90	6.30	65.30	34.80	11.47	11.25	1.040	9.02	.346	.078	.208	.252	+ 2.00		30° C	.30	.60	11.65	.24	.062	.200		
8050	9-16-'05	"	"	"	9.06	50.00	42.00	3.32	45.98	54.02	13.70	13.52	1.050	11.92	.312	.104	.308	.308	+ 1.1	+ 7	29° C	.00	.00	8.84					
8050a	9-25-'05	"	"	"	9.24	49.00	51.53	3.39	54.92	45.08									+ 2.4	+ 4	30° C	.00	.00	9.95					
8050b	9-25-'05	"	"	"	9.64	47.00	61.70	2.95	64.65	35.35	12.10	11.69	1.049	11.69	.501	.174	.247	.076	+ 2.3	+ 2.0	29° C	.15	.00	9.12					
8050c	9-19-'05	"	"	"	7.48	60.50	48.92	3.39	53.31	47.69	14.08	13.78	1.053	12.60				.040	+ 1.5	+ 1.1	28° C	.31	.58	11.65					
8050d	9-30-'05	"	"	"	8.52	53.15	50.00	3.25	53.25	46.75									+ 1.2	+ 3.3	33° C	.08	1.04	9.07					
8050e	9-30-'05	"	"	"																									
8143	9-20-'05	Guillermo, Mex	<i>Opuntia leucotricha</i>	Tuna durasilla blanca	10.60	42.90	60.50	4.90	65.40	34.60	10.39	10.22	1.033	7.98	.186	.070	.116	.164	+ 1.00	+ 1.0	35° C	.00	.00	10.44	.30	.460	.180		
8150	9-25-'05	Zacatecas, Mex.	"	"	11.10	40.60	69.16	2.96	72.12	37.88	10.00	9.95	1.030	8.628	.148	.088	.000	10.0	.079	+ 3.0	+ 3.3	25° C	.00	.00	8.84				
8545	9-19-'05	"	"	"	14.30	31.67	63.30	5.80	63.11	33.80			1.030	7.27					+ 1.0	+ 1.0	24° C	.00	.00	7.74					
8146	9-21-'05	"	<i>Opuntia sp</i>	Tuna blanca	5.90	76.30	40.63	3.03	44.56	55.44	10.81	9.60	1.043	10.31	.427	.079	.348	.587	+ 1.80	+ 1.6	23° C	.15	1.58	8.23	.20	.130	.250		
8547	9-19-'05	"	"	"	3.06	123.75	41.41	3.95	45.30	54.64	12.35								+ 1.00	+ 1.0	24° C	.38	1.32	8.99					
8141	9-19-'05	"	"	"	9.40	48.39	41.49	3.32	44.81	55.19	11.81	11.06	1.051	12.15	.326	.088	.238	.342	.062	+ 3.0	+ 8	25° C	.00	.00	9.12			.180	
8546	9-19-'05	"	"	"	9.70	46.70	45.61	3.84	49.45	50.55	12.16								.20	+ 5	24° C	.23	.46	9.31	.21				
8057	8-13-'05	San Luis Potosi, Mex.	<i>Tuna amarilla</i>		4.80	94.00	46.15	5.14	51.29	48.71	13.66	12.67	1.051	12.15	.327	.104	.223	.308	.077	+ 2.0	+ 3.0	30° C	.38	.00	11.07	.74	.117		
8485	9-19-'05	Aguas Calientes, Mex.	"	"	2.76	164.60	35.38	4.57	39.63	60.37	13.31	13.26	1.051	12.15	.330			.047	- 7.0	- 7	25° C	.00	.00	11.70	.29	.180			
8142	9-20-'05	Zacatecas, Mex.	<i>Tuna naranjada</i>		6.10	74.00	32.43	5.00	37.43	62.57	12.92	12.88	1.047	11.23	.484	.088	.306	.431	.031	+ 2.10	+ 2.1	25° C	.00	.00	9.12	.38	.166	.280	
8140	9-19-'05	"	<i>Opuntia larreyi</i>	Tuna ramuesa	2.80	163.84	42.42	1.52	43.94	56.06	11.00	11.72	1.044	10.54	.596	.096	.530	.573	.031	- 6.0	- 6	25° C	.00	.00	11.05	.34	.194	.280	
8135	9-15-'05	Aguas Calientes, Mex.	"	"	11.60	41.17	68.46	4.59	73.65	39.56	7.66	7.35	1.034	8.21	.587	.126	.448	.516	.071	+ 1.0	+ 1.1	24° C	.00	.00	7.74	.11	.300	.231	
8134	9-16-'05	"	"	"	18.80	34.08	44.85	4.98	49.83	50.17	12.14	11.97	1.048	11.46	.223	.104	.119	.134	.022	+ 2.30	+ 2.1	25° C	.15	.00	10.22	.15	.111		
8119	9-13-'05	Dulana, Mex.	"	"	14.70	30.84	57.72	4.28	62.00	38.00	10.98	10.78	1.040	9.62	.861	.052	.859	.231	.024	+ 1.30	+ 1.1	30° C	.15	.00	8.84	.02	.027	.151	
8102	9-11-'05	Encarnacion, Mex.	<i>Tuna leonera</i>		15.10	31.00	69.66	3.33	71.80	38.01	13.21	12.80	1.052	12.38	.364	.156	.338	.327	.046	+ 2.10	+ 1.6	29° C	.38	.00	10.78	.57	.048		
8100	8-29-'05	Aguas Calientes, Mex.	"	"	6.80	66.50	71.72	2.30	73.92	30.08	10.57	10.42	1.039	9.38	.253	.104	.149	.114	.087	+ 4.0	+ 4	23° C	.00	.00	9.39	.10	.034		
8136	9-15-'05	"	"	"	8.30	55.27	74.91	3.26	78.17	31.83	11.17	11.10	1.041	9.85	.377	.139	.238	.179	.070	+ 1.0	+ 1.4	28° C	.24	.00	9.12	.30	.124	.280	
8055a	8-18-'05	Yplina, Mex.	<i>Opuntia robusta</i>	Tuna teona	6.30	73.00	52.31	4.48	56.79	43.21	12.97	12.77	1.048	11.46	.213	.139	.074	.193	.210	+ 0.00	+ 0.0		.00	.00	9.30	.32	.033		
8055b	8-20-'05	Riverside, California	"	"	2.30	210.60	47.48	3.01	56.40	49.51			1.050	11.92					.073	+ 9.0	+ 9	30° C	.00	.00					
8050	8-9-'05	San Luis Potosi, Mex.	<i>Opuntia sp</i>	Tuna teca	4.30	109.00	53.60	4.56	49.10	51.90	11.21	10.97	1.048	11.46	.314	.155	.179	.252	.071	+ 3.0	+ 3	30° C	.00	.00	8.74	.34	.230	.207	
Average of Mexican Samples.					8.56	71.17	52.26	3.92	56.18	42.90	11.84	11.54	1.044	10.38	.377	.107	.276	.251	.080	+ 1.05	+ 7.8	27° C	.17	.22	9.53	.36	.160	.242	
8055	8-9-'05	San Luis Potosi, Mex.	<i>Opuntia imbricata</i>	Tuna Juell	8.80	51.56	31.45	9.68	41.13	58.87	7.57	5.54	0.903		.363	.125	.208	.186	3.48	+ 0.00	+ 0.0		.00	.00	.83	.124			
5		Agricultural College, New Mex.	<i>Echinocereus stramineus</i>	Pitalla	34.71	81.33	30.83	1	30.83	69.17	18.14								.626	+ 1.30	- 2.5	28° C	2.92	2.80	9.30	1.13**			

*—Obtained from sum of Albuminoids and Amids.

†—Ten days after gathering.

‡—Twenty days after gathering.

§—Omitted from average; not Mexican sample.

||—Small; included with Edible portion.

¶—Presence of so much plant muckage made it impossible to properly determine specific gravity.

**—Total Ash.

or epidermis, underneath which there is a rind varying in thickness from $\frac{1}{8}$ to $\frac{1}{2}$ inch. This includes the pulp or edible portion in which there are found imbedded from 100 to 200 or more seeds. In some fruits we have counted as many as 400.

The Epidermis

The epidermis is the thin outer skin, and whether the fruits are eaten raw or in conserved products, it is necessary that this be removed because of the tiny spines occurring in bunches over its tough, leathery surface. When the fruits are peeled, this portion constitutes a part of the waste together with a small part of the rind which it is necessary to remove along with it.

The Rind

The fruit itself is found enveloped in what is morphologically a portion of the stem, which we have called rind. It partakes of the nature of both fruit and stem, usually assuming the color of the fruit and somewhat approaching it in composition. In some varieties it contains sufficient sugar to make it edible, but it usually retains so much plant mucilage, always present in the stems, that it is not as palatable as it would otherwise be. With the exception of the formation of some sugar as the rind ripens, and the change in coloring matter, the rind retains the general cell structure and appearance of the stem.

The rind is usually easily separated from the pulp. It constitutes from 25 per cent. to 75 per cent. of the fruit, and when this is not eaten there is of course a very large percentage of waste. Consequently the fruit which has the thinnest rind is the most desirable.

In a number of species where the waste was large and the rind at all palatable, a separate analysis was made of this to determine its nutritive value compared with the pulp. The results are given in Table No. I. By comparing the results there given with the analysis of the pulp in Table No. II, it will be seen that the total and soluble solids of the pulp are both more than that of the rind. In fact, about 50 per cent. of

the solids of the rind are in an insoluble form, whereas in the pulp the solids are almost completely soluble. In the rind the acid is always comparatively high, as is also the alcohol precipitate, both of which make the fruits unpalatable. The specific gravity of the juice of the rind is always less than that of the pulp, and the sugar content is also much less. The results of our analysis show that the rind at times contains some sucrose which seems more often to be lacking in the pulp.

The Pulp

This is the edible portion of the fruit and is the portion that is eaten in all varieties. In some species it is insipid, but in many it has an excellent flavor. We believe that Americans will acquire a liking for this fruit more readily than they do for tropical and sub-tropical fruits in general. The amount of pulp in the different varieties varies from 30 per cent. to 65 per cent., and as a rule those with a large percentage of pulp have the best flavor.

The structure of the pulp is rather peculiar for a fruit. The walls of the cells are very thin, and there is consequently but very little fibrous substance in its make up and indeed but little insoluble solids in the majority of the species. By pressing the pulp in muslin bags practically the entire amount can be forced through the meshes of the cloth. This was found to be the most satisfactory method of separating the seed from the pulp and was the one adopted in our analytical work. The small amount of fibrous tissue is shown by the amount of insoluble solids which averages less than one per cent. for all the samples.

There is a great variation in the composition of the pulp of the different species, and, of course, for even the same species at different seasons or degrees of ripeness. The amount and character of the edible matter varies a great deal in the different samples, as will be seen when the different constituents of the edible portion are discussed. Several varieties have been worked in duplicate and by referring to the tables it will be seen that very often the two analyses are very different. This may be accounted for in several ways. In the first place, the fruit may be eaten in very different degrees of ripeness.

The pulp of tuna tapona, for instance, is palatable at least two weeks before the outside of the fruit turns red and is commonly eaten from the time the pulp turns red until the outside is a deep purplish color. The time which it takes for these changes to occur in the fruit is not less than a month. Browne* has found that apples, and Bigelow** that peaches vary a great deal in composition during their different periods of growth, and in all probability the same would be found true of fruits of the cacti. The season, climatic conditions, and soil fertility no doubt affect the composition of this fruit as they do all others.

The Seed

The seed are distributed (Pl. III, Fig. 2) throughout the mass of the pulp. They are somewhat disc-shaped, and are from 1/8 to 3/16 inches in diameter. The seed coats are very hard and are never masticated or digested when the fruit is eaten. Each fruit contains a large number of seed, varying somewhat with the different varieties. Some of the samples analyzed had not to exceed 75 seeds, while others had as many as 400. The average weight for the wild forms from Texas was 7.54 per cent. of the whole fruits, while in one of the Mexican samples of cultivated varieties there were only 1.52 per cent. of seeds. The larger cultivated fruits always have proportionally fewer seeds, and it may be that in time cultivation and selection would still further reduce the number.

The Refuse

The waste in eating the cactus fruits is the sum of the weights of its seed and rind, if the latter is rejected; when the rind is eaten, the waste is the seed with only that part of the rind which is lost in peeling the fruit. Since such a large percentage is rind, the waste is very large when this is rejected. In one variety, tuna chavena (No. 8136), it amounted to 78.17 per cent. The fruit having the smallest amount of waste of all the prickly pears was No. 8142, tuna naranjada, it having only 37.45 per cent. The average for the Mexican

* Penn. Dept. of Agriculture, Bulletin No. 58.

** U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletin No. 97.

samples was 56.18 per cent. The samples received from San Antonio, Texas, (*O. lindheimeri*) averaged 71.56 per cent. refuse.

The watermelon has 59.4 per cent. waste; the muskmelon, 50 per cent.; bananas, 35 per cent.; oranges, 27 per cent.; apples, 25 per cent.; pears, 10 per cent.* Thus it will be seen that the tunas have about the same amount of refuse as the melon when the rind is rejected, and about the same as other fruits when it is eaten.

Harvesting the Tuna

The method of harvesting the tuna is influenced both by the variety gathered and the purposes to which the crop is to be put.

Harvesting for Immediate Consumption

It is common for the peon to get a large portion of his living during the tuna season from the plants as they stand in the field. A large part of the crop is therefore consumed directly from the plants. The object of the picker in such cases is to get the edible pulp separated from the remainder of the fruit with as little difficulty as possible. A sharp knife is used to make an incision across the top of the fruit and curving down on one side to or nearly to the attachment. Then the thumb and forefinger of the left hand are forced down between the rind and the pulp, loosening the latter and forcing it upward, when it is caught between the thumb, index and middle fingers and removed without coming in contact with the small spines at all. The incision is made to such a depth as to just expose the pulp and none of the rind is removed from the plant. Of course this method applies to only such fruits as are in reach of the picker and is practiced by those who eat as they gather in the field. The method of securing the tunas growing beyond reach of a man standing upon the ground is described beyond.

* U. S. Dept. of Agriculture, Office of Experiment Stations, Bulletin 28.



Figure 1.—Gathering Tunas for Immediate Consumption.



Figure 2.—Peeling Tunas for Immediate Consumption.

PLATE II.—Harvesting Tuna Cardona.



Figure 1.—General View of a Tuna Market.

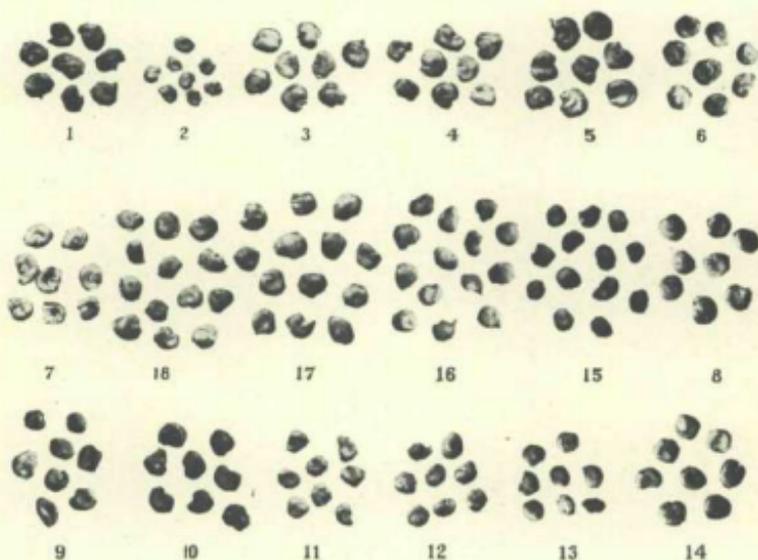


Figure 2.—Seeds of Edible Tunas (natural size).

PLATE III.—Tuna Seed, and a Scene Upon the Tuna Market at San Luis Potosi, Mexico.

Gathering Cultivated Forms

As stated elsewhere, the mansas or tame forms are not disfigured by cutting the joints as are the wild ones described beyond. The vast majority of the cultivated tunas are produced beyond the reach of a man on the ground and they are therefore collected with a long (usually bamboo) pole. The end of this pole is divided into three or four equal segments which are held apart by a wooden plug secured firmly in place by thongs of rawhide or maguey (*Agave*) fiber. This makes a conical receptacle in the end of the pole which is thrust around the tuna, the latter being removed by twisting the pole. In this process of gathering, the fruit is more or less injured either by the end of the stick itself, or by the wrenching process used in loosening it from the tree. Sometimes the fibers entering the tuna from the joint are twisted off, leaving a lacerated hole in the end of the fruit. At other times the base of the tuna itself is twisted off. It is evident that fruit injured in this way will not keep long. A large part, however, of the fruit of the cultivated forms upon the markets is gathered in this way.

Gathering Wild Forms

(See Plate II.)

Whenever the preservation of the plants is not an important consideration, the Mexican gathers the tunas which are beyond his reach with a gancho (hook) made by fastening a strong knife blade at right angles to a long pole. With this he cuts the joint nearly off, thrusts the point of the gancho into the severed joint and lowers it to the ground. Commonly but very little attention is paid to the quantity cut from the plant, the place of the incision depending upon the number and distribution of the tunas. Often two or three joints are taken off together, but more commonly only that portion of the one containing tunas.

After the joints have been lowered to the ground in this way, the pulp is removed as described above under "Immediate Consumption", the operator either standing in a bent-over position with one foot upon the segment of joint or kneeling upon one knee.

Gathering for the Market

When tunas are desired for the market, for shipment or for storage in a fresh condition, more care is exercised in picking them. Instead of tearing or twisting them from the joints, they are carefully cut off with a sharp knife. The fruit is taken between the thumb, fore and middle fingers of the left hand, pushed to one side slightly, when, with the point of a knife, its connection with the stem is severed. The difficulty of this operation may not be apparent to the reader unfamiliar with the small spines with which the fruits are protected. The handling must be very carefully done, and the native becomes so adept that he grasps the fruit between the cushions of spines with much less likelihood of being injured than the novice. Owing to the fact that there is no appreciable fruit stock as there is in the apple, peach, or pear, it is difficult to remove the fruits from the trees without injuring them. Italian shipments upon the markets of this country usually have a small portion of the joint attached to the fruit. It is usually less difficult to collect in this way, but the small piece of joint probably has no advantage over a perfect fruit removed without it. The difficulty of picking without injury varies with different varieties and in the same variety under different conditions of development. A plump fruit is much more difficult to remove without injury than one which is shriveled, as will be readily apparent. Such forms as the amarilla, naranjada, camuesa, etc., which assume more of the shape of the common pear, are more easily picked than the more nearly globular forms such as cardona, chavena, etc.

Comparison of Different Methods of Harvesting

Personal observations of the thickets, and the opinions of the more intelligent people, lead us to believe that on the whole cutting off the joints results in injury to the succeeding crop of tunas. Fruits are produced upon the last year's growth, and if this be very severely pruned, as is often the case when a large crop is harvested with the gancho, the growth the following season is very largely vegetative joints and not fruits, but the second year after the severe pruning is likely to produce a large crop of fruit again. In fact, the pruning is not

wholly bad, for the joints strewn over the ground often give rise to new plants, thereby extending the thickets.

Keeping Qualities of Tunas

Contrary to popular opinion, some tunas can be preserved in the fresh condition about as long as the common fruits of the temperate zone, if properly handled. It is not at all uncommon to find the Italian forms upon the markets of the chief cities of this country in the fall and early winter. These withstand the transportation, besides two or three months in storage on this side of the ocean. The writers have had samples of yellow tunas of Italian origin secured upon the markets in Washington City remain in good condition in their possession for two months while subjected to the irregular temperatures of an ordinary living room.

Like all other fruits, different forms have different keeping qualities, and freshness is of longer duration when the picking is done before maturity than when dead ripe. Tuna cardona will remain good for from twelve to fifteen days upon the open markets of Mexico, after being picked and packed on burros a distance of ten or twenty miles. The mansa forms keep longer if cut instead of being twisted or pulled off. The best keepers are, without doubt, some of the forms of joconoxtle and chavena. The latter is the one commonly kept over winter in the region of Aguas Calientes. The packing of this species is a regular business and it may be found upon the markets as late as the first of May. It is one of the latest to mature in the fall and has a comparatively thick, firm rind, well adapted to being stored. On the whole it may be said that tunas are easily injured and consequently much care is necessary in handling them when they are intended for packing. They must also be well aerated in storage, which is true of all fruits.

At the present time there is quite an extensive shipment of tunas by mail from place to place in Mexico. One of us happened to be in Torreon one Sunday last September when a carload was brought from near Aguas Calientes. It contained cardona mostly, but also some fafayuca, amarilla, naranjada, and durasnilla. They were shipped loose in an ordinary box

car, piled upon the bottom of the car to a depth of about two feet. They are commonly shipped packed in crates with straw, the crate being usually a little smaller than our common orange boxes.

They are usually brought to market in crates packed on burros. When intended for immediate market use they are emptied in piles upon the ground, those not actually in use being covered with green herbage or old cloths and kept at a lower temperature than the surrounding atmosphere by the evaporation of water sprinkled over them from time to time. Handled in this way they keep in the open air for ten to twenty days.

Some species, chavena especially, in the vicinity of Aguas Calientes, are regularly kept over winter in the fresh condition and one may find some of the various species and varieties upon the market places practically the entire year. From late May to early December there are fresh forms constantly found and even in the spring some of the forms of joconoxtle, which are eaten only after being cooked, may be found upon the trees. However, the majority of those upon the markets after December have been packed. Around Aguas Calientes these are almost invariably chavena which have been put in storage. They are spread in thin layers, alternating with layers of straw or old hay in a dry aerated situation. Handled in this way they will keep from October or November to the first of May.

Tuna Products

Of the numerous products manufactured from the prickly pear only those which appear to us to be the most important have been selected for discussion. To consider all of the products would necessitate more space than can be devoted to the subject. Those enumerated will give a very fair idea of the importance of the crop upon the high lands of Mexico.

In detailing the methods of manufacture, it is realized that the descriptions given constitute simply the recipe used by the people in a certain locality. There may be variation in the methods employed in different sections, but the essential fea-

TABLE NO. III.—ANALYSES OF SOME TUNA PRODUCTS

Lab. No.	Name of Product	PERCENTAGE COMPOSITION												
		Total Solids	Soluble Solids	Total Proteids (N × 6.25)	Water Soluble Pro- teids (N × 4.25)	Acids Expressed as H ₂ S O ₄	POLARIZATIONS		Temperature	Sucrose by Polariza- tion	Sucrose by Reduction	Total Sugars as Dex- trose (Allihn)	Ash in Soluble Solids	Alkalinity of Ash as K ₂ C O ₃
							Direct	Invert						
2356	Dried Tunas * (Tunas pasadas).	92.54	81.58	12.12	1.20	2.34	—	6.00	22° C	.75	1.18	51.06	4.45	
2357 ††	Meicocha	86.64	84.46	12.12	1.22	.54	++	6.40	22° C	.46	0.00	63.35	4.70	1.24
2357 ††	Meicocha †	77.50					++	4.20	20° C	1.55		64.15		
2358 †	Miel	68.58	68.65	3.06	1.19	.26	++	7.00	22° C	1.88	0.00	61.47	1.19	.62
2359 ††	Queso de Tuna †	91.56	89.06	12.55	.53	.44	++	14.00	17° C	0.00	.10	55.29	3.64	1.66
2360 ††	Concentrated pulp of Opuntia leavis ‡	86.06	83.87	12.11	1.21	.51	++	10.00	17° C	.75	.10	55.42	3.06	1.66

*—Per cent. seed, 24.50. This was prepared from Tuna amarilla.

†—Analyses made by Bureau of Chemistry, U. S. Dept. of Agriculture.

‡—Large sample from Hacienda Los Campos.

§—Small sample from public markets at Aguas Calientes.

§—See page 79.

††—Manufactured from Tuna carbona.

tures of the processes do not differ. The methods here outlined are those employed in the vicinity of Villa Garcia in the State of Zacatecas.

The tuna products are usually manufactured in the season when the fruit is thoroughly ripened. At any other time the business would not be as profitable, because the labor of collecting would be much greater if it was done while the crop was only partially ripe. Again, there is less need for preservation of the valuable material so long as it remains in good condition upon the trees and may be eaten in the fresh state.

In the different manufacturing processes all available tunas may be used indiscriminately, but there are certain characteristics essential in certain products. However, the pickers usually gather all fruits of whatever species they can find, but the prevailing material will be of one species usually best suited to the process.

The tunas may be divided into two great classes, based upon their condition when ripe. One group or class has pulp which, when squeezed through a fine cloth, gives a limpid liquid with most of the solid constituents in solution. To this group belong the more important of the mansa or cultivated forms, such as amarilla, naranjada, blanca, palo alta, fafayuca, camuesa, ranchera, and morada. The other class has fruits whose pulp when treated in the same manner yields an opaque liquid having much solid matter in suspension in a fine granular condition. The foremost of this group is cardona and with it should be classed tapon, agua-mielilla, leonera, pachona, and opalilla. For the manufacture of queso, melcocha, and miel, only those forms are used which have solid or semi-solid substances in suspension in their extracted juices. The members of the other group are more often used for drying.

Colonche may be manufactured from almost any of the species, but as a matter of fact it is seldom made from the mansas because of the higher value of the fresh fruit. In practise the species used in a locality is quite constant, and the products manufactured are quite pure, for one species usually predominates to such an extent as to necessitate its use to the exclusion of others. For instance, in the vicinity of San Luis

Potosi and Aguas Calientes the cardona predominates, while farther south leonera, agua-mielilla, or artona are more prevalent. It is not economy to prepare the products from the large mansa forms until late in the season, and then they are usually dried. They command a better price fresh because the supply is rather limited.

Different colored species produce products of different color, as would be expected. The color for a given product from any species, however, may or may not be constant, for the process of manufacture may vary to such an extent as to change the color. This applies especially to such products as miel, melcocha and queso, which have a somewhat complicated process of manufacture, are subjected to a considerable heat, and, in the case of the last named especially, are modified by aeration and kneading after the boiling ceases. The boiled paste from tuna cardona is almost black, and melcocha is consequently of the same color, but the queso is light brown. Tuna tapona, on the contrary, retains its red color through the boiling process, and consequently makes red queso which does not seem to be in much favor.

When tunas are gathered for manufacturing purposes the pulp—the part ordinarily used—is removed in the field as described elsewhere. On account of its exceedingly juicy nature it is gathered in earthenware vessels or ollas (o-yas) and taken into the factories in fifty to seventy-five pound lots. The picker usually has the earthenware vessel strung across his shoulders by means of ropes of maguey (*Agave*) fiber. When the vessel is filled, it is delivered to the factory either in a cart or by the picker himself if the factory is not too far away. Material delivered to the factories consists of the seedy pulp which is ready for the kettles or the seeders.

The Machinery Used in Making Tuna Products

It is scarcely necessary to state that all of the appliances used in the manufacture of tuna products are of the most primitive nature, simple and crude, but still often exhibiting a great deal of skill and ingenuity in the use of inexpensive materials at hand which might not be recognized as at all suitable by more highly civilized people. It must be remembered that the

processes described here are essentially those of the primitive peoples of the Republic. They are processes which have probably been followed in all essential particulars since Cortez first landed, and how long before no one knows.

It is a common practice for a suitable number of people to establish a camp in the prickly pear thickets late in the season for the purpose of manufacturing queso and the other products. A factory and a few rude huts are quickly thrown up, giving shelter to the workers as well as to the manufactured products. Factories which we have seen consist of a small adobe building of one room about twenty-five feet long by fifteen feet wide, thatched with the leaves of the yucca. (See Pl. VII, Fig. 1). They usually contain one or two kettles, usually of copper although pottery is sometimes used, one or two troughs hewn out of willow, three or four earthenware tubs, and smaller earthenware vessels with which the liquids and plastic materials are handled. The kettles are set in the ground up to their handles on a slightly elevated side of the room, over a rude furnace consisting of earth, rock, and adobe. The essential machinery is fairly well represented in Pl. VI, Fig. 2. Besides the kettles, there may be seen in the rear of the room two seeders of tin, supported upon a frame and shown in more detail in Pl. V, Fig. 1. On the left of the factory is seen a large trough hewn from the trunk of a willow, and in the rear of the room is another smaller one of the same material. Under the seeders are seen earthenware tubs. The bottom of an olla (earthenware urn) projects above the first kettle. The kettles are reinforced to a height of about eighteen inches by slabs of wood cut from the trunk of a large yucca. These are tightly fitted together, and the whole tied with a rope made of agave fiber as shown in Pl. VI, Fig. 2. Some of the yucca wood is macerated and used to chink in around the top of the kettle to make it tight. The kettles are about twenty inches deep and three and one-half feet in diameter.

The seeder consists of a tin vessel with a short conical base having a pivot support in the center to receive an axial shaft upon which are hung paddle-like wings, shown in more detail in Pl. V, Fig. 1. This axis with the paddles is operated by a

crank, as shown in the illustration. The tin vessel is perforated by nail holes of such size that they will not allow the seeds to pass.

The furnace is exceedingly crude. It consists of a fire pit under the kettles, and somewhere a smoke flue. Pl. VI, Fig. 1, shows the outside of the right of the room shown in Pl. VI, Fig. 2. The center holes shown are the two orifices through which fuel is fed into the furnace. The other two openings are the smoke flues, but as a matter of fact, in this particular instance the doors act as the principal smoke flue, as is plainly seen, by the deposit of soot upon the wall shown in the picture.

Miel de Tuna

In the manufacture of this product the seeder is usually not employed. The peeled tunas are put in the kettles and boiled until the free seeds fall to the bottom. This occupies usually about two hours, fresh material being added from time to time as the water evaporates. The seeds are removed with a sieve and the sirup returned to the fire and boiled slowly for two or three hours more, or until it approaches the consistency of honey. It is then poured into wooden troughs where it is thoroughly mixed with wooden paddles until completely cooled. After setting for twelve to twenty-four hours it is packed away in bottles or earthenware jugs. It may be kept about the same as molasses, and is said to remain in good condition indefinitely. After a time, however, it candies and becomes difficult to handle.

The method of cooling is considered very important in the manufacture of this product as well as in the manufacture of melcocha and queso, for if the material is allowed to cool without stirring it is said to have a tendency to sour. After it has cooled there is said to be no further danger of deterioration. The only change which appears to take place thereafter is crystallization which begins rather soon and is said to continue for a couple of years until a completely candied mass is formed. Upon the large haciendas away from town this sells for from fifteen to twenty cents a liter (about one quart).

Melcocha

In the manufacture of melcocha peeled tunas are put in the machine and seeded. The kettles are filled two-thirds full of juice, which is boiled with a brisk fire for about three-quarters of an hour, when more juice is added and the boiling continued. The foam arising from the boiling is very great when the sirup is thin, but as it thickens this becomes less, and more of the fresh juice is added to thin it until, little by little, the supply is all used up. This takes four or five hours in all. The material is then kept warm by banking the ashes. After this it is kept in such a condition that it thickens very gradually for one or two hours more, the object now being to keep the evaporation constant and low, until the proper consistency is reached. When a spoonful can be dipped up and the material will not run out when turned upside down, the process of evaporation is stopped, and all fire removed from the furnace.

The processes for the manufacture of melcocha are exceedingly variable. The one detailed above is that interpreted to us by Senor Enrique Guerra in 1905. In 1906 other persons upon the same hacienda were preparing melcocha somewhat differently.

The puddled paste from which queso is made is also called melcocha, and often this is preserved for future use with no kneading or other preparation except packing away in suitable receptacles as described elsewhere. The only difference between melcocha and queso in that case consists in the kneading and puddling which the paste gets after being cooled, the melcocha being simply unkneaded queso. We might liken the two products roughly to taffy in the different stages of its manufacture, the taffy corresponding to the queso, and the cooked sugar or molasses before being pulled to the melcocha.

The melcocha is then poured into a trough as in the case of miel, and worked with wooden paddles very rapidly, in order that it may cool as quickly as possible. When the temperature is reduced so that it is not uncomfortable to the touch, the vessel is covered and left until the next day, or it may be left two or three days. The best way, it is said, is to puddle upon a stone or wooden table twenty-four hours after evapor-

ation has ceased. The rule here is to "strike" the "dough" one hundred times on a stone, the whole lump being raised above the head and then dropped forcibly one hundred times. During this process flavoring matter, almonds, etc., are sometimes added to the product, but usually nothing is added to the concentrated juice.

Crystallization begins in melcocha within a month or six weeks after manufacture and continues indefinitely, the material becoming more and more candied with time, like miel.

Melcocha may be kept in earthen jars with wide mouths, which is the common method of preservation. Another poorer way is to preserve without puddling. In this case, about two tablespoonfuls is put in a corn husk and covered completely and as tightly as possible with this kind of covering. In this form it is a common article upon the market places in the larger cities and this quantity usually sells for one cent. The price of melcocha put up in quantity in earthenware jars is from \$1.50 to \$2.00 per aroba (twenty-five pounds).

Queso de Tuna

The queso, or cheese of the tuna, is made the same as melcocha, except that the evaporation is carried a little further, until the cooled material will not "leave the spoon" when it is shaken. The puddling is also more thoroughly done. The rule here is to "strike" one hundred and fifty or two hundred times upon a flat stone or wooden table. This, although so similar to melcocha, never crystallizes, although the evaporation is carried but little farther.

After puddling, the product is put in any shape desired. It is commonly shaped in small hoops of white pine or willow about three inches in diameter, or in larger boxes dove-tailed at the corners so they can be removed in pieces. The first method gives the product the form of the common cottage cheese found upon the markets, and it is from this that it receives its name, "Queso de tuna", or cheese of the tuna. These molds are moistened just before the material is packed into them to be shaped. They are then removed immediately. The queso sets perfectly in from one to two hours. It is a

common practice at the larger haciendas, where a first class product is desired, to cover the queso with tin foil to preserve the color and prevent evaporation. No other changes appear to take place in this product.

Queso will keep indefinitely, if put away in a dry place to prevent moulding. However, it gets harder and harder from loss of moisture as time goes on. Covering with tin foil delays hardening and prevents darkening to some extent. The more puddling or kneading the material gets in its manufacture the harder it becomes, and the lighter is its color. To avoid the labor of puddling it is a common practice to get rid of the natural dark color by adding dyes. This leaves the queso soft, and gives to the trade the color that is pleasing. Beet, carrot, and other vegetable juices are used for this purpose.

Sometimes one will find queso and melcocha packed in vessels in alternate layers. After a few months the melcocha is candied to a considerable extent, while the queso remains soft and plastic, giving what is considered a very desirable product.

The treatment of the paste after leaving the kettles is one of aeration, and does not differ essentially in effect upon the products from the process of pulling taffy. Although it would seem that the details of the process might be very varied, wherever we have observed queso puddled the method has always been the same. A batch of the paste consisting of from ten to twenty pounds is placed upon a flat rock which has been previously moistened with water. The paste is gathered into a compact mass by hand and the whole raised above the head of the operator and dropped, or, really, thrown forcibly down upon the rock again. The edges of the flattened mass are gathered together again and the process repeated many times. Usually two persons work in relays, for the labor is very exhausting, the mass of paste being quite heavy, and the movements necessary being quite rapid and vigorous to handle properly.

Colonche

In the preparation of colonche, which is a fermented drink, the pulp, including the seed, is boiled slowly two or three hours, fresh material being added from time to time as evapo-

ration goes on. The whole mass is then strained, and the liquid set away to cool. Usually a little old colonche is added to start fermentation. This beverage is used from the time fermentation begins up to twenty days or more. The longer it stands the more violent is its intoxicating effect. The seeds may also be removed by the seed extractor when the juice is boiled as before. Sometimes, but not as frequently as formerly, old colonche is distilled into an alcoholic beverage. It was a common practice a few years ago to distill the fermented peelings of the tuna, but the practice has not been successful because of the ill effects which the product is said to have. The natives say it produces violent headaches, and for this reason is almost entirely supplanted by mescal, tequilla, and other maguey (*Agave*) products which produce less deleterious effects.

No successful method seems to have been devised for the preservation of colonche. Some have tried to bottle it, but without success. It is quite probable that the fresh juice could be preserved by boiling, thus killing all germs, and then hermetically sealing in vessels in much the same way as fresh fruits are preserved in this country. The failures appear to us to be due to imperfect methods of sterilization.

Relation of Tunas to Finished Product

It is seldom that one can get any idea of the amount of boiling and evaporating to which the tuna juice is subjected by talking to the men who make the queso. Fortunately, in 1906, an opportunity was had to visit Los Campos in season. Through the kindness of Señor Enrique Guerra a day was spent at the queso factory, illustrated in Pl. VI, and notes were secured upon the work carried on that day, including the entire process from the charging of the kettles in the morning to the puddling in the evening. The next morning the kneading of the paste was also witnessed.

At six o'clock in the morning of the day spent at the factory the kettles were charged with sixty-five gallons of the juice of tuna cardona, a portion of which had been seeded the night before. A brisk fire was started at the same time, of



Figure 1.—Peeling Tunas for Drying, Montesa, Mexico.

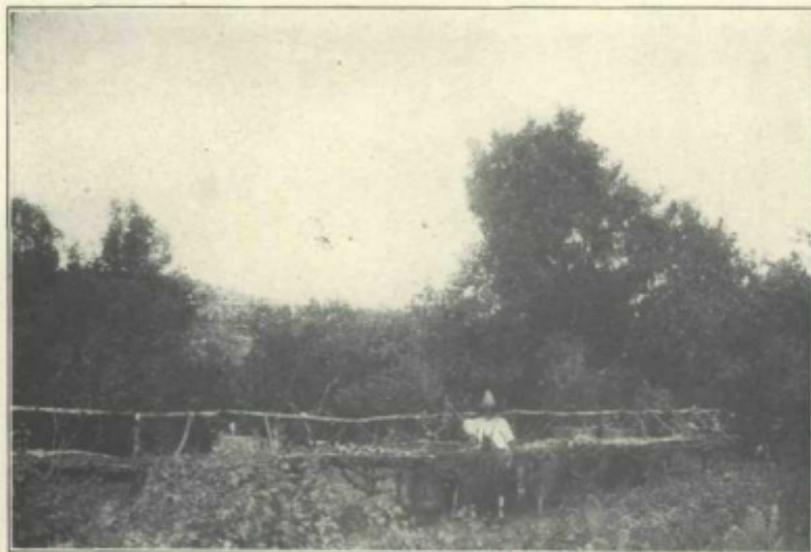


Figure 2.—Drying Tunas in the Sun, Montesa, Mexico.

PLATE IV.—Dry Tunas (Tunas Pasañas).

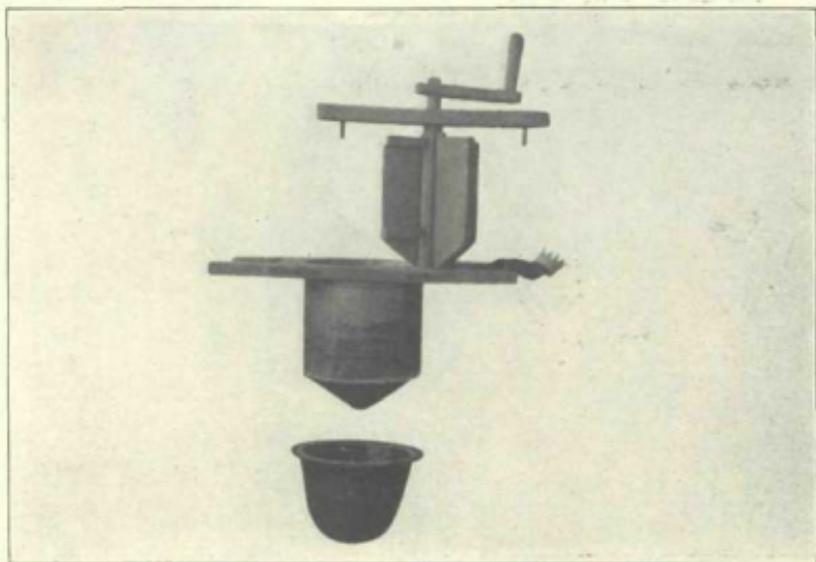


Figure 1.—A Seeder Dissected.



Figure 2.—Nonal Agua-Mielilla, Dublan, Mexico.

PLATE V.—The Nonal and a Tuna Machine.

wood of the same species of prickly pear. During the day twenty-five gallons more of the juice were added as evaporation proceeded. The evaporation was carried on very slowly and somewhat irregularly until eight o'clock in the evening. But little attention was paid to the kettles until toward evening, when the juice was constantly stirred. The juice was secured from one hundred and fifty gallons of peeled tunas from which the rind had been completely removed, the shrinkage in seeding being very largely due to the bulky seed. These, however, we did not have a chance to weigh. The melcocha which was kneaded into queso the next day measured twelve gallons and weighed one hundred and thirty pounds. These figures are accurate within the limits of error incident to working with crude instruments of measure and are accurate enough for ordinary computations upon these processes.

The relation of rind to pulp and seed in tuna cardona as determined by our laboratory investigations is as 42.66 to 57.34. In the above charge of the kettles, therefore, the tunas, if they had been picked in the field, rind and all would have measured about 261.66 gallons, yielding 150 gallons of tunas with the rind removed, which, when seeded, gave 90 gallons of juice. This when boiled gave twelve gallons of queso, weighing one hundred and thirty pounds.

These figures apply only to tuna cardona. The proportions might be very different for any other species, but the amount of queso prepared from any other species is small. Cardona is preeminently the queso tuna. It is a native species of average size, weighing about $1\frac{1}{2}$ oz. It is only one-half to one-fourth the size of many of the cultivated forms. Of course even with an invariable thickness of rind the larger the tuna the smaller the proportion of rind. The tunas vary in the thickness of their rind, in the relative number of seed, and in the relative amounts of fibrous material in the pulp.

Dried Tunas

(Tunas Pasadas. Tunas Secas.)

The native exhibits a great deal of dexterity in the use of the knife in the preparation of the tuna to be dried. The thin outer skin of the fruit is so impervious to moisture that evap-

oration does not take place rapidly, and the fruit dries very slowly until this skin is removed. At the same time, because of the small amount of pulp and large amount of juice, it is not a good plan to slice the fruit as apples are sliced. The plan followed is to peel very thinly, and dry the pulp and rind intact. The tuna to be peeled is grasped with the thumb and middle finger of the left hand and the epidermis literally whittled off with a sharp knife in small pieces almost as thin as paper. The operator saves all of the rind he can, taking off only the thin, tough epidermal covering, together with the areoles containing the spicules. The flower scar is left unmolested to dry upon the fruit. When peeled the fruits are sun dried upon a lattice work of switches tied together with maguey fiber or narrow strips of rawhide. (See Pl. IV, Fig. 2.). The drying occupies from 10 to 15 days, when a yellow deposit consisting probably in large part of crystals of dextrose incased in a covering of gum, plant mucilage, and possibly some uncrystallizable levulose completely covers the outside of the fruit. They are then packed in woven rush bags and in this condition are said to keep quite as well as other dried fruits. An attempt is made to get the outside thoroughly dried, but there is a great deal of moisture left in the pulp. After being packed loosely in a box for six months the pulp is still quite pasty and on the whole little drier than fresh dates as ordinarily found upon the markets. When kept in large quantities, tightly packed, the evaporation is, of course, not as great.

Considerable dexterity is exhibited by the operators in preparing the tunas for drying. We had the good fortune to observe the process in Montesa, in the State of Zacatecas. Pl. IV, Fig. 1, tells better than words the attitude of the operator in peeling tunas. The fruit is held between the thumb and middle finger of the left hand, the thumb resting on the flower scar, and with a sharp knife in the right hand the epidermis is whittled off. The movements, contrary to what one would expect, are comparatively simple, the right hand moving the knife rapidly in one plane, the left holding the tuna between the thumb and middle finger, the index and third fingers rolling it on its axis. It makes two revolutions before it is completely divested of its epidermis. During the first revolution



Figure 1.—Exterior of Factory, Showing Furnace and Flues.



Figure 2.—Interior of Factory, showing Seeders, Evaporation Kettles, Etc.

PLATE VI.—A "Queso de Tuna" Factory, Los Campos, Zacatecas, Mexico.

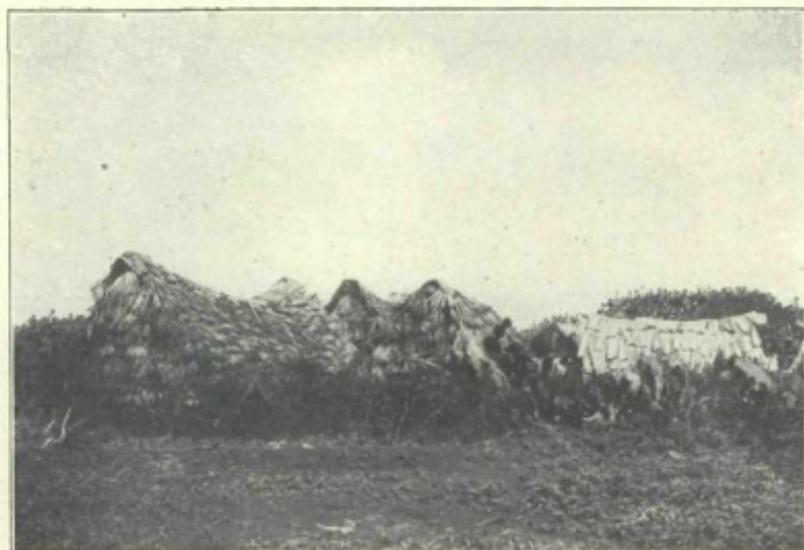


Figure 1.—A Temporary Camp in a Tuna Thicket at Harvest Time, State of Zacatecas, Mexico.



Figure 2.—First Crop of Tunas in the Second Year From Two to Three-Joint Cuttings. (Nopal Mansa Morada). San Luis Potosí, Mexico, August 20, 1906.

the epidermis is removed from the upper portion, then the fruit is tilted slightly as it revolves slowly and the epidermis is removed from the lower half during the second revolution on its axis. The knife moves in one place, the tuna being held stationary in the left hand and revolved on its axis by the movements of the index and third fingers, and at about the middle of the process it is tilted on its axis. The epidermis is thus removed in small, very thin pieces. Before being peeled the fruit is brushed, to remove the spicules as described elsewhere. The operator shown in the above figure was timed repeatedly to determine the speed with which he worked. A fruit was peeled with from twenty-eight to thirty-five strokes of the knife, and in the remarkably short space of ten seconds.

At times a small stick about the size of a lead pencil is thrust into the proximal end of the tuna after it is peeled. It is then squeezed between the fingers to express as much of the juice as possible. This shortens the drying period three or four days, but much valuable material is, of course, lost, and the product prepared in this way is of inferior quality.

Cartons in which the dry tunas are packed, contain about an *aroba* (25 lbs.) or 600 dry tunas, for which the producer realizes from \$1.50 to \$2.50, depending upon the character of the crop.

Unusually dry tunas are prepared from the white and yellow *mansa* forms such as *amarilla*, *naranjada*, *fafayuca*, *palo alena*, *blanca*, *teca*, etc. The wild forms such as *cardona*, *pachona*, *agua-mielilla*, etc., are too small and contain relatively more spicules, both of which characters are objectionable. Again, the red species dry almost black, and are, consequently, not nearly as attractive in the finished product as the lighter colored varieties.

Methods of Analysis

The methods of analysis which were used in this work are for the most part those of the Association of Official Agricultural Chemists.* In some cases the nature of the work seemed to demand a modification of these methods, and the

* U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletins 65 and 66.

scheme as used in the laboratory for the determination of each constituent is briefly outlined below.

(1)—*Average Weight.*

Weigh 8 or 10 average sized fruits and divide the total weight by the number taken.

(2)—*Per cent. Rind.*

Remove the rind from the fruit by cutting off each end just through to the pulp, then cutting once lengthwise through the rind to the pulp, and peeling back the rind. A distinct division usually exists between pulp and rind rendering their separation easy. Calculate percentage from average weight of rind and fruits taken.

(3)—*Per cent. Seed.*

Squeeze, by hand, the pulp obtained in (2) through a piece of stout thin muslin. By this means practically all but the seed is forced through the meshes of the cloth. After washing with water dry the seed on water bath and weigh. Calculate percentage from average weight of seed and fruits taken.

(4)—*Per cent. Refuse.*

The per cent. of total refuse represents the sum of average weight of seed and rind divided by the average weight of fruits taken.

(5)—*Per cent. Edible Portion.*

Take the difference between the total refuse and 100 for edible portion.

(6)—*Per cent. Total Solids.*

Place 20 grams of the fresh pulp obtained in (3) in a flat-bottomed dish, which contains from 4 to 5 grams of freshly ignited asbestos. Dry in water jacketed vacuum oven at 70° C. to constant weight, and calculate the total solids.

(7)—*Insoluble Solids.*

Use Kremla's method as modified in Bul. 66, p. 13, Bureau of Chemistry.

(8)—*Specific Gravity of the Juice.*

Filter some of the pulp obtained in (3) through a piece of

thin cloth, and determine specific gravity by means of a Westphal balance. Determine total solids of the juice from its specific gravity by Bul. 65, table IV, p. 32.

(9)—*Total Nitrogen.*

Determine the nitrogen in 10 grams of fruit by Kjeldahl method. Results obtained are used for calculation of amids below. Total proteids are a sum of the albuminoids and amids.

(10)—*Albuminoids.*

Determine in 10 grams of the fruit by method of Stutzer as given in Bul. 46, Rev. Ed. p. 24. Multiply nitrogen by 6.25 for albuminoids.

(11)—*Amids.*

Subtract the nitrogen of albuminoids from the total nitrogen, and multiply the remainder by 4.25 for amids.

(12)—*Acids.*

Take from 10 to 30 grams of the pulp, or better 100 c. c. (10 grams) of filtrate from insoluble solids (7) and titrate with N-10 potassium hydroxid. When the juice is highly colored, its own coloring matter will serve as an indicator of the end reaction, otherwise use phenolphthalein or cochineal, (calculate to per cent H_2SO_4 .)

(13)—*Polarization (Direct).*

Weigh 26.048 grams of the fruit, transfer to 100 c. c. flask, add 50 c. c. water, and from 3 to 5 c. c. subacetate of lead, and about 10 c. c. alumina cream to clarify. Make up to volume, filter and polarize.

(14)—*Polarization (Invert).*

In a flask graduated to 50 and 55 c. c. place 50 c. c. of the clear solution prepared in (13). Fill to the 55 c. c. mark with concentrated hydrochloric acid. Place flask in the water bath and heat until the thermometer marks $68^\circ C.$, requiring 15 minutes in the heating. Remove. Cool to room temperature, polarize and note temperature. Calculate percentage sucrose

by Clerget's formula, $S = \frac{(a-b) 100}{144 - \frac{T}{T}}$

(15)—*Reducing Sugars.*

Take 25 c. c. of the solution prepared for polarization under (13) and add sufficient sodium sulphate to precipitate excess of subacetate of lead, filter, take an aliquot part (5 c. c.) of this filtrate containing not over .2 grams of reducing sugars, and add to a beaker containing 25 c. c. each of Soxhlet's copper, and alkaline tartrate solutions, and make volume to about 100 c. c. with water. Heat the contents of the beaker over wire gauze with flame so regulated that boiling begins in 4 minutes. Continue boiling for exactly 2 minutes, keeping the beaker covered with a watch glass. Without diluting, filter the cuprous oxide at once on a weighed asbestos felt in a Gooch crucible using suction. Wash thoroughly with distilled water at 60° C., then with 10 c. c. alcohol and finally with 10 c. c. ether.

Dry for 30 minutes in water oven at 100 c. c., cool in desiccator and weigh as Cu_2O . Calculate sugars as dextrose from Allihn's table. Make correction for spontaneous precipitation of Cuprous oxide.

(The asbestos used is specially prepared by digesting with 1 to 3 hydrochloric acid for 2 or 3 days. Wash free of acid and digest for a similar period with a soda solution, after which treat for a few hours with hot alkaline copper tartrate solution of the strength employed in sugar determinations. The asbestos is then washed free from alkali, finally digested with nitric acid for several hours, after washing free from acid, it is shaken up with water for use.)*

Reducing sugars were calculated to dextrose in this work because an excess of dextrose over levulose appeared to be present in the tunas. Since we know the reducing powers of dextrose in terms of other reducing sugars, these values can be converted into any form of reducing sugars desired by means of their dextrose ratios as given by C. A. Browne, Jr., in the J. A. C. S. XXVIII No. 4.

(16)—*Sucrose by Reduction.*

Invert the same amount of solution (15) as was used for reducing sugars, using hydrochloric acid in the same proportion for inversion as under (14), and invert in a similar manner. Neutralize with sodium hydroxide and determine total

* Munson and Walker. J. A. C. S. XXVIII No. 6, p. 666.

sugars as dextrose. Subtract from this the reducing sugars obtained under (15) and multiply the difference by .95 for sucrose by reduction.

(17)—*Ash in Soluble Solids.*

Treat 50 c. c. of the solution obtained under (6) as outlined under Determination of Ash, on page 13, Bul. No. 66, U. S. Dept. Agric., Bureau of Chemistry.

(18)—*Alkalinity of Ash.*

Add in known amount an excess of N-2 hydrochloric acid to the dish of ash from (17). Add 1 c. c. cochineal solution and titrate with N-10 Potassium hydroxid. Calculate to K_2CO_3 . One c. c. N/10 KOH equals .00691 grams K_2CO_3 .

(19)—*Alcohol Precipitate.*

(*Vegetable mucilage, pectin, and salts of organic acids*). Determine by method given in Bul. No. 66, Bureau of Chemistry, p. 21.

Composition of Tunas

Total Solids

The solid matter in the fruit is about an average of that found in other fruits as may be seen from Table No. 5. Like all other fruits the amount of solids differs for the different varieties, amounting to from 5.33 in No. 6, San Antonio (*O. lindheimeri*), to 11.60 in No. 8057 (tuna amarilla). No. 5, Agricultural College, had a higher solid content than the latter, but is not comparable with the other fruits because it is an *Echinocereus* and the seed were included with the other solids, they being edible in this group of the plants.

The amount of total solids in any fruit is not necessarily an indication of their value, though usually high solids indicate high soluble solids and a high sugar content, and the nutritive value of any fruit is dependent on the amount of these. Since the solids of the tuna are practically all soluble in water, and a large percentage of the soluble material is sugar, the total solids of this fruit is usually an index of its nutritive value, but this is not always the case. No. 5, San Antonio, for example, has 7.13 per cent. solids and only 1.41 per cent. of these

solids is sugar. But with most tunas practically all the total solids of the pulp exclusive of seed are soluble, and a high percentage of the soluble portion is sugar. There are few fruits that will make as good a showing as the tunas in this respect. In many of the small seeded fruits like figs and strawberries the seed are included in the total solids, while in other like apples and pears there is a large amount of marc*, and both the seed and marc being insoluble make a large difference between total and soluble solids. In the total solids determinations of the tuna the seed were not included and the marc is exceedingly small in quantity, as may be seen by taking the difference between the total and soluble solids.

The total solids of the juice is calculated from its specific gravity. This determination should be about the same as the soluble solids and total sugars. Where the sugars are more than the soluble solids or the total solids of the juice, there is probably some error in soluble solids determination. The total solids of the juice is quite often higher than the soluble solids, due no doubt to the fact that some pulp was in the juice when its specific gravity was taken.

Almost without exception the fruits from Mexico contain more solids and sugar than those varieties native to the United States.

Protein

The proteids are a group of bodies found in greater or less quantity in all foods, but the amount found in any fruit is usually quite small.

Bananas, figs, currants, and apricots have been found to contain over one per cent. proteids, but as a rule fruits have less than one-half per cent. This is true of the tunas, which average about the same as is found in the pear, the apple, or the peach.

Protein alone can furnish material for building flesh or muscle in the animal body. A man of moderate work will require as much as one pound of protein for every six pounds of carbohydrates eaten. If the cactus fruit should have .5

* Material insoluble in water.

per cent. protein and 10 per cent. sugar, and all, or equal amounts of both, be digested, those Mexicans who make this fruit their exclusive diet would get 20 pounds of carbohydrates for each pound of protein obtained. It is plain to see, therefore, that some other nitrogenous food should be eaten with tunas as with all other fruits to balance a ration.

The proteids are not compounds of definite chemical composition, but they are made up of a group of bodies each differing somewhat from the others in their composition. One element common to all the proteids is nitrogen, but the amount of this element varies in each compound.

The food chemist usually makes no attempt to separate completely the various proteids occurring in any food, but he often separates them into two smaller groups of *Albuminoids* and *Amido bodies*, or *Amids*.

Albuminoids

The albuminoids are those nitrogenous compounds which more nearly resemble the white of an egg in their composition and function in the animal body. They all contain very close to 16 per cent. nitrogen in the molecule, hence in the method for their estimation in the laboratory the amount present in a food is determined by multiplying the percentage of nitrogen which they contain by the factor 6.25, which has been used in all of our calculations of albuminoids in the tables.

The albuminoids are the most valuable of all the protein compounds because they are the only ones that can serve as building material in the animal body. In an average of all the Mexican samples there were .377 per cent. total proteids. Of this amount only .107 was albuminoids. Thus it may be seen that roughly, not one-third of the total proteids of the tuna is in the form of albuminoids, which, of course, means that less than one-third of the total proteids of this fruit is muscle and flesh-forming.

Amids

Amids, the other group of compounds into which the chemist divides the total proteids, are a group of nitrogenous compounds that are present in plants, especially their fruits.

They constitute one of the first products formed by the plant in its synthesis of nitrogen with the other elements in forming the more complex albuminoids, or they are cleavage products formed in the decomposition of the latter, hence they have fewer atoms in the molecule and a greater proportion of nitrogen. In our calculations we have assumed that all the amids of the tunas contain 23.53 per cent. nitrogen, and have consequently calculated the amount present by multiplying the percentage of nitrogen which they were found to contain by 4.25.

The amids are not so valuable a food as the albuminoids. They are probably incapable of serving as building material, but may, like the carbohydrates, serve as fuel and are also thought in some way to protect and prevent the consumption of proteids of the body tissue.

Because of the comparatively large quantity of amids in the total proteids the amount of the latter in the tunas would not be equal in value to the same amount of proteids in meat or many other nitrogenous foods.

In our analyses we have determined the water soluble proteids, which no doubt include all of the amids and a part of the albuminoids. This determination was made to ascertain the probable available proteids and partly to serve as a check on the total proteids.

Acidity

A study of the tables of analyses of the whole fruit as well as rind and pulp shows the amount of acid to be exceedingly variable in the different varieties of this fruit. In fact, it was found to be variable for different samples of the same variety, depending, no doubt, upon the degree of ripeness of the fruit.

The amount of acid in the rind varies from .13 per cent. in tuna amarilla (8057) to .96 per cent. in tuna chavena (8100). In the pulp of the Mexican samples there was .02 per cent. in tuna agua-mielilla (8119), and .32 per cent. in tuna durasnila blanca (8143).

The acid was found to be much more in those samples collected in the United States with the exception of the tuna tapona from California, which had only .07 per cent. The

average acid in the pulp of the samples from San Antonio was 1.2 per cent., while No. 6, from that place, has 2.15 per cent. acid. The ratio of acid to sugar in these six samples was 1 to 7.5, which is enough to give the fruits a decidedly tart taste. While the acid is not too high the sugar is not in sufficient quantity to make the fruits so desirable as the Mexican varieties. One trouble with the Mexican samples seems to be that the ratio between acids and sugars is too great to give them the requisite tartness. For example, the average acids and sugars of these samples show a ratio of 1 to 119, while even such fruits as the banana and fig have a ratio of about 1 to 70 between their acids and sugars, and in some fruits the ratio is as low as 1 to 5 or 6.

It is of interest to note the large amount of acid, 3.48 per cent., in *O. imbricata*, which is the only sample of a *Clyndropuntia* included in our list. This fruit contains no sugars and is not edible, but was analyzed because of its high acid content. Few, if any, common edible fruit contain so large an amount of acid. The acids in ripe apples rarely exceed 1 per cent., lemons and limes contain only about 5 per cent. citric acid (calculated as sulphuric).

The amount of acid found in the tunas has been expressed in the tables as sulphuric acid, (H_2SO_4), because this is the customary manner of expressing such results. This furnishes a ready means of comparing the relative amounts of acid found in different fruits. We have separated and determined the acid in several varieties of the tuna and found it to be malic acid. There were no volatile acids in any of the fresh samples tested.

Sugars

Polarizations. With very few exceptions all fruits and unadulterated fruit products are levorotatory towards polarized light, but an examination of tables No. I, II, and IV will reveal the fact that while some varieties of the tuna were levorotatory, most of those examined were dextrorotatory both before and after inversion. This unusual phenomenon has caused us to devote some little time to a study of the polariza-

tions of the tuna and some of the preserves prepared from them. While in all probability their dextrorotation is due to a large excess of dextrose over levulose, we are not prepared to say definitely that such is the case; in fact, we can not say definitely whether the dextrorotation may be due to dextrose or to some other sugar or substance. "Miel" and "melcocha", two products from the tuna that are prepared by evaporating the juice to the consistency of honey, have small white wart-like crystals somewhat larger than a pin head scattered throughout the mass. These crystals are not so soluble as the rest of the material, and a 50 per cent. solution of alcohol dissolves almost everything else, leaving them in a fairly pure condition.

When these crystals are separated they are decidedly dextrorotatory, exhibit the phenomenon of birotation, give the cobaltous nitrate test, and have other properties in common with dextrose; but a careful separation and study of the different sugars of the fruit has not been completed, and we can not yet say just what they are, or in what proportion they are to be found in the fruits, but we have made double polarizations for each sample, and from these data calculated the sucrose by Clerget's formula, as well as by reduction.

The probabilities are that the sucrose obtained by polarization, which is as a rule more than that obtained by copper reduction, is too high, the apparent large amount of sucrose having doubtless resulted from the birotary action of the fruits in the reading before inversion, which property was destroyed on boiling for inversion.

For a long time we were not aware that the fruits contained sugars that were birotary, and this no doubt explains why we had considerable trouble in getting uniform results from the same samples, and even sometimes from the same solutions. For this reason we are not sure of the accuracy of many of the polarizations reported in this bulletin. It is clearly shown, however, that most of the fruits and their products are slightly dextrorotatory. The sucrose and total reducing sugars have both been carefully determined in each sample by copper reduction, and it is believed that these results are fairly accurate.

The difficulties resulting from birotation in the polarizations

of the fruits and products may be seen in the results here given of two samples of miel, and one of melcocha. These were all read from a one-fourth normal solution, which had been treated with lead acetate and alum-cream in the usual manner.

	Miel No. 1.	Miel No. 2.	Melcocha.
Polarization immediately after solution.....	+5.6	+3.9	+3.6
Polarization six or more hours after solution...	+3.1	+1.8	+2.5

For normal solutions multiply these figures by 4.

Each of these solutions was read from time to time and its dextrorotation was found to slowly decrease until it reached the last figures given in the table in about six hours, after which it underwent no further change.

By referring to table No. 1 it will be seen that the rind was dextrorotatory before inversion in every sample, and after inversion in all but No. 8143 (*durasnilla blanca*). Another interesting fact concerning the sugars of the rinds of the fruit is that while they had less reducing sugars, they were often more dextrorotatory than the pulp of the same fruit, but there was a greater change in the readings before and after inversion, and consequently more sucrose in the rind, for the Mexican varieties at least. The average percentage of sucrose in the pulp of these is .17 per cent., while for the rind the average was .59 per cent. Of all the fruits analyzed that were grown in the United States there was an average of .70 per cent. sucrose, while in the Mexican samples there was an average of only .21 per cent.

In the analysis of a fruit product it is now customary for the food chemist to report those samples which are dextrorotatory as adulterated with glucose. If the tuna or its sugars should ever be added to the products from other fruits sufficiently to cause them to be dextrorotatory, it would be necessary to make further tests for glucose adulteration. Since in some localities an enormous yield of the fruits can be produced per acre on land not well suited to other crops, and in a country where labor is cheap, their production for the adulteration of other fruit products is at least an economic possibility.

The large amount of coloring matter, salts of organic acids, mucilage, etc., often make it very difficult to get a clear solu-

tion for reading in the polariscope. The products from the fruits, and a few of the fruits themselves had to be treated with both lead acetate and alum-cream and at times filtered through animal charcoal when very highly colored.

An attempt was made to remove the coloring matter with sodium hydrosulphite ($\text{Na}_2\text{H}_2\text{S}_2\text{O}_5$), but by the use of this reagent alone we found that we could not clarify sufficiently. If, however, we added about $\frac{1}{4}$ gram of it to a part of the filtrate from the lead acetate and sodium sulphate, we would effectually complete the decoloration. The sodium hydrosulphite reduces the polarizations, however, more than animal charcoal, especially if the solution was allowed to stand a while before reading. This seemed to indicate that the large quantity of sulphur dioxide liberated had some action on the sugars. One sample of miel, after standing until it had lost its property of birotation, polarized at +3.1, but after treating with hydrosulphite and standing for three hours more its polarization was only +2.3.

Sugars by reduction: Under total sugars by reduction in the tables of analyses all the sugars present in the fruits are reported as dextrose. As stated elsewhere, this was done because we believe that nearly all of the sugar in most of the fruits occurs in this form, rather than as levulose, or any other reducing sugar. Sucrose was not often found present, and the probabilities are that often when traces of it are reported it was in fruits that were not thoroughly ripe.

It is customary to report the total sugars in fruits as invert sugar regardless of the kind of sugars present, and in Table No. V, which is a compilation of the analyses of several fruits, from a number of sources, the total sugars are all reported as invert, but as the copper reducing power is about the same for invert sugar, dextrose, and levulose, the percentages would not differ materially when reported in any of these forms. For further discussion of this point see methods of analysis, page 38.

The percentage of sugar varied a great deal for the different varieties, and, as was to be expected, it varied at times for the same variety, depending, no doubt, upon the season and degree of ripeness.

The only *Cylindropuntia* analyzed had no sugar; it is doubt-

ful if the fruit of any of this group contain any appreciable quantity, since none are edible.

The samples from San Antonio, Texas, contained less sugars than those from any other locality; No. 6 had no sugar; No. 3 had only .85 per cent. The sample with the largest amount of sugars is 8485, (tuna amarilla). This fruit had 11.70 per cent. The sample of this same variety collected in 1905 had 11.07 per cent.

The Mexican samples averaged 9.53 per cent. sugar. The San Antonio samples averaged 2.94 per cent., but No. 2, the highest in sugar from the latter place, had 7.18 per cent. For the six American varieties in which the whole fruit was analyzed, the percentage of sugars was 5.61; this it will be seen is more than the average sugar in the pulp of the San Antonio samples as given above, but there are included some that should really be classed with the Mexican samples since they are cultivated forms of Mexican origin much superior to any received from San Antonio. The average in all of the whole fruits of Mexican samples was 7.66 per cent.

While there was some sugar in the rind of all the samples analyzed, only those that seemed of some probable value were examined. The rind of tuna cardona, (8099), and tuna durasnila (blanca and colorada, 8143 and 8150), contained more sugars than did the rinds of any of the other varieties.

The products of this fruit which were analyzed contained from 51.06 per cent. sugar in the tunas pasadas to 64.16 per cent. in one sample of melcocha.

Alcohol Precipitate

This name is applied to a group of bodies that are precipitated upon the addition of 95 per cent. alcohol to the juices of the fruits. Plant mucilage, pectin bodies, and salts of organic acids are among these bodies.

Pectin is that substance that causes juices to jell when evaporated to the proper consistency, and our object in making these determinations was to estimate if possible the relative quantity of this material present.

The alcohol precipitation in the tuna pulp is considerably less than is obtained from other fruits that are commonly used

in the preparation of jellies; the average amount found in all the pulps was .29 per cent. while .67 per cent. is found in the cherry, which, perhaps, contains about an average quantity for fruits of this character.

The alcohol precipitate of the rind is three or four times that of the pulp. In one sample there was 2.33 per cent. while for all the rinds examined the average alcohol precipitate was 1.29 per cent.

Since the rind contains more alcohol precipitate than an average fruit, one might be led to believe that its juice could be made to jell very rapidly, but such is not the case. We have been unable to make jelly from either the pulp or rind of any of the varieties tested.

A further study of the alcohol precipitate will show that evidently only a very small amount of it, if any, is in the form of pectin. No doubt quite a bit of this precipitate is plant mucilage; especially is this true of the rind, which is morphologically the modified stem, and this portion of the plant contains so much mucilage that its juice is very slimy. K. Yoshimura* found this mucilage to be composed principally of galactan. E. F. Ladd** states that the mucilage is due to "pectosic products", but if such is the case it seems that cooking should cause fruits containing it to jell.

The amount of ash in the alcohol precipitate has been determined by us in the pulp of eight samples, and in the rind of three, and the results are given below:

Ash in Alcohol ppt.

Rind.		Pulp.	
Sample No.	Per cent. ash	Sample No.	Per cent. ash
8099	40.20	4 San Antonio	27.92
8135	29.15	8099	25.10
8150	51.25	8135	26.04
		8134	29.16
		8136	17.24
		8141	24.00
		8142	20.34
		8146	26.92
Average	40.20	Average	24.59

* Note on the Chemical Composition of Some Mucilages, by K. Yoshimura. Bul. Col. of Agr., Tokyo, Japan. Vol. 2, No. 4, pp. 207, 208.

** Sixth Annual Rep. New York Experiment Station.

Thus it may be seen that about 40 per cent. of the alcohol precipitate from the juice of the rind, and about one-fourth of that from the pulp, is ash.

The amount and character of this precipitate shows that something else is precipitated in abundance by the alcohol, together with the mucilage and pectin bodies, if there be any at all of the latter. Neither of these bodies (pectin and mucilage) would contain so much ash, besides the precipitate formed would be flocculent in character, whereas in the precipitate from both the rind and pulp there was a decided turbidity, which would indicate the precipitation of salts of organic acids, with possibly some dextrose.

The ashes from the alcohol precipitate are the basic constituents of organic salts of calcium, magnesium and potassium, and the large amount of these ashes shows that the precipitate is largely composed of organic salts.

Starch

The iodine test on the ripe fruits failed to reveal the presence of starch in any of them.

Ash

The examination of the ash of the cactus fruit has consisted principally in a determination of the amount in the soluble solids. Since nearly all the solids are soluble, the soluble ash is almost equivalent to the total ash. This is seen in the few analyses of total ash recorded in the tables. The average soluble ash in the pulp is .29 per cent., which is about the same amount found in apples, pears, or watermelons, and less than is found in the citrus fruits.

As with other plants, the seed of this fruit is also quite low in ash, it being in No. 8022, for example, only .28 per cent. of the whole fruit, which is about the same as is found in the fresh pulp.

The amount of ash in the different parts of the fruit in numbers 8037 and 8038 is tabulated below:

	No. 8037	No. 8038
Rind, per cent.....	1.06	1.40
Whole fruit (pulp and rind), per cent....	.74	.42
Pulp and seed, per cent.....	.21	.31

It will be seen from the above that the ash in pulp and seed taken together is about the same as the average of the pulp alone of all the fruits (.29 per cent.).

The character of the ash is decidedly alkaline. Dr. Bigelow* has found this to be true with the ash of fruits generally. The alkalinity of the ash of the pulp calculated to potassium carbonate amounts to 55 per cent. of the total ash. The alkalinity of the ash of the rind calculated in a similar manner amounts to 41.18 per cent., while for the whole fruit 48 per cent. of the ash is potassium carbonate.

Very little can be said in regard to the plant food removed from the soil by the tunas until we can determine what the yield per acre will be. The amount of total ash removed by the fruits is very small compared to the amount removed by the stems, which in one instance amounted to 33 per cent. of the dried plant.* Most of this ash was found to be composed of lime and potash salts which are in abundance in most semi-arid soils, and if so large an amount of these salts is necessary for securing the best results with this plant, it will probably never suffer for the lack of them anywhere in the Southwest.

It will be interesting to determine whether specimens of this plant, grown for years in Florida and other parts of the world where there is not such an abundance of soluble salts in the soil, continue to have their high ash content. Such is not the case with many other plants, and we doubt if the cacti grown in regions of abundance of rainfall will be found to contain so much ash.

The ash is also characterized by a very low content of phosphoric acid. An analysis of the ash from 28 samples of cactus averaged only 1.39 per cent. (PO_4), while other plants seldom have less than 4 per cent.

* Bul. No. 66, Bureau of Chemistry.

* See Bulletin No. 60 of the New Mexico Station.

The Species and Varieties
of
Tunas Studied

No. 8057 and 8485.

TUNA AMARILLA, (Yellow Tuna)

Opuntia sp.

A tall, open branching species 10 to 15 feet high, with a black, scaly trunk 8 to 12 inches in diameter; joints narrowly oval, about 7 to 8 inches by 15 inches, but, of course, variable, bright light green; spicules yellow, not prominent on joints; spines numerous, white, turning to a chalky, mottled, dirty-gray, flattened-triangular and a little twisted, about 1 inch long, 3 to 15 in number; flowers orange with considerable red in outer segments, giving it a red appearance when closed, style and filaments containing a tinge of red and stigma light green; fruit large, oval to obovate, $2\frac{1}{2} \times 3\frac{1}{2}$ inches, usually somewhat rough, tuberculate, with greenish rind becoming reddish-yellow on complete maturity, and yellow pulp; formidably protected by large bunches of yellow spicules $\frac{1}{4}$ inch long.

Tuna amarilla is a cultivated fruit highly prized by the Mexican people. In addition to the above description, it may be stated that very often the fruit presents a tinge of deep dull red before being cut open, but usually the yellow predominates and is decidedly apparent when the fruit is cut open. The red coloration is due to streaks of red which run through the rind coincident with the vascular bundles.

Among all the samples of tunas included in our list there are none superior in size and flavor to this one. Of the earlier samples, 4.8 would weigh one pound, but of the last it required only 2.75 to weigh a pound. No. 8485 being the larger of the two samples, had, as was to be expected, less waste material than No. 8057, the smaller one. Especially was this the case when the rind was included in the refuse. There seems to be little or no difference between the two samples other than the size; and a comparison of the analysis of the edible portion of the two will show them to be very similar in composition although No. 8485 was considerably more mature than No. 8057. The large amount of total solids, soluble solids, and total sugars, together with the high specific gravity of the juice, indicate that this has no superior among the samples included in this study so far as its chemical composition goes. There are few of our highly prized American fruits that will make a better showing in this respect, as may be seen from Table No. V.

Both samples were found to contain over 11 per cent. total sugars calculated to dextrose. The results showed the presence of very little, if any, sucrose. It was one of the few samples that was levorotatory after inversion. In fact, the 1906 sample was levorotatory to the same degree both before and after inversion.

The rind of this variety is not palatable in the fresh state, and its analysis given in Table No. I shows that it contains comparatively little sugars (4.09 per cent.). Its total solids are high. The refuse material is not so very large compared with some of the other varieties, even when the rind is rejected. The composition of the whole fruit (rind + pulp) is given in Table No. III. Since the rind has less nutrients than the pulp, the whole fruit will, of course, have less than the pulp alone.

While the rind of this variety is not eaten fresh, it is one of the varieties used in the preparation of tunas pasadas (dry tunas), which are always dried with the rind left on, and subsequently eaten in this way. For this reason we have made separate analyses of the rind and pulp. While the fresh rind has only 4 per cent. sugar, this is greatly increased in the dried rind on account of the large amount of water lost in drying, and the tunas pasadas make a very suitable product for use in cooking in a manner somewhat similar to our dried fruits. A large part of the sugar from the pulp collects on the surface of the rind when dried, and this no doubt helps to make it palatable. The fruits of this variety when dried have over 50 per cent. sugar in the whole fruits.

8057. Collected at San Luis Potosi, Mexico, 12 August, 1905.

8485. Collected at Aguas Calientes, Mexico, 10 September, 1906.

No. 8142.

TUNA NARANJADA, (Orange)

Opuntia sp.

This and tuna amarilla are really very closely related, but the differences, although slight from a taxonomic point of

view, are very constant. The plants, so far as we can see, are very much alike in every way, the main difference occurring in the color of the fruit, the pulp of this one being, as the Mexican name indicates, orange instead of yellow. The fruit in both amarilla and naranjada are very likely to have its pyriform character accentuated, when the lower portion is flabby and does not contain pulp at all. Very often this basal portion has a tendency to simulate some of the characters of the joint. Externally this variety is darker colored than amarilla. Associated with the difference in color of the fruit is often to be found a similar difference in color of other parts of the plant. While size, shape, and color of joints are the same in the two forms, the spicules are somewhat darker in naranjada and the same holds true of the flowers.

This is very fine flavored, somewhat above the average in size, and has a thin rind. The rind is only about $1/8$ to $3/16$ inch thick, and constitutes only 32.43 per cent. of the fruit. This is one of the fruits from which it was found difficult to separate the seed completely from its pulp by our method of forcing the fruit through muslin, and as a result the total solids are somewhat higher and the percentage of seed a trifle lower than is shown by the analysis. This fruit contains less seed than do the majority of the other species. In a number of these undeveloped, sterile seed occur, which suggests a possible gradual disappearance of the seed through cultivation and selection.

There is 62.57 per cent. of edible portion in this fruit, which is more than was found in any of the tunas analyzed. While, for reasons stated above, the solids reported in the tables may be slightly low, tuna cardona and tuna amarilla are the only fruits analyzed that had more solids. Cardona had 13.7 per cent. solids, amarilla 13.56, and naranjada 12.92 per cent. The polarization readings on the fruit was +2.1 both before and after inversion, and the total reducing sugars were 9.12 per cent.

Collected at Zacatecas, Mexico, 20 September, 1905.

No. 8140.

TUNA CAMUESA, (Pippin, Apple)

Opuntia larreyi Weber. Cont. U. S. Nat. Herb. 3:423, 1906.

A tall, open branching plant 8 to 12 or 15 feet high, with a black, bare, scaly trunk 8 to 12 inches in diameter; joints obovate to ovate, very large, in proportion of 8x14 inches in last year's growth, bright dark green, areoles obovate for the most part; spicules yellow and commonly formidable even on the joints; spines usually infrequent and often absent entirely, but sometimes one to three in number, but never very prominent, white, with translucent, bone-like tips; fruit large, obovate, often $2\frac{3}{4} \times 3\frac{1}{2}$ inches, dull red, with comparatively thin rind which is greenish-red or streaked and mottled; pulp red, and easily separable from the seed.

This is one of the finest of the cultivated Mexican varieties, and belongs in the *Opuntia ficus-indica* group. When the rind is removed leaving the pulp intact, the latter has a distinct orange cast. When broken open, it is mottled yellow and red, but becomes deeper red with full maturity. It is one of the most palatable of these fruits, and has comparatively few seed, which, of course, is a decided advantage. Oftentimes one-half or two-thirds of the seed will be found aborted. This we have found to be the case in specimens collected at Los Campos, Aguas Calientes, San Luis Potosi, and Zacatecas.

The fruit averaged 163.84 grams each and were the largest of all the samples except those of tapona from Riverside, California, which weighed 210.6 grams, and the 1906 sample of amarilla which weighed 164 grams, or practically the same weight of this fruit. These have much fewer seed than any of the other fruits, and a comparatively thin rind, which with the seed make a total waste of 43.94 per cent. There are 11.9 per cent. of total solids in the edible pulp, nearly all of which is soluble. Acid is present in very small amount, .031 per cent. The juice is levorotatory to the same degree both before and after inversion, indicating an excess of levulose and no sucrose. The total sugars as dextrose amount to 11.05 per cent.

Collected at Zacatecas, Mexico, 19 September, 1905.

No. 8039.

TUNA MANSÁ MORADA, (Mulberry Colored)

Opuntia sp.

A large, open branching tree with hugh joints, in age often 11x19 inches and this year's growth 10x14 inches, obovate, bright dark green; spicules brown, but not prominent upon the joints; spines white, flattened, turning to a mottled, dirty-gray, slightly twisted, with opelescent points, $\frac{1}{4}$ to $\frac{3}{4}$ inch long, 2 to 3 in number, but increasing to 12 or more at times upon old trunks, erect, spreading, with one or two lower ones recurved; fruit oblong-obovate, usually slightly tuberculate, with circular areoles $\frac{1}{4}$ inch or less in diameter, bearing formidable brown glochids 1.8 inch long, dull red exteriorly; rind reddish-yellow, turning to completely red at maturity; pulp blood-red, slightly mottled until dead ripe and clinging tightly to the seed from which it is difficult to separate it.

This is one of the popular tunas of Mexico and one which has not been met with in the open country. For some reason it is not extensively grown, there being only a few plants in scattering orchards. It is finely flavored and of good size.

This sample was analyzed August 14, 1905, seven days after its collection. It was in good condition. The average weight of the fruit was 66.5 grams, which is somewhat below the average weight for the Mexican varieties, but much heavier than those of the United States. It was one of the first analyzed after this work was undertaken. At that time the significance of the method of preparing the fresh fruit to be eaten was not fully appreciated. For this reason in this sample, as well as in 8037 and 8038, we only have the analysis of the pulp with that portion of the rind which would naturally remain after peeling the fruits as one would an apple. Nearly all of the best varieties included in this bulletin have had the pulp analyzed separately and it is unfortunate that this fruit was not treated in a similar manner. However, it may be seen from an examination of the composition of the whole fruit with epidermis and seed rejected that it compares favorably with the best of those varieties that are reported in a similar manner in Table No. IV.

Since, as a rule, the pulp alone contains a greater percentage of nutrients than the whole fruit, it is likely that the pulp of

this sample would have been about equal in value to tuna cardona. The waste in this sample amounts to 21.83 per cent. If all the rind had been rejected the waste would have been 46.75 per cent., about the same as cardona. The total solids amount to 11.62 per cent., all but 1.22 per cent. of which is soluble in water. The total solids of the juice calculated from its specific gravity amounts to 9.38 per cent. The acidity of the juice is only .047 per cent., or less than the average of the pulp alone of all the fruits, which is .08 per cent. The average acidity for the whole fruits of all the Mexican varieties is .247 per cent. The sugars by reduction are somewhat less than one would expect from the soluble solids and high specific gravity. It is likely that the results for sugar, 7.82 per cent., are slightly low, although they would naturally be somewhat low because of the presence of the rind.

By peeling a quantity of these fruits and exposing them to the sun until air dry, the total dry matter was found to be 17.43 per cent. If the 4.65 per cent. seed be taken from this, we have 12.78 per cent. edible dry matter left, which, considering the small amount of water left in the air dry sample, checks the total solids determination (11.62 per cent.) fairly well.

Collected at San Luis Potosi, Mexico, 7 August, 1905, sample consisting of 19 fruits from 4 plants.

No. 8050.

**TUNA TECA, TUNA BLANCA TECA, TUNA
MEXICANA, TUNA AMERICANA**

Opuntia sp.

This variety is known by all of these appellations in the vicinity of San Luis Potosi, and it may be the same as subsequent forms which we discuss under still other names. The distinguishing characteristic of the fruit is that it is greenish-white when mature. On the whole, it resembles very much the "Mission pear" of Southwestern United States. It is very variable in spine characters, but this particular specimen

has spines 2 to 5 in number on last year's joints, but increasing very much with age. The spicules are light reddish-brown, seldom prominent upon the joints. The fruit is ovate-obovate, about $1\frac{3}{4}$ to $2\frac{1}{4}$ inches, yellowish-green throughout or possibly greenish-white would apply better to the pulp. The seed are apparently few and cling closely to the pulp.

This is a highly prized variety with fine flavor, good appearance, good size, and reasonably thin rind. It is one of the varieties that one will always find upon the market places in season.

An examination of the table will show the similarity in composition between this and the following numbers. In size No. 8050 is about a mean of that of the other two samples (8146 and 8547). The waste amounts to 48.1 per cent., which is about the same as that of the other two. They are all characterized by high total and soluble solids, but a slightly low sugar content. The total solids for the three amounts to about 11 per cent., and the sugar from 8 to 9 per cent. It is easy to tell by tasting them that they are not as sweet as tuna amarilla for example, but they have a very excellent flavor, which with their large size and thin rind makes them desirable fruits.

Collected at San Luis Potosi, Mexico, 9 August, 1905.

Nos. 8146 and 8547.

TUNA BLANCA, (White)

Opuntia sp.

This may be the same as No. 8050. The people here do not know the name tuna teca at all. This particular specimen is spiny like our "Mission pear", but some plants are to be found here which are almost destitute of spines or spicules, but this character is not constant at all, even in the same plant. This tuna sells on the markets here for about the same price as camuesa, indeed, all of the large cultivated forms sell for about the same money.

Both of these samples have been referred to in the discussion of tuna teca (No. 8050), which they very much resemble in

both appearance and composition. This is one of the large cultivated fruits, and has a good percentage of edible pulp, the seed of which are often undeveloped, and not so abundant as they are in many varieties. No. 8146 weighed 76.3 grams, and No. 8547 weighed 123.75 grams. The total solids in the first was 10.81 per cent., and 12.35 per cent. in the second. Both fruits were slightly dextrorotatory, and contained a fraction of a per cent. of sucrose. There were 8.29 per cent. total sugars in the first, and 8.99 per cent. in the last sample.

No. 8146. Collected at Zacatecas, Mexico, 21 September, 1905.

No. 8547. Collected at Zacatecas, Mexico.

No. 8037.

TUNA RANCHERA, (Ranch)

Opuntia sp.

A tall, open branching tree 8 to 10 or 12 feet high, with black, scaly trunk 8 inches or often a foot in diameter; joints ovate-obovate, with often a tendency to be pointed at both ends, although the prevailing form is obovate, in proportion of 9x15 inches, which is a common size, rather light green; spicules yellow, infrequent upon the joints; spines short, $\frac{1}{2}$ to $\frac{3}{4}$ inches long, erect, spreading, 2 to 3 or 4 on young joints, but increasing to 10 on 3-year old ones at this age turning to a dirty-gray and apparently drop off, divergent or a few recurved upon the edges of the joints; fruit large, $1\frac{1}{4} \times 2\frac{1}{2}$ inches, oval to obovate, with large circular areoles 1.8 inch in diameter, bearing yellow, formidable spicules and hair-like fugacious spines, very dull, deep red, with some green exteriorly even when mature, rind greenish or mottled yellow and red; pulp, when rind is removed, presenting light orange-yellow appearance but mottled when cut open, the red color being situated mainly around the seed.

This is a valuable cultivated variety which has a wide range in spine characters, some forms being nearly spineless. The fruit compares favorably with the other large mansa forms, such as amarilla, in flavor, but the tunas are somewhat smaller. Although described as mottled, there is usually not enough coloring matter in either pulp or rind for slices of them to stain paper when they are laid upon it. The species should be classed with *Opuntia ficus-i-jica*.

Tuna ranchera is one of the few good fruits of which, unfortunately, we have no separate analysis of the pulp, both this and the rind having been included in one sample. The analysis given in Table No. IV will show this to be one of the best fruits so far as total solids and sugar content is concerned. It is about the same size (57.3 grams) as cardona, and the composition of the edible portion when rind is included is also about equal to that of this fruit when it is prepared and analyzed in a similar manner. It was more dextrorotatory than any sample included in our list, being +3.7 both before and after inversion. There was only .07 per cent. acid in this sample, which is quite low for any of the tunas where the rind is included with the pulp. A determination of the ash content of the different parts of the fruit shows 1.06 per cent. ash in the rind, .21 per cent. in the pulp, and .74 per cent. in the whole fruit.

The fact that there was 85.08 per cent. edible portion simply shows that the fruit was peeled by removing only a very small part of the rind.

Collected at San Luis Potosi, Mexico, 7 August, 1905.

No. 8065a.

TUNA TAPONA,* (Cork or Plug)**

Opuntia robusta Wendl. Cat. Herrenh. 1835.

When well developed, this is one of the most attractive of the native Mexican tunas. It is almost globular, more or less tuberculate, and blood-red when ripe. It thrives nicely at Riverside, California. Like many other species, the pulp becomes edible while the rind, which is red when mature, is still perfectly green. In the early part of the season the fruit upon the market is, therefore, largely green, while later it is blood-red. Maturing, as it does, very early, a great deal of the fruit is destroyed by birds which begin eating it as soon as the pulp begins to turn red.

* For description of the plant see Bul. 60: 69, 1896, N. Mex. Station.

** Referring to its action on the bowels.

Although large and attractive in appearance, this is not considered a very good species of tuna, mainly on account of the deleterious effects the Mexicans believe it has on digestion. It is said that it has a tendency to produce constipation, and that death sometimes results therefrom. However, it is extensively eaten.

Collected at Ypina, Mexico, 18 August, 1905.

No. 8065b.

TUNA TAPONA

Opuntia robusta Wendl. (?)

This and 8065a are closely related, but there are constant differences which prevent our placing them together. This is a larger plant throughout, and this is the main difference, although there are other minor points of distinction which when once seen are easily recognized. This one has joints which are larger, more nearly circular, and not so thick and plump as the common tapona of the San Luis Potosi region. The fruits in this variety are larger, but otherwise the same, and the same distinctions are true regarding the flowers. Both forms grow fairly well at Riverside, California, but we have never seen it growing native like the others. There are nearly spineless forms of both varieties.

Because of its very large size, and the fact that it was one of the very few United States grown fruits analyzed that appeared to be of much value, it is to be regretted that we failed to make a more complete analysis of it. We have, however, made the complete analysis of No. 8065a, and probably the greatest difference between these two samples is in the size. The waste is less in this one. The solids, determined from the specific gravity of the juice, is just about the same, but there is a big difference in the acidity. No. 8065a contained .21 per cent. acid, while this one had only .07 per cent. This is doubtless accounted for, in part at least, by the fact that the California sample was more mature.

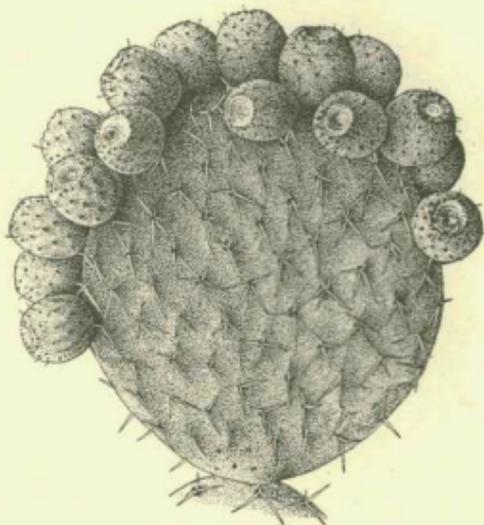
These fruits are the largest we have analyzed, being three times the size of tuna tapona, from the State of San Luis Potosi, Mexico.

Forwarded from the A. S. White Park, Riverside, California, August, 1905.

Nos. 8051 and 8099.

* TUNA CARDONA

Opuntia streptacantha Lem.* Cact. Gen et Sp. Nov. p. 62.
1839.



TUNA CARDONA.
(About $\frac{1}{4}$ natural size)

This is without doubt the most highly prized of all the Mexican tunas. It is smaller than the cultivated varieties, but is very palatable, and the Mexicans say it may be eaten in quantity without any deleterious effects. The whole fruit is purplish-red throughout, with a pulp of much deeper color than the remainder; and the epidermis showing consider-

able scaly wax covering when fully ripe. In shape it is oval to subglobose, about $1\frac{1}{2}$ to $1\frac{3}{8}$ inches in longest diameter. The fruit resembles very closely tuna cochineria and tuna artona. It is rather doubtful whether it is specifically distinct from the latter, but it is certainly distinct from the former.

Many of the cultivated species produce larger tunas and ones which are just as palatable, if not more so, but cardona has several advantages over others. It is abundant, cheap, a native species, very palatable, and with no deleterious qualities like taponia and some of the others are said to have. Fre-

* See Bul. 60: 65. 1906. New Mexico Station.

quently it is planted, but not usually in the protected orchards, for it is sufficiently spiny to need no protection. Cuttings are commonly planted in the open country, in order to extend the native thickets. It is especially abundant upon the markets of San Luis Potosi, Augas Calientes, and Zacatecas, where one may often find piles containing 30 or 40 bushels brought in from the surrounding hills and deserts.

In view of the fact that this is the most abundant, widely distributed, and most universally used of all the Mexican species, we have devoted considerable time to a study of the composition of both the pulp and rind, and an analysis of both of these parts will be found in tables No. I and II respectively, while in table No. IV the analysis of the fruit without the seed and epidermis is also given. In order to determine the effect of storage on the composition, we have also made analyses of samples at three different periods of storage, both in 1905 and 1906; the first analysis given in the table being that of the fresh fruit immediately after its receipt in the laboratory, the second, that of fruits selected from the same lot as the first after standing ten days, and the third being the analysis of fruits that had been stored, as packed for shipment, for 20 days.

Tuna cardona is at least equal in nutritive value to any of the tunas, although considerably below the average in size, and not quite as highly flavored as amarilla, naranjada, or camuesa.

Sample No. 8051 was smaller and had more rind and seed than the other two samples. It has only 34.8 per cent. edible pulp, 11.47 per cent. solids, and 9.76 per cent. sugar as dextrose, this being less than was found in the other samples, doubtless due to the fact that 18 days elapsed between the collecting of this number and the second sample, thus giving the latter time to more fully mature.

No. 8099 was, as stated above, analyzed at three different periods for both the years 1905 and 1906, and the results are reported under Nos. 8099, 8099a, and 8099b in Table No. II. The rind was also analyzed and the results reported under Table No. I. We were not able to notice any marked differ-

ence in the composition of the pulp or rind of the fruit when stored beyond what might be expected in different fruits of the same variety. One very noticeable change, on standing, however, was the loss in weight of the rind and a still greater decrease in the weight of the pulp. For the purpose of showing this change, the weights and percentages of the fruit and its rind and pulp for the different periods of storage during the seasons of 1905 and 1906 is given below. From this table it may be seen that on standing for 20 days the percentage of rind increased from 42.66 to 61.70.

Table VI. Showing Effect of Storage on Weight and Relative Amounts of Rind and Pulp

Year	WT. IN GRAMS		PER CENT. RIND		PER CENT PULP.	
	1905	1906	1905	1906	1905	1906
Fresh	50	60.5	42.66	48.92	54.02	47.69
10 days storage	49	53.15	51.53	50.0	45.08	46.75
20 days storage	47	—	61.70	—	35.35	—

The figures here given would seem to indicate that the water in the fruit passes from the pulp into the rind, but if such is the case this movement takes place without any material change in the composition of either pulp or rind that we were able to detect in the analysis.

The amount of acid in this fruit was unusually low both in the pulp and rind. In the pulp of all the samples it averaged .05 per cent., and in the rind .21 per cent., which is less than half of the average for all the other Mexican samples.

The juice of every sample of 8099 tested was dextrorotatory before and after inversion. Sometimes both polariscope and reduction methods showed a very small amount of sucrose in the pulp, and still more in the rind which at times seem to have as much as 1.5 per cent. The rind of none of the fruits contained as much total sugar as did this one (7.2 per cent.), which is almost as much sugar as the pulp of average temperate zone fruits. The total sugars as dextrose were de-

terminated in seven different samples of cardona and the average for these determinations was 10.22 per cent.

No. 8051 collected at Alonzo, Mexico, 11 August, 1905.

No. 8099 collected at Aguas Calientes, Mexico, 29 August, 1905.

No. 8436 collected at Aguas Calientes, Mexico, 4 September, 1906.

No. 8038.

TUNA PALAMITA

Opuntia sp.

A tall, open branching cultivated nopal 10 or 12 feet high, with a black, scaly trunk 6 to 10 inches in diameter; joints obovate, in proportion of $6\frac{1}{2}$ to 12 inches, which is a common size, slightly bluish-green, becoming cracked and scaly with age; areoles obovate, about 1-16x1-8 inches, but increasing slightly with age; wool tawny; spicules light brown; spines flattened, triangular, twisted, some recurved, others erect-divergent, $\frac{1}{2}$ to 1 inch long, white with opalescent darker points, 2 to 4 in number, but increasing to 6 or 7 at age of three years, and increasing slightly even beyond this, but becoming abraded from old trunks; fruit about $1\frac{1}{2}$ x $2\frac{1}{4}$ inches, ovate-obovate, mottled and dull red when fully matured; rind finally turning to a streaked brownish-red and pulp mottled.

This fruit is formidably protected with light brown spicules 1-16 or more inches long from circular areoles about $\frac{1}{2}$ inch apart. It is well flavored, but not promising, on account of the many spicules. We have never seen this species excepting in cultivation. The fruit is sweet and palatable, and, were it not for its small size (33.1 grams), and large quantity of spicules, it would be very desirable. No separate analysis was made of the pulp, unfortunately; but judging from the analysis of the whole fruit, there are few tunas whose edible portion shows a superior composition. There are 12.43 per cent. total solids in the whole fruit and 8.87 per cent. sugar.

Collected at San Luis Potosi, Mexico, 7 August, 1905.

No. 8119.

TUNA AGUA-MIELILLA, (Honey Water)

Opuntia sp.

A tall, open branching native tree 12 to 25 feet high, with a bare, scaly, black trunk 10 to 14 inches in diameter; joints ovate-obovate, about 8x12 inches, which is a common size, deep dark green, soon turning to a gray-black; spicules reddish-brown, but never prominent upon the joints; spines white, becoming mottled, flattened, twisted, erect-divergent, 4 to 6, with lower and usually two laterals recurved; flowers (only two or three seen) deep orange, with red in midribs of outer segments, always causing them to look red when closed; style bright red, filaments lighter red, stigma yellow with streaks of red through outside of the 6 or 8 divisions; fruit small; subglobose to obovate, about 1½ inches in longest diameter, deep dark red with darker pulp, which is easily separable from seed, formidably protected with small, circular areoles containing bunches of reddish-brown glochids surrounded by the blackened ends of the wool.

As the popular name suggests, this is a very sweet and palatable tuna, but is too small to favorably compare with the cultivated forms, and the better wild species, such as cardona. These fruits averaged 30.84 grams in weight which is less than half the average size of the Mexican tunas that we studied. Another serious objection is the large percentage of waste in rejecting the thick rind which amounts to 57.72 per cent. The solids and soluble solids (10.98 and 10.78 per cent. respectively) are high. The acid (.024 per cent.) is less than was found in any of the fruits. The percentage of proteids (.89 per cent.) is not high for fruits generally, but is more than was found in the other samples of prickly pears.

The total sugars amount to 8.84 per cent. No sucrose was found by reduction methods, and only very small trace by polarization, the readings being to the right before and after inversion. Because of the large quantity of rind an analysis was made to determine the nutritive value of this portion. The results are recorded in the table of analyses of the rinds, and from these it may be seen to have 7.27 per cent. solids in the juice of which only 2.76 per cent. is sugar.

Collected at Dublan, Mexico, 12 September, 1905.

No. 8102.

TUNA LEONERA

Opuntia sp.

A tall, very open branching tree 15 feet high, largely used for hedges and line plantings here. Joints deep dark green, about the same color as cardona, obovate, about 5 to 7 inches by 8 to 12 inches spicules reddish-brown, not formidable upon the joints, really seldom visible except in the spineless areoles at the base; spines 4 to 7 on last year's joints, but increasing very much on old wood, white, turning to a mottled condition, and finally dirty-black, flattened, twisted, one to two inches or more long and erect, with upper shorter, spreading and lower usually recurved; flowers (only two seen) orange with greenish filaments, reddish style and light green stigma; fruit almost globular, deep dull red, with pulp darker and rind of medium thickness, formidably protected with reddish-brown spicules from small, circular areoles, about $\frac{1}{4}$ inch apart; seed easily separable from pulp.

This tuna is small, but has a very good flavor, and is consequently well thought of in parts of Mexico. It is eaten fresh and also employed in the manufacture of miel, melcocha, and queso, for which it is said to be admirably adapted. The composition of the edible portion as seen from the analysis in the table shows it to be one of the three best fruits, but as with agua-mielilla its small size and thick rind prevents it from being classed as it would otherwise be. The fruits weighed only 30 grams, and 68.66 per cent. of this was rind, which with the 3.33 per cent. seed left only 28.01 per cent. of edible pulp. The solids of the edible portion amounted to 13.21 per cent., 10.78 per cent. being sugar. By reduction none of this was found to be sucrose, and polarization only showed .38 per cent. Both polarizations were to the right.

Collected at Encarnacion, Mexico, 1 September, 1905.

Nos. 8141 and 8546.

TUNA PACHONA

Opuntia sp.

A tall, rather compactly branched tree 10 to 15 feet high, with a black, scaly trunk 6 to 10 inches in diameter; joints ovate-obovate, about 7x13 inches, deep dark green, with waxy white covering often

prominent, resembling cardona in color very much, but on the whole a little lighter; areoles 1 to $1\frac{1}{4}$ inches apart, ovate to circular; spicules bright reddish-brown, but often yellowish at their bases, not often formidable on joints except at the bases of the younger ones; spines white, flattened or triangular, with translucent, bone-like tips, usually slightly twisted, somewhat but never tightly recurved, 2 to 5 in number; flowers not seen; fruit red, becoming decidedly purplish when fully matured, formidably protected with large bunches of reddish-brown glochids from large circular areoles.

This is a bright, clear red tuna which becomes deep red to purple when completely ripe. It is one of the most attractive of the leonera-opalilla-agua-mielilla group, and is largely used in the manufacture of queso and other pulp products. It sold on the day of collection upon the markets of Zacatecas at the rate of seven or eight for one cent, while amarilla, camuesa, etc., were selling at the rate of two for one cent.

Tuna pachona closely resembles tuna cardona in composition. The average weight of the individual fruits of the cardona sample collected in 1905 was 49 grams, while the pachona for the same year averaged 48.2. The two resemble each other also in having a "mealy" juice, that is, when the juice is expressed there is a considerable amount of very finely divided solids (marc) in suspension.

The pachona sample collected in 1906 (No. 8546) was about the same in size as the one collected in 1905, and the amount of seed and rind as well as the composition of the pulp was about the same in both. The total solids amounted to about 12 per cent., and a calculation of the solids in the juices of the two from their specific gravity shows this to be not far from 12 per cent. for both samples, while the reducing sugar amounted to about 9 per cent.

Strange to say, No. 8141 was dextrorotatory to a fraction of a degree both before and after inversion, and No. 8546 was slightly levorotatory in both cases. The latter was more fully matured than the former.

No. 8141. Collected at Zacatecas, Mexico, 19 September, 1905.

No. 8546. Collected at Zacatecas, Mexico, 19 September, 1906.

Nos. 8100 and 8136.

TUNA CHAVENA*

Opuntia sp.

When fully ripened this tuna does not differ very much in outward appearance from tuna cardona. It is, however, slightly longer and lighter in color, especially during the ripening period. It differs also in being protected by yellow, instead of reddish-brown spicules, and in maturing about six weeks or two months later. Chaveña and its closely allied varieties are among the latest to mature in the fall, with its two varieties are almost always associated. Tuna caidilla differs from it in having rather smaller joints and in the one important characteristic of dropping its fruit as soon as mature. The Spanish name "caidilla" is probably derived from "caier", to fall. The fruit is said to remain in good condition upon the ground for a month or six weeks. The other variety is tuna cascarona, differing again from chaveña in having somewhat larger and more uniformly circular joints and possibly slightly larger tunas. These three forms are very closely related and would scarcely be considered distinct species by the most critical taxonomist, but they are quite well recognized by the Mexicans, who will pick them out, especially during the fruiting season, with considerable regularity. As stated above, tuna chaveña, together with its varieties, mature late in the season, and are the forms best adapted to winter use. In the vicinity of Aguas Calientes large quantities of these are stored and placed upon the market continuously through April. They are packed, as stated elsewhere in this publication, in well aerated situations in alternate layers with straw or hay. Specimens which we have examined as late as the middle of April were in a good state of preservation.

Although somewhat under ripe No. 8100 had evidently attained its full growth and sugar content. These tunas averaged 11.23 grams heavier than the fruits of No. 8136 which were gathered in the same locality two weeks later. This va-

* See Bul. 60: 73. 1906. New Mexico Station.

riety is about an average size, but it is characterized by a very large amount of rind in proportion to pulp. The percentage of seed is somewhat less than was found in some of the other varieties, but the amount of rind is very large, and it is not edible. When this was rejected the total refuse was about 75 per cent. Because of this large amount of waste, the rind of 8100 was analyzed and found to contain 4.97 per cent. sugar. The acids were rather high in the rind, (.96 per cent.), which was probably due to the fruit not being thoroughly ripe. Both samples were somewhat similar in composition. The solids, sugars, and proteids of 8136 were somewhat more than was found in the greener sample, by far the greatest difference being in the proteids. The polarizations were to the right in both samples both before and after inversion. No sucrose was found by reduction in either, but the polarizations seem to show .24 per cent. in 8136. This is about an average of the Mexican fruits so far as sugar and proteids are concerned. The test with iodine failed to show any starch in 8100.

Neither sample changed its color when evaporated to dryness on the water bath as do many of these fruits.

No. 8100 collected at Aguas Calientes, Mexico, 29 August, 1905. This specimen was collected from the very earliest tunas to mature and is really considerably under ripe. The natives had not begun to use it at all.

No. 8136 collected at Aguas Calientes, Mexico, 15 September, 1905. This specimen was none too ripe; although the ripest fruits obtainable were selected for the analysis. The natives were just beginning to eat them at the time this sample was collected.

Nos. 8143 and 8545.

TUNA DURASNILLA BLANCA, (White Peach)*

Opuntia leucotricha DC. Rev. d. la. Fam. d. Cact. 119: 1829.

This is a light yellow fruit when mature, and reaches a size of $1\frac{7}{8} \times 2\frac{1}{4}$ inches, but is usually smaller than this. It is one

* See Bul. 60: 75. 1896. New Mexico Station.

of the very few aromatic tunas of Mexico, although we are informed by Mr. Francis Eschauzier that this is a common characteristic of the tunas which have become naturalized in Southern Spain. Differing from many species, the rind of this assumes more of the consistency and flavor of the pulp when mature and is consequently eaten, the practice usually being to cut off the peel rather roughly, leaving about one-half of it attached to the pulp when the operation is completed. In this way about one-half of the peel is consumed with the pulp. To many foreign tastes this is a pleasant fruit on account of its slight pungency, the other species being often complained of as insipid. This, however, is no more true of the tunas than of many subtropical fruits. See further discussion under next number.

No. 8143. Collected at Gutierrez, Mexico, 20 September, 1905.

No. 8545. Collected at Zacatecas, Mexico, 19 September, 1906.

No. 8150.

TUNA DURASNILLA COLORADA, (Red Peach)

Opuntia leucotricha DC.* Rev. d. la. Fam. d. Cact. 119: 1829.

We are unable to discover any constant differences, except that of color, between this and No. 8143. Both forms are aromatic and both are eaten with a portion of the peel attached to the pulp. Both have formidable spicules and hair-like, fugacious spines of the same color. It is the peel and epidermis that is most highly colored in this variety. The pulp becomes red very tardily and then it is only mottled, the red being confined to that part of the pulp adjacent to the seed.

It resembles No. 8143 as much in its chemical composition as in its botanical and physical characteristics, and for this reason the samples are discussed together. Since both rind and pulp of these two fruits are usually eaten, a complete analysis has been made in each fruit of both these portions separately, as well as of the whole fruit (minus seed and

* See Bul. 60: Pl. IV. 1896. New Mexico Station.

peeling), and the analyses as given in Tables I, II, and IV will show a remarkable similarity in the composition of the different parts of the two. The average weight of each sample was 42.9 grams for 8143 and 40.6 grams for 8150, both being considerably below the average weight and size of the larger tunas.

Like tuna chavena (8136 and 8100) they have a very thick rind, (about $\frac{3}{8}$ inch), but inasmuch as it is palatable this cannot be offered as so much of an objection to them, yet while the rind of both fruits is superior to the rind of other fruits examined, with the exception of tuna cardona (8099), it is not equal in value to the pulp either in composition or flavor, and the same fruit with a thinner rind would, of course, be preferred. As mentioned before, it is doubtless the presence of a large amount of plant mucilage and salts of organic acids that render the rinds unpalatable, and in No. 8150 these were found to be less than one-half of the amount usually found in this portion of the fruit, as shown by the amount of alcohol precipitate, (see Table I). The amount of ash was also considerably less in both samples than is usually found in the rind. About the only marked difference in the two fruits is in the amount of acid, there being more than twice the amount of acid in the white variety (8143), than was found in the red (8150).

While, as before stated, these fruits are quite similar in composition, there was found somewhat more pulp in the durasnilla blanca than in durasnilla colorada, but the total and soluble solids, the proteids, specific gravity and sugars are practically the same in both. As in the rind, the acid in the pulp of the former is more than twice that of the other. Both of these fruits are smaller, contain less sugar, and other nutrients than some of the other samples, but the palatability of their rinds makes them desirable fruits.

Collected near Zacatecas, Mexico, 22 September, 1905.

No. 8134.

TUNA VINATERA

Opuntia sp.

A tall, open branching plant often 12 to 15 feet high, with a gray, scaly trunk 8 to 12 inches in diameter; joints prominently pubescent, tuberculate, narrowly obovate, 3 to 4 inches by 10 to 14 inches in last year's growth, light yellowish-green; spicules lemon yellow, very formidable near base of joint, but not so prominent above, often $\frac{1}{4}$ inch long; spines white, erect, spreading, flattened and twisted with prominent, translucent, bone-like tips, as much as $1\frac{1}{4}$ inches long, 2 to 4 or 5 in number, very formidable and stout, increasing rapidly with age and enlarging the areoles upon the old trunks to often $\frac{1}{2}$ inch in diameter, and containing as high as 30 strong spines; flowers deep orange with red in midribs of outer segments, which are irregularly separated and often cleft; filaments and style red, with pulp deeper colored than rind and clinging closely to seed, pubescent, tuberculate, deeply pitted at top, in this respect much like fruits of some of the species of *Nopalea*, formidably protected by yellow glochids from triangular areoles 3-16 to 5-16 inch apart.

Although very pleasantly flavored, this species has many disadvantageous characteristics. The fruit is small, the pulp clings closely to the seed and the spicules are very numerous. It is quite extensively eaten in the field, but seldom found upon the markets, and is not very highly prized. It is the smallest of any of the fruits analyzed with the exception of one or two samples of little or no nutritive value. They only average 24 grams per fruit, but the rind was not so thick as in some of the other fruits of good quality like leonera and agua-mielilla. The edible pulp constituted 50.17 per cent. of the fruit, and this had 12.14 per cent. solids, nearly all soluble, 10.22 per cent. being sugar. No sucrose was found by reduction, and only a trace by polarization, the polarization being +2.3 before and +2.1 after inversion.

Collected at Aguas Calientes, Mexico, 16 September, 1905.

No. 8135.

TUNA JOCONOXTLE, (Ho-con-ox-tle)

Opuntia sp.

A medium-sized, rather compactly branched native plant 6 to 10 feet high, with a gray, scaly trunk 6 to 8 inches in diameter; joints large, obovate, in proportion of 8x11 inches, which is a common size,

minutely papillate-hairy, soft and silky to the touch, dull green, becoming yellow and scurfy and finally gray scaly; areoles circular, about one inch apart; spicules yellow and rather prominent even on joints; spines white, turning to a dirty-gray, flattened, slightly twisted, weak, erect-divergent, very unequal in length, longest about one inch, the lower often somewhat recurved; flowers yellow; fruit subglobose to slightly obovate, about $1\frac{3}{4}$ inches in diameter, dull red with pulp deep red and rind lighter, papillate-hairy, with circular to obovate areoles about $\frac{1}{4}$ inch apart.

There are several very distinct varieties which pass under the above common name. We are not certain that they all belong even to the same botanical species. The most obvious characteristics are found in fruit coloration, but there are other taxonomic distinctions also. This variety has fruit red or reddish-purple throughout. Another variety has green fruit with red pulp; another has fruit green throughout when fully mature. All of the varieties agree, however, in one respect, namely, they are not palatable in the fresh state. They need to be cooked before being eaten.

The rind in this species is comparatively thick and the pulp not palatable. It is, therefore, not eaten until cooked. Its main value is in the manufacture of preserves, for which there is a large use.

A rather complete analysis has been made of both rind and pulp, and the composition of these parts, as well as that of the whole fruit, is reported in the different tables. The average weight of this variety is 41.17 grams, which is below the average size. 68.46 per cent. of this is rind, only 26.95 per cent. being pulp free from seed. It contains less nutrients than any of the edible samples received from Mexico, with the possible exception of tuna cuija.

A comparison of the analysis of the whole fruit of these two samples in Table No. IV shows the total and soluble solids in joconoxtle to be 7.02 and 5.34 per cent. respectively, while for tuna cuija they are 8.45 and 7.50 per cent. respectively. But cuija has only 4.18 per cent. sugar, while joconoxtle has 4.76 per cent. in the whole fruit. The pulp of the latter has 7.74 per cent. sugar, but we have no data for sugar in the pulp of the former.

These are the only tunas from Mexico with less than 10 per

cent. total solids and with so low a percentage of sugar. In this respect they more nearly resemble those forms native to the United States.

Collected at Aguas Calientes, Mexico, 15 September, 1905

Nos. 1 to 6. (Wm. Sinclair).

PRICKLY PEAR, NOPAL

Opuntia lindheimeri Engelm.* Boston Jour. Nat. Hist.
6:207. 1850.

Very little use is made of this fruit, and our analyses show that it has comparatively little merit as a food. Occasionally a family is found which makes a sort of preserve of the peeled fruits; others dry them, while others eat them in the fresh state, but usually they simply drop off the plants and are eaten by hogs and cattle. There is a strong opinion prevalent among both Americans and Mexicans in portions of southern Texas that the fruit produces injurious effects. However, this may be, it is certain that it is very often eaten with no injurious consequences whatever, although not very palatable.

A total of six samples of this species have been analyzed, all collected by Mr. William Sinclair, at San Antonio, Texas, as follows:

No. 1. 1 August, 1905. This is the only one of those fruits from San Antonio, Texas, which had the pulp and rind analyzed together as one sample, and for that reason it is not readily comparable with the other numbers in its solids and sugar contents, but it is probably one of the best fruits from that locality.

The tables show about twice as much sugar in No. 2, which was collected six or seven weeks later in the season, but the solid matter is about the same for both, and the difference in sugar can be largely accounted for by the fact that the rind is included in sample No. 1.

The tables show a high percentage of edible portion because

* See Bul. 60: 32. 1906. New Mexico Station, and Bul. 91: 9-11. 1906. B. A. 1., U. S. Dept. Agriculture.

only the seed and a very thin epidermis is included in the waste. The fruits were crimson in color, averaged 43.5 grams in weight, and were about 1.5 by 2.5 inches in size. The sample had 3.94 per cent. total reducing sugars, and .88 per cent. sucrose. The total solids determination was lost, but the solids in the juice calculated from the specific gravity is 7.74 per cent.

No. 2. 19 September, 1905. This sample of *Opuntia lindheimeri* was collected about seven weeks later than the previous one, and was the largest and best sample from San Antonio. The fruits were 1.75 to 3 inches in diameter, and weighed on an average 71.63 grams. The rind of this sample was very thick (about $\frac{1}{4}$ inch in its thinnest part), and was a very deep purple. Like all the samples from Texas, there was a large percentage of waste. There were 7.78 per cent. of total solids, and 7.18 per cent. total sugars.

No. 3. 17 November, 1906. The individuals in this sample averaged about $1 \times 1\frac{1}{2}$ inches in size, and weighed 25 grams. Like all the fruits of this species, it was sour and unpleasant to the taste. In some of the fruits the pulp was gray or yellowish-green in color. The rind was very thick and constituted 67 per cent. of the total. Only the pulp was included in the analysis, and this amounted to 25 per cent. of the fruit. It has only 5.68 per cent. solids. Of these solids 1.18 per cent. was acid, .48 per cent. proteids, and .85 per cent. total sugars. If this fruit were palatable the small amount of edible portion, and the low solids and sugar render it of little value.

No. 4. 4 July, 1906. The pulp only was included in the analysis of this sample. It amounted to 33.29 per cent. of the whole fruit. There were 7.8 per cent. solids, of which 7.27 per cent. were soluble, 5.24 per cent. was sugar, and .88 per cent. acids calculated to H_2SO_4 . It is interesting to note that while this fruit contained only 5.24 per cent. sugar, it was the best sample of this species. It was levorotatory before and after inversion, both polarization and reduction showing a fraction of one per cent. sucrose.

No. 5. 16 October, 1906. This consisted of small, somewhat shriveled, green fruits, and a number of them had begun to decay. They averaged 21 grams in weight. The rind was green

to the pulp, but this was of a bright scarlet color. Like the other samples, the proportion of rind and seed was very large and only 32 per cent. was edible. Of this 7.13 per cent. was solids, and only 1.41 per cent. sugar. We were unable to notice any effect upon polarized light by the juice.

No. 6. 6 November, 1906. These fruits weighed, on an average, 26.54 grams. The pulp had only 5.33 per cent. solid matter, and this was quite unpalatable as may readily be explained by its analysis as given in Table No. II. Of this solid matter, 2.15 per cent. was acid, and the fruits contained no sugar whatever.

No. 2, NEW MEXICO COLLEGE GARDEN

Opuntia engelmannii cycloides.* Englm. and Bigel. Pacif. Ry. Rep. 4: 37. pl. 8 f. 1. 1856.

Both rind and pulp were of a deep purple color, averaged about $1\frac{1}{2}$ by 2 inches in size, weighed 18.1 grams and had about 200 seed, 3-16 inches in diameter.

In the analysis of this sample the rind was included with the pulp. The refuse, consisting of seed and peeling, amounted to 28.53 per cent. The solids calculated from the specific gravity of the juice were 11.23 per cent. One per cent. of this was malic acid, and six per cent. reducing sugars. By reduction 1.97 per cent. sucrose was obtained. By polarization it was 1.65 per cent.

In the vicinity of Hillsboro, New Mexico, the fruit of this species is prepared into an attractive palatable syrup. The juice is expressed in a fruit press, and is then boiled to one-fourth its original volume, after the addition of one-sixth its weight of cane sugar. Boiling does not destroy the color in the least. The finished product is not only palatable, but attractive in appearance.

Collected at Agricultural College, New Mexico, 10 August, 1905.

* See Bul. 60: 40. 1906. New Mexico Station.

No. 8036.

TUNA CUIJA, (Quee-ch-a)*

Opuntia engelmannii cuija G. & H.** New Mex. Exp. Sta.
Bul. 60: Pl. 2. 1906.

A deep purple fruit which ranges from subglobose to pyriform, about $1\frac{1}{4} \times 2\frac{1}{4}$ inches, and is one of the most variable species. Some forms are worthy of cultivation, being quite palatable and having a good proportion of pulp, while others are not fit to eat. When overripe the color is very deep, almost black, so much so that the vendors upon the market places where they are sparingly sold often call them tuna negra. The fruit is quite comparable with that of *Opuntia lindheimeri*. The areoles are very similarly distributed and the spicules somewhat more abundant.

No separate analysis was made of the pulp of this variety, but the analysis of the edible portion of the whole fruit shows this to be of little value compared to most of the other Mexican varieties. It resembles joconoxtle in its composition, but the fruits were only about one-half as large, the average weight of cuija being only 21.05 grams. The per cent. of refuse is reported in the table as only 15.38 per cent. of the fruits, but this is because in the analysis the rind was all included in the edible portion excepting the thin epidermis. The total solids of the fruits are 8.45 per cent., but only 4.18 per cent. is sugar.

Collected at San Luis Potosi, Mexico, 6 August, 1905.

No. 3. NEW MEXICO COLLEGE GARDEN

O. laevis? Coulter* Contr. U. S. Nat. Herb. 3: 419. 1896.

The average weight of these fruits is 29.5 grams. They are of a dark purple color, and the juice is a brilliant red both

* The "ch" having practically the same sound as the German ch.

** For description see Bul. 60: 44. Pl. II. 1906. New Mexico Station.

* See Bul. 60: 43. 1906. New Mexico Station.

for the rind and pulp. The pulp was separated from the peeling and seed in a press. The edible portion obtained by this process amounted to 78.18 per cent. of the fruit. The total solids were 10.11 per cent. and the sugars 7.51 per cent. This was one of the few tunas that was levorotatory both before and after inversion. By polarization no sucrose was found, and only .14 per cent. was found by reduction; it contained .22 per cent. acid calculated as H_2SO_4 .

This is probably the most palatable prickly pear that is at present found growing in New Mexico, and while it is not eaten as a fresh fruit very extensively here, it is used considerably by the Mexicans in the preparation of preserves.

Some of the pulp of this fruit was evaporated to about one-eighth of its original volume to a thin paste without suffering any change in its color. This paste was used for coloring apple jelly and candy, and was found to serve admirably for the former purpose. Because of the danger or prejudice against the use of the coal-tar dyes, it may have some value commercially as a vegetable coloring matter. Candy colored by means of it lacked the brilliancy of that colored with coal-tar dyes, and it is doubtful if it could ever be very generally used for this purpose. The paste prepared in this manner had 51.6 per cent. sugar, only .48 per cent. being sucrose. By removing the sugar and insoluble solids from the material the coloring matter could probably have been concentrated to as rich a color as cochineal paste. We expect to investigate the coloring matter of this fruit more fully the coming season.

As to whether or not the fruits will ever prove of commercial value for the preparation of a coloring matter will, we believe, depend solely upon the yield per acre that can be obtained. This can only be determined by experiment.

Collected from Cactus Garden, New Mexico Agricultural College, 20 August, 1906.

No. 8022.

Opuntia phaeacantha Engelm.* Mem. Am. Acad. (Plant. Fend.) 4:52. 1849.

This fruit is rather small and too acid to be of use as an article of human food. It is pyriform, about $1 \times 1\frac{1}{2}$ inches, rather sparingly beset with small areoles, having formidable yellow glochids $\frac{1}{8}$ inch or less long. It is light reddish-purple without, and has a rind of the same color, but the pulp, which is quite acid, is greenish-yellow and the seeds comparatively large.

It will be seen that this brief description varies somewhat from that given in Bul. 60. 1906, New Mexico Station. We cannot tell about the character of the fruit of the type of *Opuntia camanchica* for reasons stated in that publication and the description is not explicit. It may be necessary later to admit under this specific name forms with fruits bearing the following colors:

1. Reddish-purple throughout.
2. Reddish-purple on outside and greenish-yellow within.
3. Reddish-purple epidermis and rind and greenish-yellow pulp.

The fruit was prepared for analysis by peeling the skin or epidermis with as little waste of the rind as possible, which was analyzed together with the pulp, freed from seed. There were in this sample 15.84 per cent. seed, this being more than was found in any of the samples analyzed. The peeling was only 12.06 per cent. making a total waste of seed and peeling of 27.9 per cent.

The total and soluble solids were not determined in this sample, but the solids in the juice calculated from its specific gravity were 11.00 per cent.; and the sugars amounted to only 3.35 per cent. making a purity coefficient of the juice of only 30.5 per cent., while with the juices of the best fruits it was as high as 80 to 90 per cent. This low coefficient in the purity of the juice is found in all the fruits with a low sugar

* See Bul. 60: 50. 1906. New Mexico Station, for notes on this and *O. camanchica*.

content, when the rind was included in the analysis with the pulp. The other solids doubtless consist of acids, salts of organic acids and mucilage. 1.58 per cent. is acid calculated as H_2SO_4 .

Reduction methods showed 2.6 per cent. of the sugar to be sucrose, but we are inclined to believe that there must be an error in these results since the juice seemed to have very little if any effect on polarized light, and no sucrose was found by polarization.

Collected at El Paso, Texas, 30 July, 1905.

Nos. 1 and 4. (New Mexico Garden)

Opuntia macrocentra. Englm. & Bigel. Proc. Am. Acad. Arts and Sci. 8:292. 1856.

At the time of collection it was noticed that there were two kinds of mature fruits on the different plants in a plantation of this species upon the College campus. They resembled each other in their outward appearance, except that No. 1, collected in 1905, was about twice the size of No. 4, collected in 1906. The pulp of No. 1 was red, while that of No. 4 was green, or yellowish-green. The fruits of sample No. 1 averaged 29.28 grams, while those of No. 4 weighed only 14.5 grams.

No. 1 was prepared for analysis by peeling off the epidermis and forcing the pulp and pericarp through muslin. The amount of edible portion obtained in this manner amounted to 78.46 per cent. The edible portion in No. 4 was obtained by subjecting the fruits to pressure and weighing the juice thus obtained. In this way only 59.68 per cent. was edible. The total solids in No. 1 were not determined, but a calculation from the specific gravity of the juice shows the solids in this sample to be 8.92 per cent. The total solids in No. 4 were 12.08 per cent. and the soluble solids 11.63. Calculated from the specific gravity of the juice the solids present in No. 4 amounted to 12.60 per cent. No. 1 has .85 per cent. acid, and No. 4 .47 per cent., or about half the amount found in No. 1.

Both samples were levorotatory at both readings, and both seemed to have some sucrose, with a larger quantity in No. 4.

No. 1 had 3.87 per cent. total sugars as dextrose and No. 4 had 9.03 per cent. The small fruit with the green pulp which was collected in 1906 was a better fruit than the one collected in the previous year, as may be seen from its composition. It has more solids and sugar, and less acid. Whether this is due to the season, the fact that it was collected ten days later in the month, the difference in the size of the two samples, or varietal difference we cannot say. A difference in the color of the pulp is a common one in the prickly pears. Similar differences to the one noted here are common in *O. engelmannii*, *O. lindheimeri*, *O. phaeacantha* and many others.

No. 8035.

TUNA JUELL, (Whae)

Opuntia imbricata, (Haw.) DC.* Prodrumus 3: 47. 1828.

Cereus imbricatus, Haw. Rev. Pl. Suc. p. 70. 1821.

This is the common cylindropuntia of the highland region of Mexico. The fruit is not eaten by either man or beast, so far as we have been able to determine. As the analyses show, it is very high in acid, and because of this and the presence of so much plant mucilage and absence of sugar it is not at all palatable.

Before the advent of the coal tar dyes into Mexico this fruit had an important place in the arts. The tunas were gathered, chopped up into small pieces, and boiled, the fiber and seed being filtered out and the extract used to dissolve and set cochineal dye. It is still used in this way to a limited extent. Experiments which we have conducted show it to be somewhat efficient for the purpose, especially in the coloring of woolen cloth. Its mordanting property is doubtless due to the large amount of acids and salts of organic acids present.

This is the only analysis of cane cactus (*Cylindropuntia*) included in this bulletin. The fruits of this group of the cacti are not edible, nor was this particular sample. The analysis was made to determine its composition compared to the prickly pears. The fruits average 51.66 grams in weight.

* See Bul. 60: 97. Pl. VII, fig. 2. 1906. New Mexico Station.

The percentage of seed is 9.68, which is higher than was found in any of the fruits except *O. phaeacantha*, (8022).

The total solids were only 7.57 per cent., 5.54 per cent. being soluble in water. The juice contained an unusually large amount of plant mucilage, which rendered it so slimy that we could not determine the specific gravity at all by means of a Westphal balance, and upon attempting this determination with a gravity balance, the unavoidable bubbles in the slimy juice caused the specific gravity to be only .903, or less than water, which is, of course, too low. The proteids present were about an average of what is usually found in the other tunas. The fruit contains 3.48 per cent. of acid, which was found to be malic acid. The large percentage suggests a possibility of the use of the plant for the preparation of this acid. No trace of sugar was found either by reduction or polarimetric methods.

An analysis of the ash of the soluble solids in this fruit is given below. A comparison of its composition with the composition of the ashes of the stems of the cacti as given in Bulletin No. 60, Table No. 2, New Mexico Experiment Station, shows it to be comparatively low in lime and high in alkali salts, and sulphates.

Composition of the *ash* in the soluble solids.

Silica, iron and alumina, Si O ₂ , Fe ₂ O ₃ , Al ₂ O ₃64	per cent
Chlorine (Cl)	4.09	" "
Sulphuric acid radicle (SO ₄).....	5.12	" "
Calcium (Ca)	7.15	" "
Magnesium (Mg)	6.83	" "
Sodium (Na)	trace	
Potassium (K)	33.81	" "

Collected at San Luis Potosi, Mexico, 9 August, 1905.

No. 5 (New Mexico Garden).

MEXICAN STRAWBERRY

Echinocereus stramineus, Englm. Syn. Cact. U. S. in Proc. Am. Acad. Arts & Sci. 3: 282. 1856. U. S. & Mex. Bound Sm. 2: 35. 1859.

This is the only fruit included in this study outside of the

genus *Opuntia*. The genus *Echinocereus* includes many species with edible fruits. In fact their fruits are often preferred to the prickly pears, but their scarceness prevents their extensive use as a food. The fruits in the sample were collected somewhat late in the season and were probably not as good as some of the fruits that matured earlier. They will not stand storage as do the prickly pears, for they ferment very quickly after being collected. These are of a salmon color, weigh about 18 grams and average two inches long and one inch in diameter at the largest part. They are formidably covered with long white spines, but these are completely and easily brushed off when the fruit is ripe. It is covered with a greenish rind, which constitutes 30.38 per cent. of the fruit, but this represents the total refuse, since the small black seeds which are almost as small as those of the strawberry are eaten, and for this reason were included with the edible portion. The edible portion, therefore, amounted to 69.17 per cent., which is more than that of any of the prickly pears with their rinds rejected. The total solids of the edible portion amounted to 18.14 per cent. which is also more than that of the prickly pear, and can be explained in part at least because of the presence of the seeds. The fruit differs from the prickly pears in containing nearly three per cent. sucrose. Its polarization readings were +1.3 before and -2.5 after inversion at 28 degrees C. The total sugars were 9.3 per cent. The unusual amount of sucrose (2.8 per cent.) makes them much sweeter than the prickly pears.

The juice has a very pleasant odor and taste, and if the plants were as abundant as the prickly pear they would be preferable as a food, as they are more palatable, and do not like the tuna contain so many seed that cannot be masticated nor readily removed from the pulp. Neither do they have so much plant mucilage as do the tunas.

Collected 17 August, 1906, from garden on campus of New Mexico Agricultural College.

Collection Numbers

	Page
No. 1—College Garden	82
No. 2—College Garden	78
No. 3—College Garden	79
No. 4—College Garden	82
No. 5—College Garden	39, 84
No. 1—San Antonio	76
No. 2—San Antonio	47, 76, 77
No. 3—San Antonio	47, 76, 77
No. 4—San Antonio	49, 76, 80
No. 5—San Antonio	39, 76, 77
No. 6—San Antonio	39, 43, 47, 76, 77
No. 8022	49, 81, 84
No. 8025	84
No. 8036	19, 78
No. 8037	50, 57, 60
No. 8038	50, 57, 66
No. 8039	57
No. 8050	58, 59, 60
No. 8051	63, 64, 66
No. 8057	39, 42, 54
No. 8065a	61, 62
No. 8065b	62
No. 8099	47, 48, 63, 65, 66, 73
No. 8099a	64
No. 8099b	64
No. 8100	42, 70, 71, 73
No. 8102	68
No. 8119	42, 67
No. 8134	48, 74
No. 8135	48, 74
No. 8136	48, 70, 71, 73
No. 8140	56
No. 8141	48, 68, 69
No. 8142	19, 48
No. 8143	42, 45, 47, 72, 73
No. 8146	48, 59, 60
No. 8150	47, 48, 72, 73
No. 8436	66
No. 8485	47, 54
No. 8545	71
No. 8546	68, 69
No. 8547	59, 60

Index to Popular and Scientific Names

	Page
Tuna Agua-Mielilla (Plate V, Fig. 2).....	25, 26, 42, 67, 69, 74
Amarilla—	
.....	11, 15, 22, 23, 25, 35, 39, 42, 47, 53, 55, 56, 59, 60, 64, 69
Americana	11, 58
Artona	26, 63
Blanca	11, 25, 35
Blanca Teca	58
Camuesa (Plate I)	11, 22, 25, 56, 59, 64, 69
Caidilla	70
Cardona (Plate II)—	
11, 14, 15, 22, 23, 25, 26, 32, 33, 35, 47, 55, 58, 61, 63, 64, 67, 69, 70, 73.	
Cascarona	70
Castilla Blanca	11
Chavena	19, 22, 23, 24, 42, 70, 73
Cochinera	63
Cuija	75, 79
Durasnilla Blanca	14, 23, 42, 45, 47, 71, 73
Durasnilla Colorada	14, 23, 47, 72, 73
Fafayuca	11, 23, 25, 35
Jeconoxtle ..	23, 24, 74, 75, 79
Juell	83
Leonera	25, 26, 68, 74
Lisa	11
Mexicana	11, 58
Morada (Plate VII, Fig. 2)	25, 57
Naranjada	15, 19, 22, 23, 25, 35, 54, 64
Opalilla	25
Pachona	25, 35, 68, 69
Palamita	66
Palo altena	11, 25, 35
Ranchera	25, 60, 61
Tapona	11, 16, 19, 25, 26, 42, 56, 61, 62, 63
Teca	11, 35, 60
Vintera	74
Prickly Pear, Nopal	76
Mexican Strawberry	84
Cereus imbricata	83
Echinocerus stramineus	39, 84

	Page
Opuntia sp	53, 54, 57, 58, 59, 60, 66, 67, 68, 70, 74
arborescens	10
camanchica	81
engelmannii cycloides	79, 83
engelmannii cuija	79
imbricata (Haw) DC.	42, 83
larreyi Weber	56
laevis (?)	79
leucotricha DC.	71, 72
lindheimeri Engelm	20, 39, 76, 77, 79, 83
macrocentra	82
phaeacantha Engelm	81, 83, 84
robusta Wendl. Cat. Herrenh.....	61
robusta Wendl. (?)	62
streptacantha Lem	63
Cylindropuntia	83