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Comparative analysis of five rice campaigns in experimental lines of work of the INTA Corrientes Experimental Station. Proposal for identification by "blind" attributes

Análisis comparativo de cinco campañas arroceras en líneas experimentales de trabajo de la Estación Experimental INTA Corrientes. Propuesta de identificación por atributos "a ciegas"

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Abstract

Rice (Oryza sativa L.) is an herbaceous plant, cultivated in a wide variety of regions and climates. In our country, its production is concentrated on the littoral. As white rice, it is a primary source of food for most of the world population. In addition, it can be consumed as integral rice and is the raw material for a wide range of industrialized products.

In the present study, we worked with samples of polished rice from promising lines provided by the National Institute of Agricultural Technology, Agricultural Experiment Station Corrientes (INTA-EAA), corresponding to five campaigns from 2016 to 2021, plus nine coded samples from the 2021 campaign.

In the tests carried out, five culinary quality attributes were compared: gelatinization time, apparent water absorption, expansion ratio, weight of a thousand grain and gelatinization temperature. The techniques used are simple, friendly to the environment and low cost.

Through the analysis of hierarchical conglomerates (or Cluster Analysis) using Software R (GUI RStudio 2022.02.3+492 "Prairie Trillium" Release), it was possible to analyze individual behavior and establish comparisons between the set of variables previously studied for each campaign and classify the nine coded samples received. Significant differences were found in the variables studied, with $p<0.05$ values.

Keywords: polished rice, industrial and culinary properties, inter campaign, coded samples.

Resumen

El arroz (Oryza sativa L.) es una planta herbácea, cultivada en una amplia variedad de regiones y climas. En nuestro país la producción se concentra en el Litoral. Como "arroz blanco", es una fuente primordial en la alimentación para gran parte de la población mundial. Además, puede ser consumido como integral y es materia prima para una amplia gama de productos industrializados. En el presente estudio se trabajó con muestras de arroz pulido de líneas promisorias del Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Corrientes, correspondientes a cinco campañas, desde el 2016 al 2021 más nueve muestras codificadas de la campaña 2021.

En los ensayos realizados se compararon cinco atributos de calidad culinaria: tiempo de gelatinización, absorción aparente de agua, relación de expansión, peso de mil granos y temperatura de gelatinización. Las técnicas utilizadas son simples, amigables con el medio ambiente y de bajo costo.

Mediante el análisis de conglomerados jerárquicos (Análisis Clúster) utilizando Software R (GUI RStudio 2022.02.3+492 "Prairie Trillium" Release), se pudo analizar el comportamiento individual y establecer las comparaciones del conjunto de variables previamente estudiadas para cada campaña y las nueve muestras codificadas recibidas para su clasificación. Se hallaron diferencias significativas en todas las variables de estudio con valores de $p<0,05$.

Palabras clave: arroz pulido, propiedades industriales y culinarias, intercampaña, muestras codificadas.

Introduction

Rice is included in the basic food basket of two-thirds of the world's population and it is one of the most widely consumed cereals by humans [1].

According to the Simplified Agricultural Information System (SISA), Corrientes was the argentine province with the largest planted area in the 2021/2022 campaign, representing 48.78% of the national total. The provinces of Entre Ríos and Santa Fe were in second and third place, with 26.44% and 12.33%, respectively. The three provinces concentrate 87.55% of the total planted area [2]. According to the FAO world production in 2023 will reach 517 million tons (based on white rice) [3].

The quality of the rice grain can be evaluated from its milling, industrial and culinary attributes [4]. Industrial quality is evaluated using as a parameter the percentage of whole grains with respect to paddy rice. On the other hand, culinary quality is identified with the expected behavior of rice after cooking, represented by a set of characteristics related to the chemical structure of starch [5].

In works previously carried out, the industrial and culinary characterization of rice cultivars was achieved through the evaluation of five attributes using simple and low-cost physical-chemical techniques. Physical properties of rice such as hardness, water absorption and cohesiveness (among others), are associated with cooking and are closely related to gelatinization temperature and amylose content. Thus, gelatinization temperature is defined as the temperature at which the endosperm starch irreversibly loses its crystalline structure, with a reduction in the mechanical resistance of the grain (hardness).

On the other hand, gelatinization time is defined as the time required for 90% of the grains to go from their natural state to the gel state (ISO 14864).

This correlates with the starch hydration process when rice is cooked in high-temperature water. This process, first slow and then fast, induces an irreversible change in the physical structure of starch.

Its crystalline granules become colloidal, losing the characteristic of crystallinity. Attributes such as water absorption and solids loss, together with the expansion volume, are related to the degree of maturity of the grain and to the drying and storage conditions. Consequently, the expansion volume is a measure of the decrease in the cohesiveness (or stickiness) of the rice [6].

The aim of this work was to study the behavior of five quality attributes between samples of polished rice from experimental lines tested in the EEA INTA Corrientes during five consecutive campaigns. With the information gathered, we proposed to obtain groupings according to industrial and culinary properties to establish possible inter-sample relationships and, thereby, reveal the origin of the samples of 9 advanced materials (2020/21 campaign) under evaluation.

Materials and methods

Samples: coded samples from 100 to 120 g of processed rice (husked and polished) were used. They were provided by the Seed and Grain Quality Laboratory of the EEA INTA Corrientes and came from experimental plots from the 2016/17, 2017/18, 2018/19, 2019/20 and 2020/21 campaigns. The grains, manually harvested with sickle, were threshed and dried at 50°C up to 13% humidity to proceed with the elaboration (shelling and polishing) in an experimental mill.

Table Nº 1: Rice samples analyzed corresponding to the 2016-17 to 2020-21 campaigns and the nine coded samples*

Samples	Campaign				
	2016-17	2017-18	2018-19	2019-20	2020-21
Carnaroli	X	X			
FL 06372				X	X
FL 07627		X			
FL 09682		X			
FL 10678		X			
FL 11822				X	
FL 29			X		
FL 30			X		
Fortuna INTA	X	X		X	X
Gurí INTA CL	X	X			
IRGA 417	X	X	X	X	X
IRGA 424	X	X	X	X	X
IRGA 424 RI				X	X
IRGA 426			X	X	
IRGA 428		X			
Koshihikari	X	X			
Memby Porá		X	X	X	X
PAC 101		X	X	X	X
PAC 102		X			
PAC 103		X	X		
PAC 103 C				X	X
PAC 103 CL				X	X
Pampeira			X	X	X
Puitá INTA CL	X	X	X	X	X
Reg EEA14/PAC 102	X				
Reg EEA16/PAC 101	X				
Reg EEA24CI85 PAC 103	X				
Rocio 1	X	X	X		
Taim	X	X	X	X	X
Tranquilo FL INTA	X	X			
BIO.I.226				X	X
VIOB 395			X		
Yamaní			X	X	X
Yerua PA	X				
74.5					X
94.5					X
98.2					X
101.3					X
106.1					X
122.3					X
297.1					X
301.3					X
305.1					X

*X indicates the samples received in each campaign.

Gelatinization time: the Ranghino method [7] was used. 100 ml of distilled water were introduced into a 250 ml beaker and then brought to the boil on a heating mantle. At the beginning of boiling, 5 g of sample were added. After 12 min, 10 grains of rice were removed and arranged in line on a slide. To carry out the visual cooking test, they were pressed between two glass plates, a procedure that was repeated at 1 min intervals, until observed that 90% of the removed grains had a translucent center.

Water absorption: test tubes of 2.5-3 cm external diameter containing 20 ml of deionized water were placed in a boiling water bath. Once the temperature was equilibrated, 2 g of processed rice were added to the tubes, stirred with a tempered glass rod and let it cook without stirring for 20 min. The resulting cooked rice was transferred to a filter paper where it was spread using a glass rod. The excess water was removed by softly pressing the sample with another filter paper and, subsequently, the grains were placed in a previously tared Petri dish to be weighed. The apparent water absorption was calculated according to equation 1:

W=(mc-mo)/mo [g/g]

Where:

W' = apparent water absorption.

mc = mass of cooked rice (g).

mo = initial mass of rice (g).

Expansion volume: it was carried out according to the methodology proposed by Desikachar [8]. 20 g of processed rice were placed in 100 ml graduated cylinders with a glass base and an external diameter of 3-3.5 cm. The volume occupied by the sample was recorded, 50 ml of deionized water were added and then a cotton plug and an aluminum foil cover were placed. The graduated cylinders were then autoclaved at 100 °C for 45 min. After this time, they were removed and the volume reached was read.

After this time, they were removed and the volume reached by the cooked rice bed was read.

The following relationship was applied:

Re=Vf/Vi [ml/ml]

Where:

Re = Expansion ratio

Vf = Final volume

Vi = Initial volume

Gelatinization temperature: It was estimated indirectly from the degree of alkali dispersion (alkali test) based on the method developed by Little [9].

For this method, 10 whole grains of polished rice are evenly distributed in a Petri dish, 10 ml of a 1.7% KOH solution is added and then it is incubated at 30 °C for 23 h. However, adaptations were made for practicality: 6 whole grains of polished rice were evenly distributed in 6-compartment Wells plates with a diameter of 35 mm and a height of 20 mm. Then, 6 ml of a 1.7% KOH solution were added and after that, it was incubated at 30 °C for 23 h [10]. Finally, comparisons with pattern images were made.

Thousand grains weight: the weight of a thousand whole grains of rice was recorded according to the methodology proposed by Puig [11].

Statistical methods: assays were carried out in triplicate. Data analysis was performed using the multivariate statistical technique: Hierarchical Cluster Analysis (or Cluster Analysis) using Software R (GUI RStudio 2022.02.3+492 "Prairie Trillium" Release), to analyze the joint behavior of the variables.

Results and discussion

Table Nº2 shows the results obtained expressed as the average of three determinations. The results presented here are subject to agronomic management and the environmental conditions of each zone and campaign; therefore, we consider approximations acceptable. It is cited as an example in Martínez & Cuevas work (1989) [12], how the thermal variations of the environment can cause changes in the gelatinization temperature (degree of dispersion). It is also considered that some characteristics are "inheritable" such as size, weight of a thousand grains, etc.

The data available in the bibliography is scarce. González et al. [13] reported cooking time values of 12.5 min for the IRGA 424 and 417 varieties, significantly lower than those obtained in the five campaigns analyzed in this work. Also, for Carnaroli variety samples, we obtained the longest cooking times (22 min 2016/17 and 21.3 min 2017/18), in accordance with the results cited by Shinde [14]. Simonelli et al. [15] had previously reported 19.7 min for the same variety of polished rice in the Italian market.

The results obtained for IRGA 417, IRGA 424, Puitá INTA CL and Taim for gelatinization temperature coincide with those obtained by Liberman [16]. Nevertheless, this does not happen with water absorption values. For its part, although the gelatinization times do not coincide quantitatively, it was observed that the highest value were for the Taim variety as occurs with the results obtained in this work (20.8 min '16/17; 20.7 min '17/18; 21.7 min ´18/19, 21.3 min ´19/20 and 20.7 min ´20/21).

Gonzalez et al. [13] reported a water retention value for IRGA 424 of 2.8 g/g, while the average obtained in our work was of 2.6 g/g. For the varieties IRGA 417, Puitá INTA CL and Gurí INTA CL from the 2014/15 campaign, Liberman [16] reported slightly lower values than those reported here. On the other hand, it mentions lower GT for the IRGA

Table Nº 2: Average results of three determinations for the attributes analyzed.

Samples	Gel time (min)	Water absorption (g/g)	Expansion volumen (ml / ml)	Thousand grains weight (g)	Alkaline Dispersion						
	Av	S d	Av	S d	Av	S d	Av	S d	Av	S d	
Campaign 16-17	Carnaroli	22,0	0,7	2,88	0,06	2,17	0,04	28,66	0,22	4,1	0,2
	Fortuna	18,3	0,4	2,54	0,02	2,11	0,03	29,29	0,15	4,9	0,1
	Gurí	17,0	0,7	2,83	0,01	2,91	0,03	17,78	0,15	5,9	0,1
	IRGA417	16,8	0,4	3,05	0,04	2,58	0,04	17,93	0,07	5,9	0,1
	IRGA424	17,5	0,5	2,93	0,01	2,42	0,05	17,99	0,12	6,0	0,1
	Koshihikari	19,5	0,5	2,85	0,01	2,25	0,03	19,04	0,14	4,3	0,1
	PAC101	17,5	0,5	2,65	0,05	2,34	0,09	18,83	0,15	5,8	0,1
	PAC102	18,0	0,0	2,91	0,01	2,46	0,10	19,44	0,14	5,5	0,0
	PAC103	18,8	0,4	2,82	0,02	2,41	0,19	19,41	0,15	6,0	0,1
	Puita	16,3	0,4	3,09	0,03	2,55	0,05	16,78	0,11	5,9	0,1
	Rocio	17,5	0,5	2,85	0,04	2,70	0,06	17,93	0,14	6,0	0,1
	TAIM	20,8	0,4	2,64	0,03	2,83	0,07				
	Tranquilo	17,8	0,4	2,55	0,02	2,20	0,05	18,31	0,07	4,6	0,0
	Yeruá	17,8	0,4	2,89	0,01	2,58	0,02	25,16	0,15	4,0	0,3
Campaign 17-18	Carnaroli	21,3	0,6	2,04	0,03	2,82	0,10	27,93	0,39	4,5	0,6
	Fortuna	18,3	0,5	2,20	0,03	2,67	0,00	29,46	0,21	4,1	0,6
	Gurí	17,3	0,5	2,72	0,04	2,94	0,06	17,63	0,23	5,4	0,3
	IRGA 417	16,3	0,5	2,49	0,03	2,95	0,02	18,07	0,45	5,1	0,5
	IRGA 424	16,7	0,6	2,45	0,08	2,86	0,08	17,64	0,04	5,0	0,3
	Koshihicari	19,7	0,6	2,47	0,07	2,83	0,14	16,38	0,09	4,1	0,8
	Puitá INTA	16,7	0,6	2,51	0,10	2,94	0,04	17,15	0,20	5,0	0,5
	PAC 102	17,5	0,6	2,51	0,09	2,76	0,10	18,92	0,09	4,2	0,4
	PAC 101	16,7	0,6	2,57	0,01	2,83	0,01	18,10	0,30	4,7	0,5
	PAC 103	17,7	0,6	2,43	0,10	2,61	0,20	19,79	0,16	4,6	0,5
	Rocío 1	16,3	0,5	2,65	0,05	2,63	0,09	16,87	0,25	4,6	0,7
	Taim	20,7	0,6	2,77	0,08	2,90	0,09	17,13	0,20	3,0	0,5
	Tranquilo	18,3	0,5	2,49	0,01	2,63	0,08	18,22	0,32	3,3	0,3
	IRGA 428	17,7	0,6	2,21	0,07	2,61	0,07	19,33	0,15	5,1	0,1
	Memby Porá	17,5	0,6	2,43	0,05	2,69	0,18	19,36	0,20	3,0	0,7
	FL 07627	17,5	0,6	2,19	0,07	2,80	0,01	21,76	0,12	3,7	0,7
	FL 10678	17,5	0,6	2,42	0,13	2,56	0,02	20,03	0,07	3,4	0,0
	FL 09682	17,5	0,6	2,31	0,05	2,71	0,04	19,00	0,28	3,6	0,3
Campaign 18-19	FL 29	18,7	0,6	2,31	0,07	2,96	0,02	21,30	0,05	4,5	0,4
	FL 30	16,7	0,6	2,68	0,03	2,92	0,04	16,85	0,15	3,7	0,3
	IRGA 417	16,7	0,6	2,49	0,03	3,00	0,04	18,03	0,08	4,6	0,3
	IRGA 424	16,7	0,6	2,47	0,06	2,91	0,06	18,09	0,09	4,6	0,3
	IRGA 426	17,3	0,6	2,44	0,03	3,02	0,02	19,07	0,21	4,9	0,1
	Memby Porá	17,3	0,6	2,29	0,07	2,81	0,07	16,83	0,06	3,8	0,2
	PAC 101	16,7	0,6	2,69	0,07	2,84	0,04	17,53	0,08	4,2	0,3
	PAC 103	17,7	0,6	2,58	0,07	2,77	0,04	20,08	0,08	4,1	0,2
	Pampeira	18,7	0,6	2,32	0,08	2,69	0,04	19,70	0,05	3,8	0,5
	Puitá INTA	16,7	0,6	2,73	0,05	2,96	0,04	17,32	0,10	4,6	0,2
	Rocío 1	16,7	0,6	2,57	0,04	2,63	0,04	17,89	0,13	4,5	0,4
	Taim	21,7	0,6	2,85	0,14	2,89	0,07	18,40	0,13	2,2	0,2
	VIOB 395	19,7	0,6	2,45	0,07	2,69	0,05	22,78	0,08	3,1	0,1
	Yamani	18,7	0,6	2,37	0,04	2,60	0,01	20,08	0,07	2,9	0,1
Campaign 19-20	FL 06372	15,7	0,6	2,65	0,09	2,87	0,07	17,06	0,09	3,3	0,2
	FL 11822	18,3	0,6	2,35	0,08	2,82	0,06	20,03	0,06	3,4	0,3
	Fortuna	20,7	0,6	2,11	0,02	2,75	0,06	28,74	0,18	2,4	0,1
	IRGA 417	16,3	0,6	2,46	0,07	3,05	0,03	17,52	0,08	3,2	0,2
	IRGA 424	16,3	0,6	2,34	0,01	2,84	0,05	17,79	0,05	4,6	0,3
	IRGA 424 RI	16,7	0,6	2,49	0,11	2,82	0,03	17,18	0,11	4,1	0,2
	IRGA 426	16,3	0,6	2,40	0,06	2,96	0,05	17,81	0,08	3,9	0,2
	Memby Porá	16,7	0,6	2,32	0,04	2,90	0,04	16,53	0,15	3,6	0,1
	PAC 101	16,7	0,6	2,55	0,06	2,85	0,03	16,92	0,08	4,1	0,1
	PAC 103 C	17,7	0,6	2,52	0,03	2,86	0,05	19,70	0,18	3,1	0,3
	PAC 103 CL	18,3	0,7	2,29	0,01	2,73	0,01	20,41	0,05	3,7	0,1
	Pampeira	17,7	0,6	2,36	0,07	2,90	0,06	19,48	0,15	3,4	0,1
	Puitá	16,7	0,6	2,17	0,04	2,92	0,05	16,34	0,05	3,9	0,1
	Taím	21,3	0,7	2,47	0,02	3,01	0,03	16,62	0,14	2,2	0,1
	VIO IP 226	22,3	0,7	1,73	0,03	2,79	0,05	29,10	0,07	2,9	0,1
	Yamaní	17,5	0,4	2,37	0,07	2,67	0,05	20,63	0,09	3,9	0,2
Campaign 19-20	FL06372	16,7	0,6	2,62	0,09	3,06	0,05	17,85	0,15	5,3	0,2
	Fortuna	20,7	0,6	2,87	0,07	3,00	0,05	18,89	0,20	2,0	0,2
	IRGA 417	16,7	0,6	2,69	0,12	3,11	0,06	16,99	0,05	5,0	0,3
	IRGA 424	16,3	0,6	2,65	0,02	2,99	0,05	19,28	0,13	4,9	0,2
	IRGA 424 RI	17,3	0,6	2,53	0,07	2,93	0,05	18,97	0,06	5,5	0,2
	Memby Porá	16,7	0,6	2,43	0,11	3,04	0,04	17,28	0,03	4,8	0,3
	PAC 101	16,3	0,6	2,32	0,16	3,02	0,02	20,64	0,13	4,8	0,2
	PAC 103 C	16,3	0,6	2,58	0,10	2,90	0,04	17,96	0,06	4,7	0,2
	PAC 103 CL	17,7	0,6	2,51	0,09	2,84	0,04	20,53	0,10	3,5	0,4
	Pampeira	17,3	0,6	2,30	0,10	2,84	0,02	20,09	0,04	3,8	0,3
	Puitá INTA	16,7	0,6	2,41	0,05	2,77	0,01	19,43	0,04	3,1	0,3
	Taim	21,3	0,6	1,78	0,22	2,80	0,02	29,03	0,05	3,7	0,0
	VIO IP 226	22,3	0,6	1,78	0,07	2,64	0,04	30,51	0,23	3,1	0,1
	Yamani	18,3	0,6	2,39	0,10	2,86	0,06	21,35	0,11	4,8	0,1

Coded samples	74.6 Tranquilo	19,7	0,6	2,85	0,23	2,82	0,06	18,42	0,01	2,0	0,0
	94.5 Fortuna	22,0	0,0	1,82	0,28	2,83	0,04	30,48	0,04	3,1	0,1
	98.2 Fortuna	22,7	0,6	1,75	0,29	2,82	0,00	29,82	0,03	3,1	0,1
	106.1 Tranquilo	19,7	0,6	2,47	0,17	2,89	0,06	18,71	0,05	2,5	0,4
	101.3 IRGA	15,7	0,6	2,84	0,18	2,99	0,04	17,38	0,03	5,6	0,1
	297.1 Taim	20,7	0,6	2,88	0,25	2,69	0,02	18,23	0,05	2,0	0,0
	122.3 Tranquilo	16,3	0,6	2,69	0,10	2,96	0,05	18,02	0,02	3,3	0,2
	301.3 Taim	19,7	0,6	2,85	0,25	2,73	0,01	18,18	0,06	2,0	0,0
	305.1 Taim	20,7	0,6	3,01	0,05	2,75	0,03	18,91	0,01	2,0	0,0

417, IRGA 424, Puitá INTA CL and Gurí INTA CL varieties and intermediate for Tranquilo FL INTA from the 2014-15 campaign, in coincidence with our results.

Farco et al. [6] demonstrated that, with the five attributes that were studied in the present work, it is possible to establish differences between the properties of polished rice samples, with significant savings in resources and time.

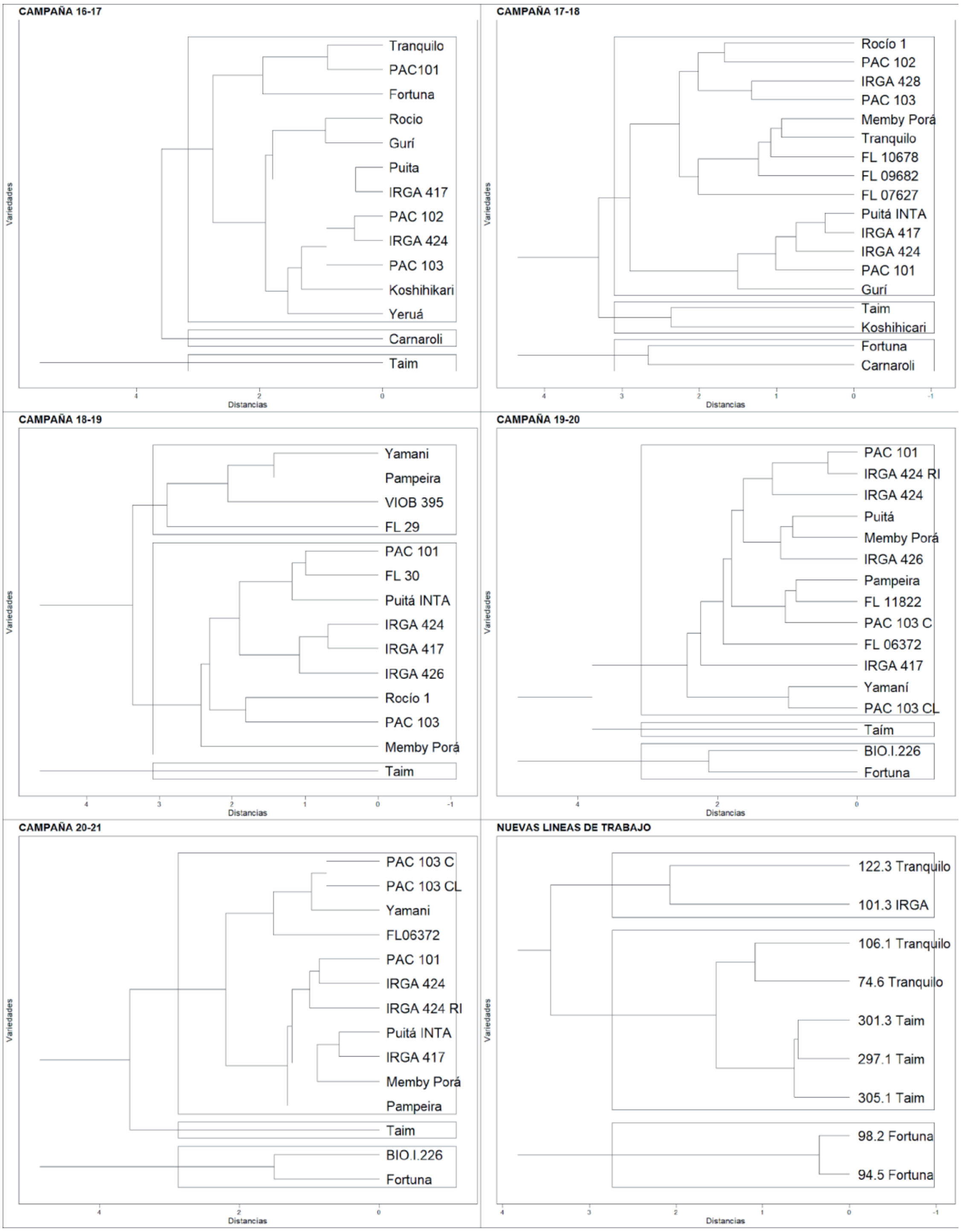

Figure N° 1: Cluster analysis of the rice samples analyzed corresponding to the 2016-17 -2020-21 campaigns and the new lines of work.

Figure N°1 shows the six dendrograms obtained after the corresponding analysis. Establishing comparisons, it can be observed that in the diagrams of the successive campaigns, three large groups are differentiated. For the 2016/17, 2017/18, 2019/20 and 2020/21 campaigns, the varieties and lines classified as "long thin rice" are grouped at the top of the diagram, "long wide rice" and " short rice" are at the bottom and the Taim variety at the center. In the 2018/19 campaign, except for Yamaní ("short" variety), all the samples corresponded to the "long thin rice" classification, so the Taim variety is observed at the bottom.

The results obtained from the samples coded as: 74.6; 94.5; 98.2; 106.1; 101.3; 297.1; 122.3; 301.3; 305.1, could be distributed into 3 groups according to industrial and culinary properties, giving hint of intersample relationships. Once the variety of origin of each sample was revealed, the result was: 74.6: Tranquilo FL INTA, 94.5: Fortuna INTA, 98.2: Fortuna INTA, 106.1: Tranquilo FL INTA, 101.3: IRGA 424, 297.1: Taim, 122.3: Tranquilo FL INTA, 301.3: Taim, 305.1: Taim.

From the analysis of the dendrograms for the different campaigns, we found that there are certain similarities between them. In all the campaigns, the data of those lines of work that are classified as long thin type predominate. A particularity of the 16-17 Campaign is the behavior of the Fortuna INTA variety, the long wide type, which was grouped with the long fine varieties. This may be due to the Gelatinization Time attribute, which resulted in 18 minutes, lower than what is usually found in other campaigns, and also to a significant difference in the Alkaline Dispersion attribute, higher than the later ones. It is also noteworthy the presence of the Taim variety, which is not usually grouped with other varieties. This is possibly due to its high value in Cooking Time and, generally, lower values in the Alkaline Dispersion attribute.

Conclusions

Through the present work, it was possible to determine the main industrial and culinary properties of polished rice samples.

The conformation of the groups through the campaigns is directly related to the type of grain of the varieties.

In the case of the results for the new lines of work, the 9 coded samples, the grouping responds to the lines of work from which they derive. Three clearly defined groups were obtained, two corresponding to the long-thin and one to the long-wide classification.

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