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Introduction

In Spain, among other breeding objectives, improvement of the grain quality is necessary regarding the following attributes: grain length and shape, translucency, the quantitity of defective kernels and milling quality. Nevertheless, the northern European Market, which prefers long grain varieties, is a potential outlet for long grain rice. Therefore, cooking and eating qualities have recently been considered in Spain.

Amylose content is considered to be the single most important characteristic for predicting rice cooking and processing behaviors (Juliano, 1979a, 1979b; Webb, 1985; Carreres, 1988). This parameter is therefore being used for screening breeding lines in specific Spanish rice improvement programs for better cooking quality.

I – Use of undefatted rice

The amylose content is analysed in the whole rice flour by the means of a colorimetric iodine method (Williams *et al.,* 1958), modified by the use of acetate buffer at pH 4.5–4.8 (Juliano, 1971). The major objection to this method is the strong interference of lipids in the iodine-amylose color. Therefore, defatting milled-rice flour with refluxing methanol is recommended (ISO, 1987). This method is somewhat cumbersome, time consuming, and not very suitable for routine application. It would then be useful to study the effect of using undefatted milled or brown rice on the amylose content of rice. For these reasons, amylose content was determined in 52 varieties and breeding lines either in defatted or undefatted samples.

Rough rice samples were collected from our experimental fields at Valencia. The samples covered a wide range of amylose content (AC); *indica* and *japonica* grain type rices and their hybrids were well represented. Brown rice was prepared by dehulling rough rice with a Satake dehuller. Milled rice was prepared from 100 g of rough rice using a Olmia (UNIVERSALE model) miller. AC was measured in duplicate on 60-mesh milled rice flour by iodine colorimetry (ISO, 1987), using potato amylose Merck 4561 and amylopectine from waxy rice Mangetsumochi (ISO 6647 method) as standards.

As is shown in *Table 1* below, undefatted milled (UM) rice generally gave 2.7 to 4.0 percentage points of mean amylose values lower than defatted milled (DM) rice. The higher difference was found at the higher AC values. The average AC of UM rice was about 85% of the DM rice. The differences in AC among DM rice and undefatted brown (UB) rice ranged from 4.2 to 7.4 percentage points and were also correlated with amylose content. The average AC of UB rice was about 72% of the DM rice.

As is shown in *Figures 1* and *2*, amylose content of DM rice correlated with amylose content of UM ($r=0.996$, $P<0.01$, $n=52$) and UB rice ($r=0.974$, $P<0.01$, $n=52$). As a consequence of these results, the use of undefatted brown rice samples for measuring amylose content is a source of low inaccuracy and may be useful for screening breeding lines in quality improvement programs.

Table 1. Amylose content as affected by milling and defating rice grain

	Defatted milled (DM)	Undefatted milled (UM)	DM-UM	Undefatted brown (UB)	DM-UB
	12.4	9.3	3.1	8.2	4.2
	13.1	10.4	2.7	8.2	4.9
	14.0	10.9	3.1	8.8	5.2
	14.6	11.5	3.1	9.8	4.8
	15.2	12.5	2.7	10.3	4.9
	19.5	16.6	2.9	14.8	4.7
	20.2	17.5	2.7	14.5	5.7
	21.6	18.4	3.2	15.7	5.9
	21.6	18.4	3.2	15.7	5.9
	22.5	19.0	3.5	15.8	6.7
	23.9	21.0	2.9	18.5	5.4
	24.7	21.7	3.0	18.5	6.2
	25.6	22.5	3.1	19.0	6.6
	26.7	22.7	4.0	20.4	6.3
	27.3	23.6	3.7	19.9	7.4
Mean	**20.1**	**17.0**	**3.1**	**14.5**	**5.6**

II – Relationship between amylose content and cooked rice texture

The texture of food, together with its appearance, determines its consumer acceptability. Rice texture has been usually evaluated with taste panels. However, taste panels are time consuming, require large samples and have no fixed point of reference. In recent years, a number of methods using instruments have been developed for assessing rice texture. Some of these are based on the Instron testing machine. Since 1988 and through the CEE Regulation no. 2580/88 (17th August 1988), the EU proposed a modified Ottawa texture measuring system cell to assess cooked rice hardness and stickiness.

In addition to studies carried out in many world Rice Research Centers, it would be useful to evaluate the relationship between cooked rice texture and amylose content using a large range of Spanish rice varieties and breeding lines. For this reason, stickiness and hardness of cooked rice was ascertained (CEE Regulation N° 2580/88) on 52 varieties and breeding lines grown in our experimental fields at Valencia.

Hardness of cooked rice showed a positive correlation with amylose content but provided more spread of values at intermediate and high amylose rices, or less at low amylose rices, than stickiness *(Figures 3 and 4)*. According to Pérez *et al.* (1976), these results suggest that varietal differences in the texture of cooked rice of similar amylose content are probably related to differences in hardness, since the range of stickiness values is narrow, except among low amylose rices. As major rice varieties grown in Spain are low amylose rices, the stickiness of cooked rice is more useful to test texture differences among varieties of similar amylose content.

III – Variability in amylose content

Because of the wide variability in amylose content within a variety, screening for amylose types in a breeding program presents serious problems. Therefore, a study was undertaken to examine the magnitude of variability due to several nonheritable factors: a) plant from which grain samples are obtained; b) sample size for rice grain; and c) storage period of either milled or rough rice and rice flour.

Two varieties, Senia (medium grain type) and L-202 (long grain type), differing in amylose content were selected to gain maximum information on how varieties interact with the factors studied. In a), 4 hills in a field and 72 bulk samples within a hill *(Four sample size x Nine analysis each sample size x Replications)* were analysed. In b), 4 sample sizes (10, 20, 30 and 40 grains) and 72 bulk samples, each sample size *(4 hills x 9 analysis each hill x 2 replications)*, were used to ascertain amylose. In c), 3 rice forms (rough, milled and flour), 20 times of analysis (1 each 15 days) and 3 duplicated samples each time were used to obtain the amylose content (ISO 1987). The three rice forms were stored at ambient temperature (22–27°C).

According to statistical analysis, and as shown in *Figure 5,* the amylose content ranged from 17.73 to 18.99% d.b. in Senia, a low amylose content variety, with a standard deviation of 0.535 and a variation coefficient of 2.89% among hills. In L-202, a high amylose content variety, the values ranged from 26.87% to 28.19% d.b. with a similar standard deviation (0.644) and variation coefficient (2.34%).

As is shown in *Figure 6,* and according to statistical analysis, 30-grains was found to be the optimum sample size for rice grain in both Senia and L-202 varieties.

Even though amylose content showed a slightly decreasing trend with storage period (*Table 7,* p. 60), almost no change occurs (low slope and correlation coefficients) in both Senia and L-20 varieties. Amylose content change during storage showed a similar trend regardless of whether the rice was stored in rough or milled form or as rice flour.

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Figure 1. Regression plot of amylose contents of defatted and undefatted milled rice

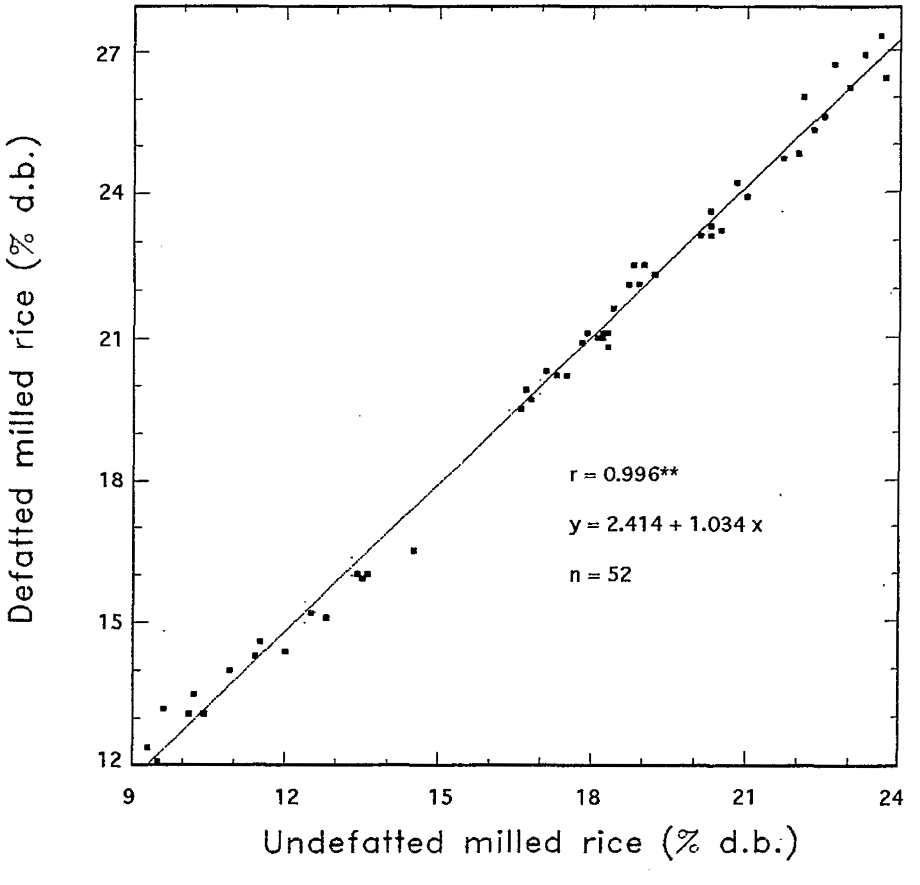

Figure 2. Regression plot of amylose contents of defatted milled rice and undefatted brown rice

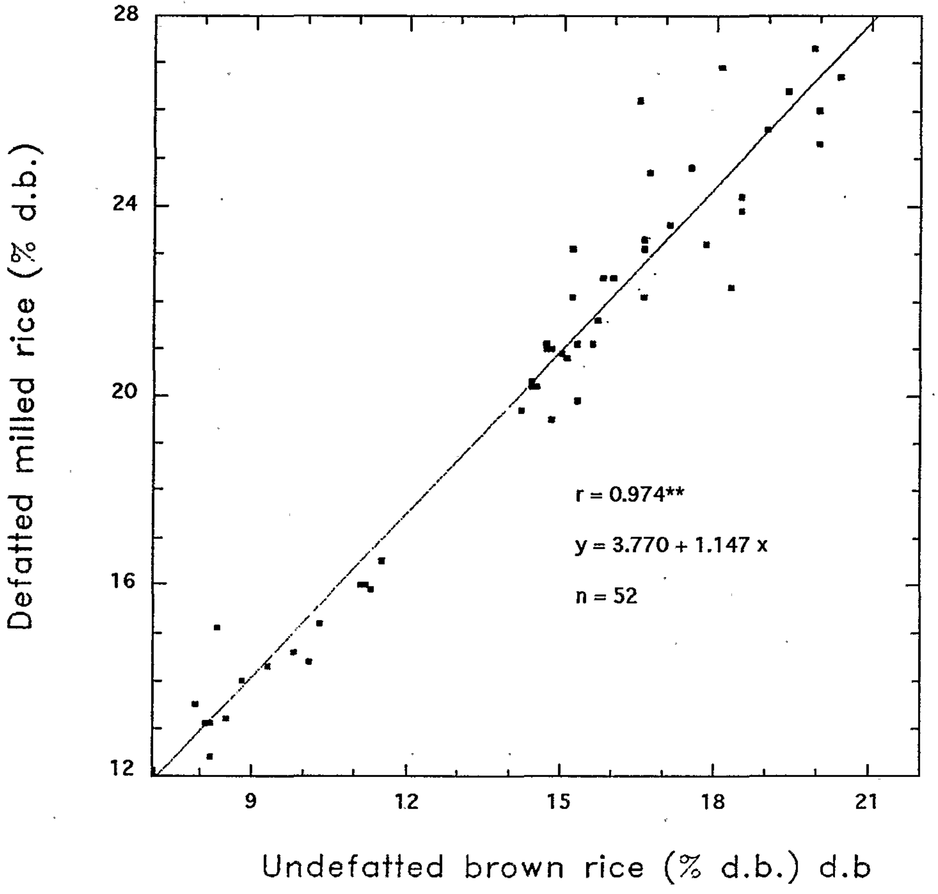

Figure 3. Relationship between amylose content of defatted milled rice and Instron stickiness of cooked rice

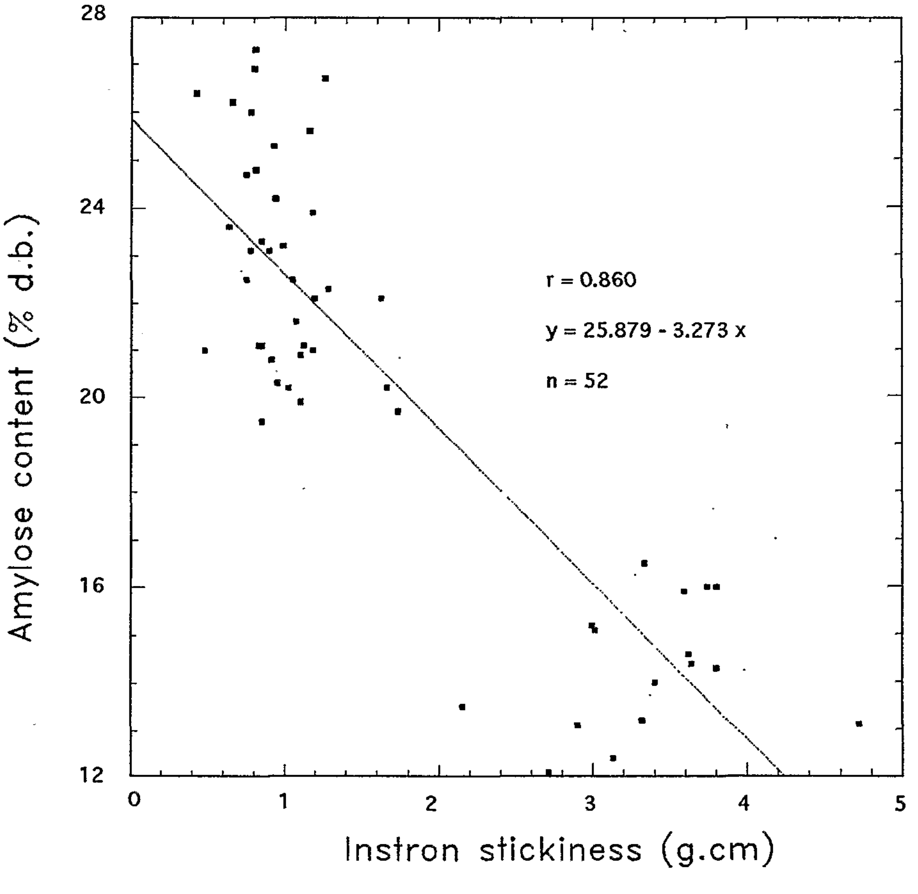

Figure 4. Relationship between amylose content of defatted milled rice and Instron hardness of cooked rice

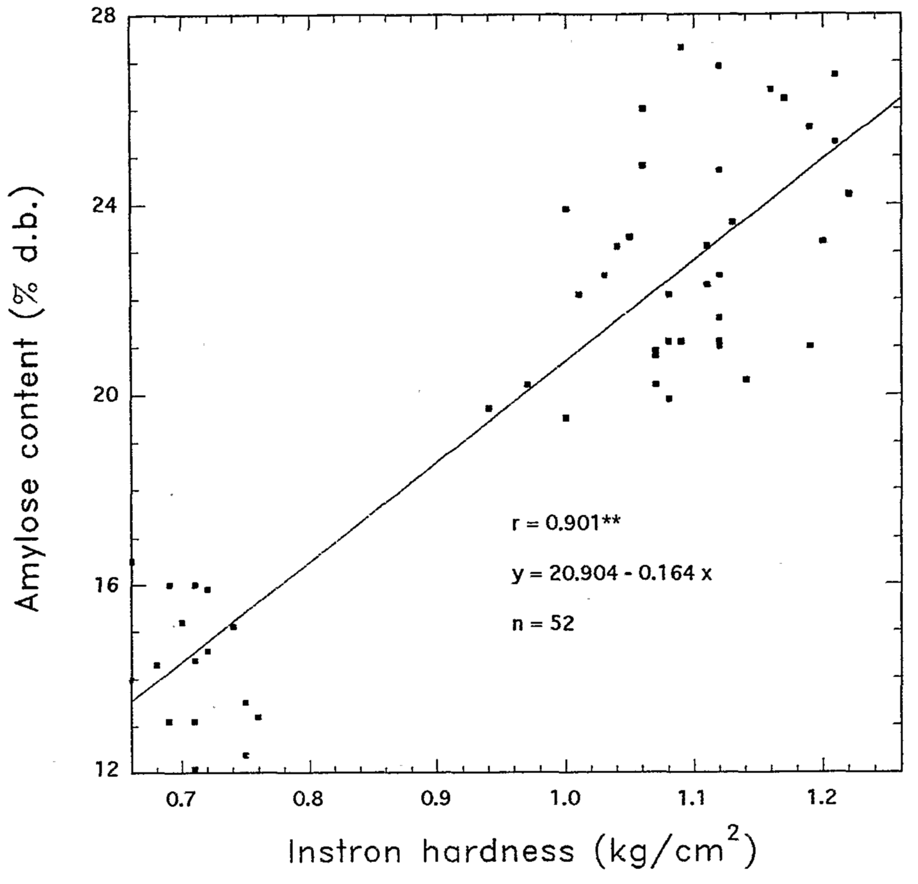

Figure 5. Amylose content variability among hills in Senia and L–202 varieties

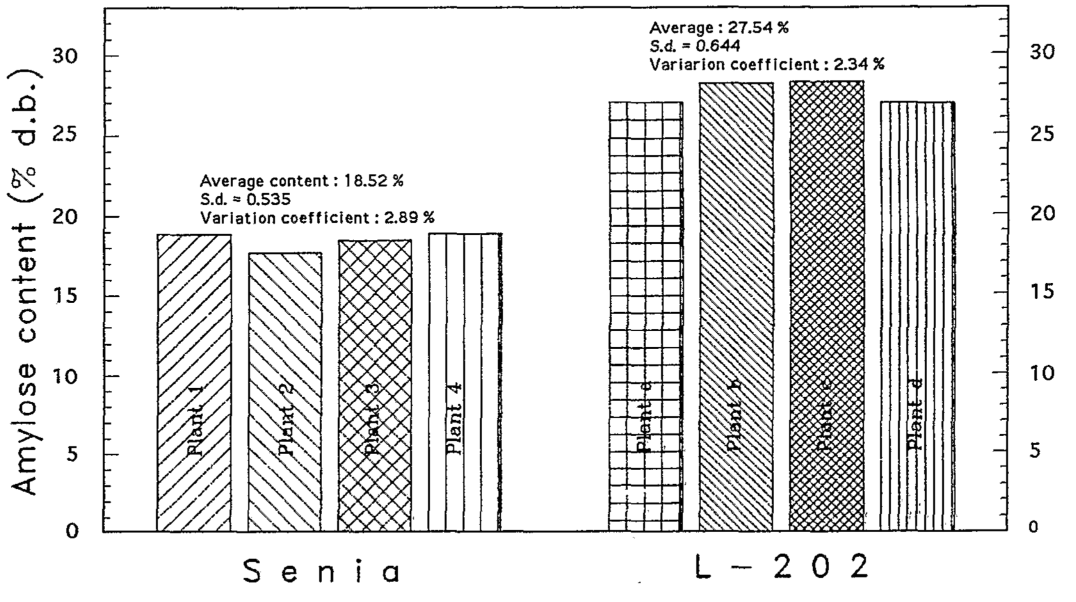

Figure 6. Effect of sample size on amylose variability (in Senia and L–202 varieties)

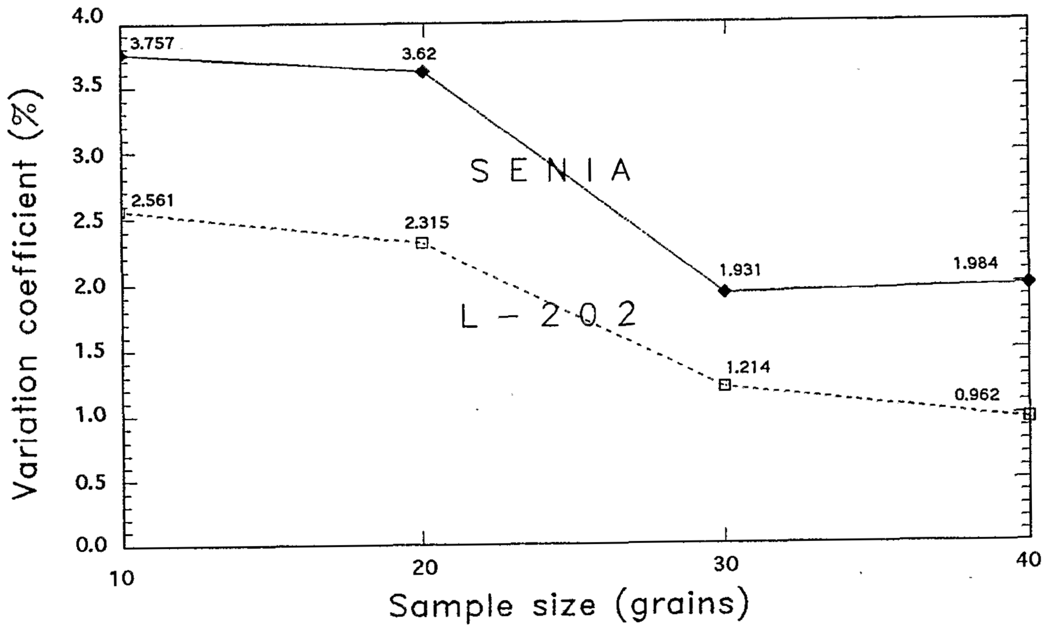

Figure 7. Effect of the storage period on amylose content of rice