QUALITY OF GRAIN LEGUMES: EVALUATION OF BEAN COOKING

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Abstract

Legumes have been consumed for years for their nutritional qualities, but only during the past few decades the potential impact of grain legumes or pulses on human health has been revived. The soaking, cooking, germination or fermentation processes are part of the traditional preparation of the grains of legumes that improve their acceptability, palatability and nutritional quality. One of the main limitations to the consumption of legumes is the long cooking time required to achieve an attractive texture. The objective of this research was to assess the cooking characteristics of improved varieties of common bean using equipment specifically designed at the MBG-CSIC. Three varieties of common bean have been used two of them, Montcau and Galaica, represent Spanish quality brands of beans with Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI), and the international variety Matterhorn was also studied. The highest value of experimental cooking time was presented by Galaica in 2019 (68 min), while the minimum corresponded to Montcau in 2020 (23 min). These results should be considered as preliminary, since it would be necessary to carry out more tests with the cocidimeter, and with more bean varieties, so that the measurements were more consistent.

Resumen

Las legumbres se han consumido durante años por sus cualidades nutricionales, pero sólo durante las últimas décadas se ha revivido el impacto potencial de las leguminosas o legumbres en la salud humana. Los procesos de remojo, cocción, germinación o fermentación son parte de la preparación tradicional de los granos de leguminosas que mejoran su aceptabilidad, palatabilidad y calidad nutricional. Una de las principales limitaciones al consumo de legumbres es el largo tiempo de cocción necesario para conseguir una textura atractiva para su consumo. El objetivo de esta investigación fue evaluar las características de cocción de variedades mejoradas de judía común utilizando equipos diseñados específicamente en la MBG-CSIC. Se han utilizado tres variedades de judía común, dos de ellas, Montcau y Galaica, representan marcas españolas de judía de calidad con Denominación de Origen Protegida (DOP) o Indicación Geográfica Protegida (IGP), y también se ha

estudiado la variedad internacional Matterhorn. El valor más alto de tiempo de cocción experimental lo presentó Galaica en 2019 (68 min), mientras que el mínimo correspondió a Montcau en 2020 (23 min). Estos resultados deben considerarse preliminares, ya que sería necesario realizar más pruebas con el cocidímetro, y con más variedades de judóa, para que las mediciones fueran más consistentes.

Introduction

The grain legumes

Legumes have been consumed for years for their nutritional qualities, but only during the past few decades the potential impact of grain legumes or pulses on human health has been revived. Many different studies have reported that the consumption of pulses have beneficial physiological effects in the prevention and control of a broad range of chronic and degenerative diseases such as obesity, cardiovascular diseases, diabetes and cancer (Bazzano et al. 2011). Grain legumes could potentially be considered as "functional foods" in addition to their accepted role of providing proteins and fibres. The consumption of pulses is recommended as part of healthy eating by governments and health organizations globally (Clemente and De Ron 2016, De Ron, 2015).

The processing of grain legumes

Legume grains have been part of the human diet for centuries. These dried grains must be processed prior to consumption, to make them edible and more digestible. The soaking, cooking, germination or fermentation processes are part of the traditional preparation of legumes that improve their acceptability, palatability and nutritional quality. The transformations that occur in legumes during these processes improve their nutritional value, favor the reduction of non-nutritive factors and promote the formation of bioactive compounds that contribute to the reduction of highly prevalent degenerative diseases (De Ron 2015).

One of the main limitations to the consumption of legumes is the long cooking time required to achieve an attractive texture. Legumes stored at high temperatures and humidity develop the phenomenon of hard to cook (HTC), which is directly related to a loss of sensory acceptance by the consumer. Therefore, the consumption of legumes of the year is recommended, avoiding their prolonged storage that can cause negative effects on their organoleptic properties. The soaking to which the legumes are subjected to achieve their initial softening favors the solubilization of the oligosaccharides of the raffinose family and, therefore, reduces flatulence. On the other hand, some digestive enzyme inhibitors are heat labile and factors such as temperature and humidity contribute to their inactivation. It has been described that cooking processes at temperatures between 100 - 150 ºC produce the inactivation of these compounds in bean flour, significantly improving protein digestibility (Sparvoli et al. 2015).

Cooking legumes also favors the digestibility of the starch by producing its gelatinization and the inactivation of the enzymes responsible for quality degradation. In chickpeas previously soaked for 24 h, the cooking process both in a conventional casserole for 90 min, in a pressure cooker for 20 min or in a microwave for 15 min, achieves a reduction in easily assimilable sugars, improves digestibility of starch and the low glycemic index starch content is increased. Cooking also increases the fiber and resistant starch content, non-digestible components of legumes that cause a feeling of satiety and have interesting physiological effects on disease prevention. The analysis of 14 cooked legumes has shown that the total fiber intake ranges between 2.7-11.2%, contributing significantly to the recommended fiber intake. These hydrothermal processes, in turn, favor the solubilization of water-soluble vitamins such as B1, B2 and B3, as well as minerals that are discarded both with the soaking and cooking water. However, during these processes the phytic acid content drops significantly, considerably favoring the mineral bioavailability of the legumes (Sparvoli et al. 2015).

Due to their nutritional attributes, legumes are positioned as one of the pillars of the Mediterranean Diet. However, the consumption of legumes in Spain is in decline and, currently, it stands at just over 3 kg/person/year, a trend that is intended to be reversed, especially since 2016 designated by the FAO as the International Year of Pulses. Among the specific challenges set for this year, it is proposed to increase the consumption of legumes to levels of the year 2000 and get closer to 4 kg/person/year. In fact, legumes are being promoted as healthy traditional foods in the context of a balanced diet and facilitating their consumption with new presentations to make them more attractive to the consumer (Martín Pedrosa et al. 2016).

In the case of the common bean (*Phaseolus vulgaris* L.) the characters that determine the commercial quality of the grain are, mainly, the size, shape, color, related to consumer preferences, and the percentage of water absorption, related to the hardness and time of seed cooking (Bourne 1967, De la Fuente et al. 2006, Wood 2016). A related character is the proportion of seed coat or tegument, since a high proportion of coat implies less water absorption, influencing cooking time and grain palatability (Quenzer et al. 1978). With regard to this aspect of commercial quality, various works have been published on physical characters and grain quality (Hosfield and Beaver 2001) and their relationship with characters of agronomic interest (Casquero et al. 2005, Elia et al. 1997, Santalla et al. 1995).

The objective of this research was to assess the cooking characteristics of improved varieties of common bean using equipment specifically designed at the MBG-CSIC.

Material and methods

Plant material and field trials

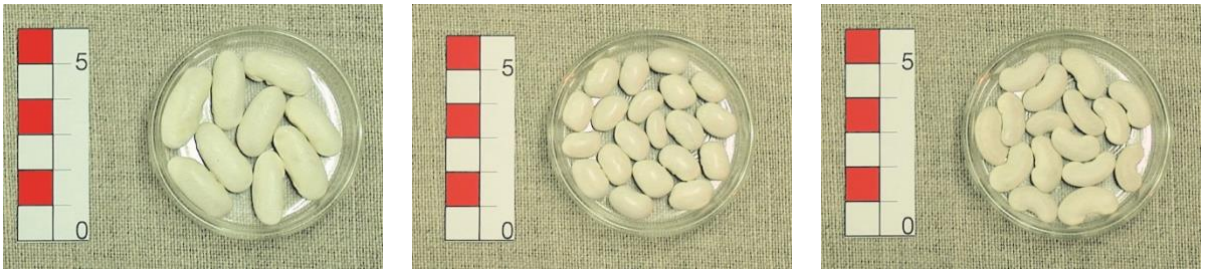
Three varieties of common bean have been used, two of them represent Spanish quality brands of beans with Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI), and an international variety, as follows (figure 1).

Protected Geographical Indication (PGI) Faba de Lourenzá. Production is based on the variety Galaica (plant variety 20170135) (Rodiño et al. 1998) belonging to the international market class Favada (Santalla et al. 2001) of the Andean gene pool, with indeterminate climbing habit type IV, extra-large white grain (approx. 100 g 100 seeds^{-1}) and very late vegetative cycle.

The Matterhorn variety belongs to the market class Great Northern (Santalla et al. 2001) and is tolerant to drought and some diseases such as halo blight (*Pseudomonas syringae* pv *phaseolicola*) and the common mosaic virus (BCMV and BCMNV) (Kelly et al. 1999). It is of Mesoamerican genetic origin and is a variety of recognized international use. It has medium-large sized white grain (approx. 40 g 100 seeds^{-1}) and type II indeterminate growth habit.

Protected Designation of Origin (PDO) Mongeta del Ganxet. Production is based on the bean variety Montcau (plant variety 20050133) that belongs to the market class Hook (Santalla et al. 2001), of the Mesoamerican gene pool with indeterminate growth habit and a very late vegetative cycle. Its white grain is medium-large sized (approx. 50 g 100 seeds^{-1}) and strongly kidney shaped (Casañas et al. 1998).

These varieties were grown in the experimental farm of the MBG-CSIC (20 masl, latitude 42º 26' N and longitude 08º 38' W), with an extension of 10 ha, located in Salcedo (Pontevedra, Spain). The experimental trials under a factorial design were carried out from May to October in 2019 and 2020.



Galaica Matterhorn Montcau

Figure 1. Seeds of the bean varieties: Galaica, Matterhorn and Montcau.

Laboratory material and methodology

The characteristics of the seeds that influence their culinary quality are cooking time and grain hardness. These characters were evaluated using a cocidimeter designed at the MBG-CSIC based on a Mattson type (Jackson 1979). This cocidimeter consisted of a steel plate with 20 cavities. In this plate, 20 bean grains are placed, which were previously soaked for 16 hours. Twenty 20 steel rods with the same weight (40 g) were placed on the grains in the cavities of the plate and the whole system was placed in a beaker Pyrex with about 3.5 L of distilled water and brought to boil. The figure 2 describes the process of the bean cooking with the MBG-CSIC cocidimeter.

The onset of boiling time was recorded, and the intensity of the hotplate was reduced to sufficient heat to maintain the slow boil throughout the cooking period. The number of rods penetrating the grains were counted at 10 min intervals until all the rods penetrated the grains. It has been considered that the cooking time corresponds to 80% of the rods (16) introduced into the grains.

Results and discussion

The table 1 displays the results of the cooking tests performed in the three bean varieties in 2019 and 2020. According to these results, 31 tests have been carried out in 2019, while in 2020 there have been 35. The possibility to carry out these tests on bean grains depends of the harvest of each year and the availability of grain that was different in 2019 and 2020, which, in addition, must be used for other tests, such as water absorption and tegument proportion (Bourne 1967; Hosfield and Beaver 2001). On the other hand, as the cocidimeter is just a prototype, some initial tests have not provided consistent results, for which reason they have not been considered.

The highest value of experimental cooking time was presented by Galaica in 2019 (68 min), while the minimum corresponded to Montcau in 2020 (23 min). The average values vary from a minimum of 31.8 min from Montcau in 2020 to a maximum of 55.5 min from Matterhorn in 2019. There was marked differences between years since the average values in 1029 were 55.2 (Galaica), 55.5 (Matterhorn) and 44.0 (Montcau) while in 2020 they were 37.0 (Galaica), 42.0 (Mattherhorn) and 31.8 (Montcau). Usuallly, there are differences in the harvested grain between years and it seems that the grains harvested in 2020 were easier to cook than those from 2019.

However, because this prototype of cocidimeter was used for the first time, to adapt the methodology to its characteristics will be needed in future (Jackson 1979). These results should be considered as preliminary, since it would be necessary to carry out more tests with the cocidimeter, and with more bean varieties, so that the measurements were more consistent (Hosfield and Beaver 2001; Wood 2016).

Despite this, having the equipment and the methodology to evaluate a character of great importance (cooking) for the consumption and industrial processing of bean grain should be considered as an innovative process, which can open the way for further research in breeding bean for improved cooking quality (Wood 2016).

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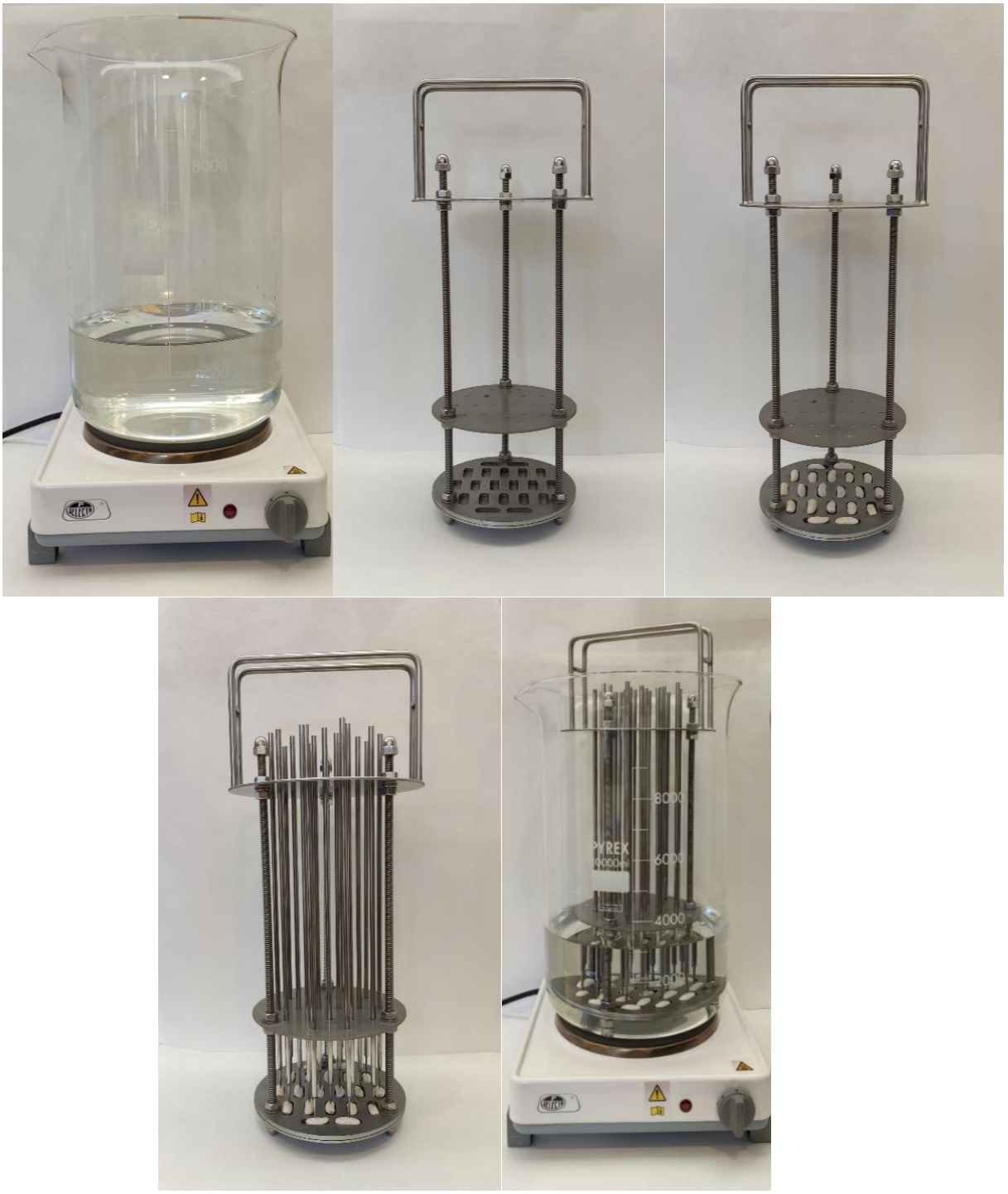

Figure 2. Process of the bean cooking with the MBG-CSIC cocidimeter.

Table 1. Results of the cooking tests performed in the bean varieties tested in 2019 and 2020.

	Cooking time (min)					
VARIETY	GALAICA		MATTERHORN		MONTCAU	
YEAR	2019	2020	2019	2020	2019	2020
	40	40	67	33	59	30
	38	32	60	30	35	29
	59	41	36	37	29	36
	47	37	49	55	54	26
	67	36	54	43	40	30
	53	32	49	32	38	23
	61	28	64	40	45	30
	64	35	57	47	51	38
	68	38	59	39	47	48
		36	51	46	32	28
		51	65	38	54	29
		38		64		
Minimum	38	28	36	30	29	23
Average	55.2	37.0	55.5	42.0	44.0	31.8
Maximum	68	51	67	64	59	48

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