

Technological quality of grain of common bean genotypes of the black commercial class

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ABSTRACT: The technological quality from grains of bean should be evaluated in trials of elite lines to complement the agronomic performance evaluation, ensure the selection and recommendation of new cultivars, and guarantee its greater acceptance by the consumer market. Thus, this study aimed to evaluate the technological quality from selected genotypes of black bean grains. We used 12 elite lines and 4 cultivars from commercial black group constituents of the Value for Cultivation and Use (VCU). The trial was carried out on the Experimental Farm of Federal University of Viçosa-MG, in Coimbra County, in the 2012 crops of autumn/winter seasons. The experimental design was in randomized block, with three replications. The evaluated characteristics were shape, degree of flattening, thousand grains weight, hard-to-cook grains percentage, cooking time, husk percentage and the hydration capacity of the grains. The lines VP 24, VP 25 and VP 29 present the medium level of resistance to cooking similar to the cultivars (controls), and the other evaluated lines have normal resistance to bean cooking. The genotypes CNFP 11977, VP 29 and 'Ouro Negro' attain, in shorter time, 50% of the maximum hydration capacity of the grains, and resistance between normal and medium for cooking time. The lines VP 29 and CNFP 11977 also obtained the greatest hydration capacity for most evaluated times. The lines VP 26, VP 29, CNFP 11992, VP 27, VP 28, and CNFP 11977 present the best characteristics associated with technological quality of grains.

Key words: cooking; elite lines of bean; *Phaseolus vulgaris* L.; soaking; VCU trial

Qualidade tecnológica de grãos de genótipos selecionados de feijão-comum da classe comercial preta

RESUMO: A qualidade tecnológica de grãos de feijão deve ser avaliada em ensaios de linhagens-elite para complementar a avaliação do desempenho agrônomo, assegurar a seleção e recomendação de novas cultivares e garantir maior aceitação pelo mercado consumidor. Assim, o objetivo deste trabalho foi avaliar a qualidade tecnológica de grãos de genótipos selecionados de feijão-preto. Foram utilizados grãos de 12 linhagens-elite e quatro cultivares constituintes do ensaio de Valor de Cultivo e Uso (VCU). O ensaio foi conduzido na Fazenda Experimental da UFV, localizada em Coimbra-MG, na safra de outono-inverno de 2012. O delineamento experimental utilizado foi o de blocos casualizados, com três repetições. As características avaliadas foram forma, grau de achatamento dos grãos, massa de mil grãos, porcentagem de grãos duros, tempo de cocção, porcentagem de casca e capacidade de hidratação dos grãos. As linhagens VP 24, VP 25 e VP 29 apresentam o nível de resistência média ao cozimento semelhante às cultivares (testemunhas), e as demais linhagens avaliadas possuem resistência normal ao cozimento de feijão. Os genótipos CNFP 11977, VP 29 e Ouro Negro atingem, em menor tempo, 50% da máxima capacidade de hidratação dos grãos e resistência entre normal e média quanto ao tempo de cocção. As linhagens VP 29 e CNFP 11977 também obtiveram a maior capacidade de hidratação na maioria dos tempos avaliados. As linhagens VP 26, VP 29, CNFP 11992, VP 27, VP 28, CNFP 11977 apresentam as melhores características associadas à qualidade tecnológica de grãos.

Palavras-chave: cocção; linhagens elite de feijão; *Phaseolus vulgaris* L.; embebição; ensaio de VCU

Introduction

Brazil excels in the world production of common beans (*Phaseolus vulgaris* L.) and is also one of its largest consumers, whose average consumption is 18 kg hab⁻¹ year⁻¹ (Mapa, 2018). Daily consumption of beans is healthy due to the protein quality and high mineral content (Brigide et al., 2014).

There are a variety of commercial types of beans in the country, with the 'carioca' and black beans grains being the most known and consumed (Conab, 2018).

Despite the large number of cultivars recommended for cultivation in different regions of Brazil, the high demand for more productive cultivars may lead to the loss of some traits, and/or not include other characteristics of interest in the bean production chain (Faria et al., 2014). Among these, the technological quality of the grains is distinctive. Thus, in addition to the agronomic performance, it is important to know the lines technological quality, so that there is greater acceptance of the grain by consumers.

Technological quality refers to culinary characteristics wanted by the consumers, in which are included the form, grain mass and rapid hydration, and shorter cooking time. Among them, cooking time is the main evaluation in breeding programs, due to the relevance attributed by the consumer, and because it is a restriction factor for the acceptance of a cultivar in the market. However, all the above mentioned characteristics may be influenced by the genotype and environment, as well as by their interaction (Ribeiro et al., 2013; Perina et al., 2014; Ribeiro et al., 2014a).

In the lines selection in the Value for Cultivation and Use (VCU) assays, besides evaluating the agronomic performance, technological quality tests are required, such as cooking time and sample water absorption before and after cooking, in order to register the genotypes in the National Register of Cultivars from the Ministry of Agriculture, Livestock and Food Supply (Brazil, 2006). However, other characteristics related to technological quality, such as shape, size and percentage of grain husk, might influence the product acceptability by the consumers.

Genetic variability for water absorption capacity and cooking time of the beans has been observed (Ganascini et al., 2014; Morais et al., 2016). However, little is known about the genetic differences for other traits associated with technological quality in the cultivars recommended for cultivation and in the component lines of VCU assays. Therefore, studies to complement the agronomic performance evaluation of the lines, associated with the technological characteristics of the grains, can ensure the selection and recommendation of new cultivars, and contribute to the greater acceptance by consumers.

Thus, the objective was to evaluate the technological quality of grains from selected genotypes of black bean.

Materials and Methods

The experiment was carried out at the Beans Research Laboratory of the Federal University of Viçosa (UFV), in Viçosa

- MG, and at the Animal and Vegetable Products Technology Laboratory of the State University of Montes Claros (UNIMONTES), Janaúba Campus. - MG. The field trial that originated the grains used in this experiment was conducted at the UFV Experimental Farm located in Coimbra-MG, in the 2012 autumn-winter seasons.

Treatments consisted of evaluating freshly harvested beans from 16 genotypes, with 12 elite lines and four common bean cultivars (BRS Campeiro, BRS Valente, BRS Splendor and 'Ouro Negro') selected by the State Research Agreement (EMBRAPA, UFLA, UFV and EPAMIG) in order to compose the black commercial class Value for Cultivation and Use (VCU) assay. The experimental design employed was the randomized block design, with three replications.

After harvesting, which was performed manually, the bean plants from each experimental plot were set to dry in the shade until they reached adequate moisture for the threshing, which was performed with the aid of a mechanical thresher for experimental plots. Right after that the grains underwent manual cleaning, using sieves to separate dry stems, clods and dirt (impurities). Afterwards, a sample of approximately 600 grams of grain from each plot was sent to the Seed Analysis Laboratory from UNIMONTES, in Janaúba-MG. These samples were put in craft paper bags and kept in a cold chamber at 10 ± 2 °C and 65% relative air humidity until the end of the experiment evaluations. The initial grain humidity ranged from 9.7 to 10.9% with no grains drying process being required.

Evaluated characteristics were shape and degree of flattening of the grains (mm), thousand grain weight (g), percentage of hard-to-cook grains (%), cooking time (min), husk percentage (%) and hydration capacity (%).

To evaluate the shape and degree of flattening of the grains, a sample of 20 grains was randomly taken from each plot to measure the length, width and thickness of each grain in mm, with the aid of a caliper. Grain shape was determined by the relation between its length and width and later classification as spherical (1.16 to 1.42), elliptical (1.42 to 1.65), short reniform oblong (1.66 to 1.85), medium reniform oblong (1.86 to 2.00) and long reniform oblong (> 2.00). The degree of flattening was determined by the relation between the thickness and the width of the grains, with subsequent classification as flattened (< 0.69), half-full (0.70 to 0.79) and full (> 0.80), according to Puerta Romero (1961).

In order to estimate the thousand grains weight, three samples of one hundred grains from each plot were randomly taken and weighed on a 0.001 g precision scale, correcting the obtained value to 13% humidity, according to the used methodology in researches with beans crop (Ribeiro et al., 2014b; Oliveira et al., 2012).

To estimate the percentage of hard-to-cook or unhydrated grains, three samples of one hundred grains from each plot were used. The beans were soaked in 200 mL of distilled water at an average temperature of 25 °C. After 16 hours, the non-soaking grains were identified by wrinkling of husk (Ramos Junior et al., 2005; Ribeiro et al., 2007). The result was expressed as hard-to-cook grains percentage.

Hydration capacity was determined by the adapted method of Garcia-Vela & Stanley (1989), which considers the mass difference before and after the grains soaking. Approximately 8 g of grains from each plot were weighed and put in a 400 mL plastic cup containing 100 mL of distilled water for 24 hours. At the first four hours, the beans were drained for 1 minute every 1 hour and then weighed. After 8 and 24 hours, the grains were drained and weighed again. The percentage of absorbed water was obtained according to Equation 1.

$$\% \text{ of absorbed water} = \left[\frac{(\text{hydrated grain mass} - \text{dry grain mass})}{\text{dry grain mass}} \right] \times 100 \quad (1)$$

In order to estimate the husk percentage, a sample with about 8 g of grains from each plot was used, being soaked in 100 mL of distilled water for 24 hours. After soaking, the beans were placed in a 250 mL beaker containing 100 mL of water and then boiled until they softened. Afterwards, a sample of five cooked grains from the previous step was taken. From these, the husk and cotyledons were separated, weighed in a precision 0.001 g scale and then put in paper bags for subsequent oven drying at 105 °C until reaching constant weight. Subsequently, the husk and cotyledons were weighed again on a precision scale to determine the husk percentage, according to Equation 2.

$$\% \text{ husk} = (\text{husk mass} - \text{cotyledon mass}) \times 100 \quad (2)$$

Cooking time (cooking) was determined by two 25-grain samples previously immersed in 50 mL of distilled water for 16 hours. After hydration, the beans were cooked using the 25-stalk Mattson cooker, with 25 stalks (Proctor & Watts, 1987). The apparatus was put in a 2 L beaker containing boiling distilled water, while it kept heated. As the cooking took place, the stalks fell and went through the grains. The elapsed time from the beginning of the boil to the fall of the thirteenth stalk on the grains was recorded, with this being considered the cooking time, in minutes. From the cooking time, the resistance level to cooking was verified for each bean genotype, using the Proctor & Watts scale (1987) (Table 1).

The obtained data were submitted to the analysis of variance. In the case of the F test significance, the means of the thousand grains weight, hard-to-cook grains percentage, cooking time and husk percentage were compared by the Scott-Knott test, at 5% of significance. Analysis of the hydration capacity was done in a 16 x 7 factorial scheme with

three replications, composed by 16 genotypes and seven hydration times (0, 1, 2, 3, 4, 8 and 24 hours), with the data submitted to the mean test in order to study the genotype effects; on the other hand, the hydration times effects were studied by regression analysis. The sigmoidal model $\hat{y} = a / (1 + \exp(-(x - x_0)/b))$ was adopted, in which a describes the maximum percentage of the hydration capacity, b describes the slope of the hydration capacity response and x_0 estimates the imbibition time value equivalent to 50% of the maximum hydration capacity of the common bean genotypes.

Results and Discussion

Regarding the grain form, 14 of the genotypes were classified as elliptical, except for the CNFP 10793 and CNFP 11980 lines, which were considered as spherical (Table 2). These results corroborate with Mambrim et al. (2015) who, while evaluating 16 common bean genotypes, verified elliptical grain shape for most genotypes. In Brazil, the desirable and most widely accepted commercial standard shape of black beans is the elliptical one (Carbonell et al., 2010).

In relation to the grains degree of flattening, 12 of the 16 genotypes were classified as flattened, which is undesirable by the consumer market due to its preference of grains with the half-full to full profile (Carbonell et al., 2010). However, the lines VP 25, VP 26, VP 29 and CNFP 11992 had their grains classified as half-full (Table 2), which meets the standard recommended by packaging companies and the final consumer.

Considering the grains shape and degree of flattening, the genotypes that meet the commercial standard were the VP 25, VP 26, VP 29 and CNFP 11992 lines (Table 2). Evaluating the shape and degree of flattening of common bean genotypes is necessary, since, besides being considered attributes for commercialization, they can interfere with the cooking time of beans (Santos et al., 2016).

The values of thousand grains weight varied between genotypes from 166.40 to 244.24 g (Table 3), ratifying Ribeiro et al. (2014a) who stated that black class grains have small grains and a hundred grains weight of less than 25 g. In addition, it has genetic variability, being it a feature much influenced by the environment, and of great importance to the consumer market (Perina et al., 2014).

The line CNFP 10793 stood out among the other genotypes for having the largest of the thousand grains weight, followed by the BRS Campeiro cultivar, with values of 244.24 and 221.88g, respectively (Table 3). This will probably contribute to the selection of genotypes with better technological or culinary quality, since a larger grain mass generally presents higher food yield.

The genotypes BRS Valente, 'Ouro Negro', VP 24, VP 26, VP 27, VP 28, VP 29 and CNFP 11992 showed no hard-to-cook grains, while the others presented them with values between 1.00 and 1.67% (Table 3). According to Siqueira et al. (2013), grain hardness is highly affected by the cooking time. Thus, the absence or low number of hard-to-cook grains

Table 1. Mean reference values to the bean cooking time.

Cooking time (minutes)	Resistance level for cooking time in beans
16 <	Very susceptible
16 - 20	Medium susceptibly
21 - 28	Normal resistance
29 - 32	Medium resistance
33 - 36	Resistant
36 >	Very resistant

Source: Proctor & Watts (1987).

Table 2. Mean values of the length/width ratio (RCL), thickness/width ratio (REL) and classification regarding the grain shape of 16 common bean genotypes from the black commercial class, produced in Coimbra, MG.

Genotypes	Grain Form		Degree of flattening	
	RCL (mm)	Classification ¹	REL (mm)	Classification ¹
BRS Campeiro	1.54	Elliptical	0.64	Flattened
BRS Esplendor	1.42	Elliptical	0.60	Flattened
BRS Valente	1.47	Elliptical	0.65	Flattened
Ouro Negro	1.48	Elliptical	0.66	Flattened
VP 24	1.61	Elliptical	0.69	Flattened
VP 25	1.60	Elliptical	0.71	Half-full
VP 26	1.61	Elliptical	0.73	Half-full
VP 27	1.59	Elliptical	0.67	Flattened
VP 28	1.53	Elliptical	0.65	Flattened
VP 29	1.45	Elliptical	0.70	Half-full
CNFP 10103	1.42	Elliptical	0.66	Flattened
CNFP 10793	1.40	Spherical	0.65	Flattened
CNFP 11977	1.57	Elliptical	0.68	Flattened
CNFP 11980	1.40	Spherical	0.67	Flattened
CNFP 11990	1.45	Elliptical	0.68	Flattened
CNFP 11992	1.63	Elliptical	0.71	Half-full

¹ Classification established in accordance to Puerta Romero (1961).

usually shortens the cooking time due to the grains softening, increasing the commercial value of the cultivar.

The VP 28 and CNFP 11992 lines had shorter cooking times, with values of 20.5 and 21.6 minutes, respectively (Table 3). In that way, these lines were superior to the commercial cultivars used, which presented cooking time of grains between 29.1 and 31.8 minutes (Table 3).

The variability for cooking time (20.5 to 31.8 min) observed in this study (Table 3) has already been found in other studies with common bean genotypes, which obtained values from 12.39 to 36.21 minutes (Ribeiro et al., 2013; Ribeiro et al., 2014c; Silva et al., 2016), which confirms the interaction between genotype and environment.

In general, it was found that with the exception of the BRS Esplendor, BRS Valente, 'Ouro Negro' and VP 27 genotypes,

twelve genotypes had cooking times shorter than or up to 30 minutes (Table 3), which is considered desirable because it means both energy and capital savings.

Thus, due to these genotypes having a reduced cooking time, selection for this trait may also be useful in the identification of lines with greater ease for water absorption by grains as long as there is a relation between these traits.

It is noteworthy that the lines VP 24, VP 25 and VP 29 presented the medium level of resistance to cooking, being similar to the other cultivars used in this experiment. However, the other lines evaluated obtained normal resistance to the beans cooking (Table 3), ratifying Proctor & Watts (1987), beans with cooking time between 21 and 28 minutes are considered as of normal resistance to cooking.

Table 3. Means of the thousand grain mass (TGM), hard-to-cook beans percentage (HTCB), cooking time (Cooking), resistance level to the bean cooking time (NR) and husk percentage (Husk) of grains from 16 genotypes of common bean from the black commercial class, Coimbra, MG.

Genotypes	TGM (g)	HTCB (%)	Cooking (min)	NR	Husk (%)
BRS Campeiro	221.88 b ¹	1.67 a	29.1 a	Medium resistance	12.46 c
BRS Esplendor	168.71 h	1.00 b	30.9 a	Medium resistance	12.81 c
BRS Valente	192.94 e	0.00 c	31.8 a	Medium resistance	15.45 b
Ouro Negro	180.26 g	0.00 c	30.5 a	Medium resistance	11.68 c
VP 24	197.03 d	0.00 c	28.5 b	Medium resistance	11.76 c
VP 25	191.69 e	1.00 b	30.0 a	Medium resistance	11.85 c
VP 26	209.00 c	0.00 c	27.3 b	Normal resistance	9.78 d
VP 27	194.60 d	0.00 c	27.4 b	Normal resistance	8.62 d
VP 28	166.40 h	0.00 c	20.5 d	Normal resistance	11.45 c
VP 29	183.40 f	0.00 c	30.6 a	Medium resistance	10.80 c
CNFP 10103	196.32 d	1.00 b	26.5 b	Normal resistance	9.81 d
CNFP 10793	244.24 a	1.00 b	26.5 b	Normal resistance	8.61 d
CNFP 11977	187.43 f	1.00 b	26.8 b	Normal resistance	17.78 a
CNFP 11980	187.39 f	1.00 b	27.6 b	Normal resistance	11.38 c
CNFP 11990	192.69 e	0.00 c	24.5 c	Normal resistance	9.71 d
CNFP 11992	173.87g	1.00 b	21.6 d	Normal resistance	12.10 c
CV (%)	2.74	5.24	5.23		9.90

¹ Means followed by the same letter in the column belong to the same group by the Scott-Knott test at 5% of significance.

If a long time is required to obtain the right softness and texture for consumption, there are losses in the grain nutritional value (Vanier et al., 2014). Furthermore, more energy is spent on preparation, and so consumers may reject this product. Therefore, the development of fast-growing bean cultivars is essential to meet the needs of the consumer market that has reduced meal preparation time and wants to reduce energy use costs (Oliveira et al., 2013; Santos et al., 2016).

The evaluated genotypes had the husk percentage between 8.61 and 17.78% (Table 3), with the highest percentage displayed by the CNFP 11977 line, followed by the BRS Valente cultivar, with values of 17.78 and 15.45, respectively. On the other hand, the lines VP 26, VP 27, CNFP 10103, CNFP 10793 and CNFP 11990 presented the lowest values for this trait, with values between 8.61 and 9.81% (Table 3). Thus, it is verified that these lines stood out among the evaluated genotypes, because the husk percentage is a very relevant factor in the bean cultivars selection, since the lower the obtained value is, the smaller the husk remnants will be at the end of chewing due to it being less thick, resulting in greater acceptance (Oliveira et al., 2013).

The unfolding of the genotypes source of variation at each hydration time revealed that, for time 0 (initial), there was no significant difference between the evaluated genotypes (Table 4). Thus, the values found at this time represent the initial grain humidity. It is worth mentioning that, in this case, the initial humidity was equal for all evaluated genotypes, preventing that the test was not influenced by any possible difference in humidity.

The CNFP 11977 and VP 29 lines had the highest hydration capacity at time 1 (one hour of soaking), followed by the 'Ouro Negro' and VP 24 genotypes (Table 4). At times 2 and 3 (2 and 3 hours of imbibition), the 'Ouro Negro', CNFP 11977 and VP 29 genotypes had higher hydration capacity, followed by the

VP 24 line (Table 4). Thus, the rapid selection of genotypes with greater hydration capacity is essential to ensure softness, reduce cooking time, energy expenditure and cost for bean preparation (Ganascini et al., 2014).

The 'Ouro Negro', CNFP 11977 and VP29 genotypes obtained higher hydration capacity at time 4 (four hours of soaking), followed by the BRS Campeiro, BRS Esplendor, BRS Valente, VP24 and VP 25 genotypes (Table 4). Within 8 hours of soaking, the BRS Campeiro, BRS Esplendor, BRS Valente, CNFP 11977, VP 24, VP 25, VP 26 and VP 29 genotypes presented the highest hydration capacity when compared to the other genotypes (Table 4). Although these genotypes have the highest hydration capacity, it does not mean that they have shorter cooking time, since there are conflicting results regarding the correlation between hydration and cooking times (Carbonell et al., 2003; Rodrigues et al., 2005).

CNFP 10103, CNFP 10793, CNFP 11980 and VP 28 lines displayed the lowest hydration capacity (Table 4). According to D'Albuquerque (2013), this differential behavior of genotypes in hydration capacity may be associated with integument stiffness, cotyledon adherence, elasticity, porosity and colloidal properties in water absorption by the different cultivars. Lemos et al. (1996) related aspects of bean grain brightness as the possible cause for low hydration capacity in addition to differences in the genetic constitution of genotypes (Santos et al., 2015).

The CNFP 11977 and VP 29 lines displayed the highest hydration capacity at times 1, 2, 3, 4 and 8 hours of soaking (Table 4), followed by the 'Ouro Negro' cultivar at times 2, 3, 4 and 8 hours of soaking. In the hydration time of 24 hours, there was no difference between the evaluated genotypes (Table 4).

The unfolding of hydration times for each genotype was performed by regression analysis, in which the coefficients

Table 4. Mean values of hydration capacity in different grains hydration times from 16 selected genotypes from common bean of the black commercial class, Coimbra, MG.

Genotypes	Hydration capacity (%)						
	Time (hours)						
	0	1	2	3	4	8	24
BRS Campeiro	12.03 a ¹	18.17 c	27.48 c	36.41 c	49.40 b	116.40 a	137.31 a
BRS Esplendor	11.45 a	16.55 c	28.46 c	40.27 c	56.38 b	116.09 a	137.20 a
BRS Valente	11.58 a	20.92 c	32.32 c	42.21 c	59.53 b	122.64 a	138.30 a
Ouro Negro	11.12 a	26.78 b	53.71 a	70.45 a	85.94 a	121.50 a	132.21 a
CNFP 10103	10.98 a	11.20 c	12.66 d	15.06 d	18.05 e	72.54 d	128.29 a
CNFP 10793	11.54 a	13.18 c	14.57 d	15.39 d	17.00 e	66.39 d	133.63 a
CNFP 11977	12.28 a	39.36 a	62.51 a	72.74 a	83.08 a	117.97 a	145.31 a
CNFP 11980	11.11 a	13.93 c	16.27 d	18.71 d	22.29 e	82.37 c	130.62 a
CNFP 11990	11.29 a	12.22 c	14.64 d	21.15 d	30.19 d	99.77 b	131.13 a
CNFP 11992	10.76 a	15.10 c	19.76 d	23.83 d	27.89 d	84.20 c	134.22 a
VP 24	11.87 a	25.50 b	40.16 b	50.73 b	64.98 b	117.90 a	142.29 a
VP 25	12.23 a	20.02 c	33.06 c	44.54 c	60.62 b	120.75 a	135.60 a
VP 26	11.66 a	14.71 c	19.06 d	30.07 c	43.25 c	111.57 a	135.73 a
VP 27	11.06 a	13.87 c	18.33 d	25.71 d	33.90 d	100.37 b	136.94 a
VP 28	11.60 a	12.58 c	13.37 d	14.33 d	16.50 e	65.53 d	141.35 a
VP 29	11.82 a	38.91 a	64.73 a	82.44 a	91.58 a	112.90 a	132.37 a
CV (%)	13.15						

¹Means followed by the same letter in the column belong to the same group by the Scott-Knott test at 5% of significance.

of the obtained equation for each genotype are displayed in Table 5. All evaluated genotypes presented a response that followed the sigmoidal model (Figure 1).

The VP 29 line, followed by the 'Ouro Negro' and CNFP 11977 genotypes, reached in a shorter time 50% of the maximum grain hydration capacity in the soaking process (Table 5). In addition, the VP 29 and CNFP 11977 lines also obtained the highest hydration capacity at 1, 2, 3, 4 and 8 hours of imbibition (Table 4). Determining the hydration capacity of the beans before cooking may be a good indication of the cooking time, i.e. less hydration time and more water absorbed would reduce cooking time. However, not always a greater hydration capacity indicates a shorter cooking time (Albuquerque, 2013).

CNFP 10103, CNFP 10793 and VP 28 lines needed a longer time both to reach 50% of the maximum hydration capacity, and for the highest hydration capacity at the 1, 2, 3, 4 and 8 hours of soaking times (Table 5 and 4). However, these lines had a cooking time of less than 27 minutes, especially the VP 28 line, which had one of the shortest cooking times of the beans, 20.5 min (Table 3). Possibly, due to these lines presenting some property that confers less permeability to the integument caused slower water absorption, but without increasing the grains cooking time.

There is divergence in the literature regarding hydration capacity and cooking time, which may happen due to the lack of methodologies standardization such as the difference in water temperature during hydration, which accelerates this process and promotes a higher percentage of hydration (Coelho et al., 2008), besides the genotype x environment interaction, crop harvests, and storage conditions (time, temperature and form) (Ribeiro et al., 2014a; Ribeiro et al., 2014c; Nalepa & Ferreira 2013). It is also noteworthy that there is no relation

Table 5. Sigmoidal logistic regression coefficients of the relation between soaking time and hydration capacity of 16 genotypes from black commercial class common bean, Coimbra, MG.

Genotypes	<i>a</i>	<i>b</i>	<i>x₀</i>	R ²
BRS Campeiro	138.5445**	1.9790**	4.9664**	0.99
BRS Esplendor	137.1851**	1.9379**	4.6923**	0.99
BRS Valente	139.3848**	1.8938**	4.4642**	0.99
Ouro Negro	128.3889**	1.4590**	2.7853**	0.99
VP 24	141.5109**	2.1920**	4.3245**	0.99
VP 25	136.3829**	1.8864**	4.3279**	0.99
VP 26	136.5891**	1.8864**	5.3302**	0.99
VP 27	137.6137**	2.1028**	6.0495**	0.99
VP 28	142.0411**	2.7220**	8.5514**	0.99
VP 29	122.5680**	1.3505**	2.1287**	0.96
CNFP 10103	128.7332**	2.3445**	7.5213**	0.99
CNFP 10793	134.2937**	2.7237**	8.2162**	0.99
CNFP 11977	138.9631**	2.1101*	3.0327**	0.96
CNFP 11980	131.2381**	2.3166**	6.9542**	0.99
CNFP 11990	131.9706**	1.8912**	6.0102**	0.99
CNFP 11992	134.7801**	2.5417**	6.8465**	0.99

a = maximum percentage of hydration capacity, *b* = leaning of the hydration capacity response, *x₀* = soaking time value equivalent to 50% of the hydration maximum capacity; $\hat{y} = a/(1+\exp(-(x-x_0)/b))$; ** not significant; * *p* = 0.05; ** *p* = 0.01.

between hydration capacity and cooking time, since lines with low hydration capacity may have excellent cooking times (Durigan et al., 1978).

Therefore, more or less time for water absorption or cooking may be required depending on the grain quality of the used genotypes, employed methodologies and or environmental conditions. It should be noted that for the selection and recommendation of new cultivars, the characteristics related to the technological quality must be evaluated together with the agronomic performance in order to ensure the cultivation recommendations and a greater acceptance by the consumer market of new common bean cultivars.

Conclusions

VP 24, VP 25 and VP 29 lines displayed medium level of resistance to cooking, similar to the cultivars (control), and the others evaluated lines have normal resistance to the bean cooking.

CNFP 11977, VP 29 and 'Ouro Negro' genotypes attained, in less time, 50% of maximum grains hydration capacity and resistance between normal and medium regarding the cooking time. VP 29 and CNFP 11977 lines also obtained the largest hydration capacity in most evaluated times.

Lines VP 26, VP 29, CNFP 11992, VP 27, VP 28 and CNFP 11977 had the best characteristics associated with the technological quality of grains.

Acknowledgements

Thanks to the Federal University of Viçosa for the concession of the seeds, the State University of Montes Claros for holding the research; to the FAPEMIG, Capes and CNPq, for the scholarships concessions.

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