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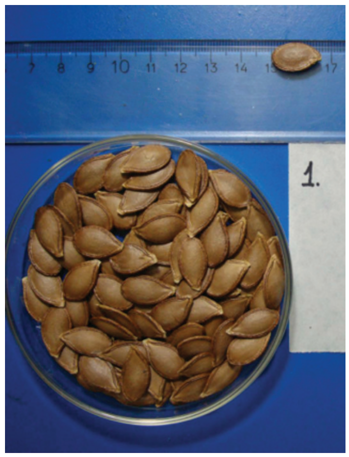
Selecting squash (*Cucurbita* sp.) introductions by seed nutritional quality and seed meal

Selección de introducciones de zapallo *Cucurbita* sp. por calidad nutricional en semilla



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Brown seed, characteristic of the cultivar Unapal Abanico-75.

Photo: M.-P. Valdés-Restrepo

ABSTRACT

Squash (*Cucurbita* sp.) is widely used in Colombia as both food and animal feed. However, its seeds are discarded. This study aimed to identify squash genotypes with a high nutritional value in the whole seed meal (WSM) and defatted seed meal (DSM) within a group of 19 introductions (14 of *Cucurbita moschata* and 5 of *C. sororia*). For WSM, 70% of the introductions presented above-average values for extract (36.9%) and crude protein (26.34%); the fiber values were 20.34% neutral detergent fiber (NDF) and 13% acid detergent fiber (ADF). For DSM, 57% of the introductions presented above-average crude protein (43.5%) and 52% above-average crude energy values (4078 cal g^{-1}). Based on the relative feed value (RFV), introductions 1229, 1200, 1201, 1219 and 1206 were selected for WSM, and 1206 1229, 932, 1200, 786 and 954 were selected for DSM. In the selected *C. moschata* introductions, parents with general and specific combining abilities for ether extract and crude protein in WSM or high RFV in DSM should be identified. *C. soraria* introductions 1202 and 954 should be used in crosses that aim to obtain F_2 segregants for seeds with a high oil content and high RFV in DSM.

Additional key words: *Cucurbita moschata*; *Cucurbita sororia*; defatted seed meal; squash seeds; whole seed meal; high forage value.

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RESUMEN

Zapallo (*Cucurbita* sp.) se ha utilizado como alimento en humanos y animales. Sin embargo, sus semillas, son descartadas. Por consiguiente, este estudio tuvo como objetivo identificar los genotipos de zapallo con alto valor nutritivo en harina de semilla entera (HSE) y harina de semilla desgrasada (HSD) dentro de un grupo de 19 introducciones (14 de *Cucurbita moschata* y 5 de *C. sororia*). En cuanto a la HSE, el 70% de las introducciones presentaron valores superiores a la media para el extracto de éter (36.9%) y proteína cruda (26.34%). Con respecto a la HSD, el 57% de las introducciones presentaron proteína bruta por encima del promedio (43.5%) y el 52% tenían valores de energía bruta por encima del promedio (4078 cal g^{-1}). La HSE de zapallo presenta un 20.34% de fibra detergente neutra y un 13% de fibra detergente ácida. Con base en al valor de relativo del forraje (VRF), las introducciones 1229, 1200, 1201, 1219 y 1206 se seleccionaron para HSE y 1206 1229, 932, 1200, 786 y 954 para HSD. En las introducciones seleccionadas de *C. moschata*, la recomendación es identificar a los padres con habilidades combinatorias generales y específicas para el extracto de éter y la proteína bruta en HSE y para una alta VRF en HSD. Las introducciones de *C. soraria* 1202 y 954 deben usarse en cruzamientos que pretenden obtener segregantes de F2 para semillas con alto contenido de aceite y alta VRF en HSD.

Palabras clave adicionales: *Cucurbita moschata*; *Cucurbita sororia*; harina de semilla desgrasada; semillas de zapallo; harina de semilla entera.

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INTRODUCTION

Identification of the place of origin has been the main research topic in Cucurbitas; however, little is known about the seed as a source of energy despite its high content of ethereal extract (Rodríguez *et al.*, 2018). The sororia subspecies includes wild populations with a broad distribution, from Mexico to Nicaragua, which is the wild ancestor of the domesticated species *C. argyrosperma*. The fruits are white with green and have varied sizes. The pericarp is usually coriaceous and is hard to fracture even with a percussion tool, with a bufoid pericarp and bedding (Valdés *et al*., 2014). The mesocarp can be colorless in some introductions; in others, it has an intense yellow color and bitter taste. Some fruits have a salmon-yellow mesocarp, which, upon, contact with air turns from deep green to completely black in a few minutes after removing the seeds, as seen in *C. moschata* (Hidalgo and Vallejo, 2014). *C. moschata* is a domesticated species in South America. Although there is no agreement on the precise area of its domestication, it has been mentioned that northern Colombia is possibly the center of origin (Ortiz *et al*., 2013). The seeds have different shades of coloration in the testa, ranging from havana to coffee with golden edges; the fruits usually have a soft pericarp, which can be smooth or curled, with soft bufoids, sardines, particular colors, one or two colors in bands or spots and variable format. The mesocarp is orange, ranging from pale orange to deep orange. The matrix has an intense orange; some matrices, upon contact with air, become intense green (Hidalgo and Vallejo, 2014).

The economic value of tropical pastures –the basis of nutrition for cattle, goats, and sheep– has been widely documented (McIlroy, 1973; Roy, 2000; Ramírez *et al*., 2012; Sánchez *et al.,* 2015). However, the forage that has been used to feed animals in the tropics lacks protein and energy (Cook *et al*., 2005; Holguín *et al.* 2015) and must be supplemented with agro-industrial raw materials or cereal and legume grains. New genotypes must be identified that can replace the available feed resources to ensure balanced livestock production, enhancing animal performance while reducing the need to use costly imported grains (Ortiz *et al.,* 2013).

Ruminants, for example, are capable of degrading low-quality forage that is rich in plant cell walls, which is not suitable for feeding most monogastric animals that have enzymatic digestive processes (Pereira *et al.,* 2015) because of multiple symbiotic, physical and mechanical associations that occur in the digestive tract, specifically in the rumen (McSweeney and Mackie, 2012). Starch is fermented into volatile fatty acids and nitrogen sources that are degraded to ketoacids and ammonia, the latter being the main source of N for microbial synthesis (Nikkhah, 2015). The intensity of this degradation process varies, depending on the magnitude of the potential degradable fraction and the retention time in the rumen as a function of forage quality, the amount of ammonia in the substrate and the available energy derived from high-quality grains, which degrade more quickly and yield more nutrients for cattle, improving the nutritional efficiency (Olabisi, 2015). Therefore, research is needed on a new source of nutrients for animals, such as Cucurbita Spp seeds.

The whole seed meal (WSM) from squash cultivar Abanico-75 contained 36.25 ± 3.25% ether extract (EE), which was composed of 55.28% unsaturated fatty acids (of which 55.11% was linoleic acid). The defatted seed meal (DSM) contained 51.1 ± 0.95% protein and 4604.66 ± 134.08 kcal kg^{-1} crude energy (CE). The seed starch content ranged from 13 to 28% (Valdés *et al.,* 2014). In 2009 and 2013, the Vegetables Research Group of the Universidad Nacional de Colombia-Palmira campus studied a collection of butternut squash (*Cucurbita moschata* Duch.) genotypes from Central America to determine whether the nutritional composition in the WSM and DSM was sufficiently variable to select superior genotypes for farmers or animal feed (Valdés *et al.* 2014; Ortiz *et al.,* 2013).

The present study aimed to identify squash genotypes with a high nutritional value in WSM and DSM in a group of introductions that belong to the Vegetable Research Program's work collection of the Universidad Nacional de Colombia-Palmira campus.

MATERIALS AND METHODS

Trial site

The experiment was carried out during the first semester of 2017 on the Mario Gonzales Aranda Experimental Farm and in the Seeds and Animal Nutrition Labs of the Universidad Nacional de Colombia,

Table 1. Squash introductions used in the quality screening trial.

Serial	Introduction Code	*Cucurbita* species	Lugar	Municipio	Estado
1	Unapal Abanico-75	*C. moschata*	Palmira	Valle del Cauca	-----
2	419	*C. moschata*	Ocozocoautla	Ocozocoautla de espino	Chiapas
3	1201	*C. moschata*	Tecomatlan	Autlan de navarro	Jalisco
4	786	*C. moschata*	Eji. Plan de juarez	Xilitla	SLP
5	802	*C. moschata*	Eji. huichihuayan	Huehuetlan	SLP
6	1222	*C. moschata*	Teneria del Santuario	Celaya	Guanajuato
7	932	*C. moschata*	Guayabitos	Choix	Sinaloa
8	1219	*C. moschata*	La cienaga	El limon	Jalisco
9	1213	*C. moschata*	Espinal	Ocozocoautla de espino	Chiapas
10	1235	*C. moschata*	El encanto	Las Margaritas	Chiapas
11	1229	*C. moschata*	Col. A López Mateos	Tepalcingo	Morelos
12	1206	*C. moschata*	El chante	Autlan de navarro	Jalisco
13	1205	*C. moschata*	Ahuacapan	Autlan de navarro	Jalisco
14	1200	*C. moschata*	El chante	Autlan de navarro	Jalisco
15	1202	*C. sororia*	El cuastecomate	Ejutla	Jalisco
16	1210	*C. sororia*	------	Amatlan de cañas	Nayarit
17	954	*C. sororia*	Culiacan	Culiacan	Sinaloa
18	1215	*C. sororia*	Ejutla	Ejutla	Jalisco
19	1207	*C. sororia*	El chante	Autlan de navarro	Jalisco
Reference	Abanico-75	*C. moschata*			

SLP, San Luis Potosi.

located in the municipality of Palmira, Colombia (03°30'26.8'' N 76° 18'47.6'' W; average annual temperature, 24°C; 1,000 m a.s.l.; average annual precipitation, 1,000 mm) (Valdés *et al.,* 2010).

Biological study materials

The WSM and DSM came from 19 squash introductions: 14 butternut squash (*Cucurbita moschata*) introductions from Colombia and 5 introductions of a wild Mexican gourd (*Cucurbita sororia*), which belong to the Vegetable Research Program's work collection, Universidad Nacional de Colombia-Palmira Campus (Tab. 1). The WSM and DFM made from the fruit of squash cultivar Unapal Abanico-75 were used as the reference.

Seed treatment protocol. All squash seed samples were lyophilized and minced in a 2-blade Wiley Mill to obtain 1 mm-sized particles. The EE of the ground and lyophilized WSM and DSM was determined using a Soxhlet extractor, preserved separately in 50 ml Eppendorf tubes kept under refrigerated conditions (between 4 and 12°C) for a subsequent quality analysis based on complete proximate analysis, along with fiber analysis using the Van Soest method (Tab. 2).

Table 2. Proximate and fiber analyses of the butternut squash whole seed meal and defatted seed meal based on dry matter content.

Component	Component determined	Method used
Crude protein (CP)	Nitrogen × 6.25	Kjeldahl
Total ashes	Minerals	AOAC 942.05
Ether extract (EE)	Crude fat	Soxhlet
Fiber	Neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin	Van Soest
Crude energy (CE)	Total energy content	Calorimetric pump

Selection of introductions for their nutritional value

The results of the proximate and fiber analyses were used to select the introductions with the highest nutritional value in the WSM and DSM. The weighted selection index (WSI) was used (Roy, 2000; Valdés *et al.,* 2014) as follows: (1), where $WSI_{(k)}$ was the standardized selection index for the k-th introduction (k: 1,2,3…), P_i was the weighted factor assigned to i-th descriptor (i: 1, 2, 3…), $\overline{X}_{i(k)}$ was the average of the i-th descriptor in the k-th introduction, $\overline{X}_{g(i)}$ was the overall average of the collection for the i-th descriptor, and $S_{g(i)}$ was the overall standard deviation of the i-th descriptor considering the k introductions.

$$WSI_{(k)} = \sum_{1}^{19} Pi \frac{(\overline{X}_{i(k)} - \overline{X}_{g(i)})}{S_{g(i)}} \qquad (1)$$

The WSI value was calculated for each of the 19 introductions based on the following characteristics: ash content, crude protein (CP) and EE in the WSM and ash content, CP and CE in the DSM. The weighting factor Pi was assumed to be 0.33 and was equal for all variables, based on the assumption of equality of relative importance when studying an introduction for animal nutrition purposes.

Selecting introductions by relative feed value

The protocol of Hoffman and Combs (2014) was followed to determine the relative feed value (RFV) of each introduction. The fiber analysis, in terms of neutral detergent fiber (NDF) and acid detergent fiber (ADF), was used to determine the feed value and forage quality. The following general model was used:

$$RFV = (DDM \times DMI) / 1.29 \qquad (2)$$

where DDM was digestible dry matter = 88.9 - (0.779 × % ADF) and DMI was dry matter intake (% liveweight) = 120 / (% NDF).

The data were processed using Excel and subsequently analyzed using the SAS (statistical analysis software) statistical package (SAS, 2013).

RESULTS AND DISCUSSION

Proximate characterization of the squash whole seed meal and defatted seed meal

The dry matter content of the WSM was higher than that of the DSM, probably because the DSM components (sugars, starches) are fat-free and, as a result, are not protected from atmospheric humidity, possibly expressing some sort of hygroscopic ability (Tab. 3 and 4).

In general, the average ash and CP contents of the WSM were lower than those of the DSM, while the CE was higher in the WSM than in the DSM. This was due to the fact that oil, the largest source of energy, was eliminated from the WSM during the ether extraction, whereas in the DSM, the mass ratios favored the remaining metabolites, especially starch and CP (Tab. 3 and 4).

The overall mineral content, represented by the ash content, in the WSM and DSM in this study was higher than the ash content in the squash WSM (3.9%) reported by Ortiz *et al.* (2009) and that of peanut seed meal (2.6%) reported by Pascual *et al.* (2006) (Tab. 3 and 4). The reference material, a WSM made from the fruit of cultivar Abanico-75, presented above-average mineral ash content values (6.18–7.62%), as compared with the WSM (4.13%) and DSM (5.31%) (Tab. 3).

The three introductions with the higher EE contents were 1200 (43.61%), 1219 (42.03%) and Unapal Abanico-75 (41.86%). Based on this information and reports by Ortiz *et al.* (2009), squash seed can be considered an oleaginous raw material.

Of the 19 studied introductions, 70% presented an above-average EE content (36.9%) in the seeds (Tab. 3). According to Younis *et al*. (2000), the EE of squash seeds is higher than that of sunflower seeds (36%), except in the case of squash introduction 802 (30.43%), agreeing with results found by Roy (2000) when compared with maize (5% EE) and linseed (20.7% EE).

Table 3. Nutritional value and weighted selection index (WSI) for whole seed meal of 19 squash introductions and cultivar Abanico-75 (the latter used as the reference).

Introduction	Dry Matter (%)	Ash (%)	Ether extract (%)	Crude protein (%)	Crude energy (cal g^{-1})	WSI	Ranking
1205	94.17	4.41	35.96	23.99	6075.62	-0.1022	12
1207	94.79	4.46	38.77	26.45	5935.76	0.2457	8
1202	93.85	4.12	37.84	29.91	5760.64	0.3211	7
1213	94.29	4.31	34.75	30.0	5691.34	-0.2040	14
1206	94.58	3.05	33.75	28.0	5740.3	-0.8258	19
1229	95.03	4.27	41.37	27.12	6097.11	0.3325	6
1201	93.57	4.35	38.9	30.22	6523.15	0.4998	4
1200	93.62	4.13	43.61	29.2	5747.29	0.5691	2
419	92.31	3.62	37.89	21.33	5002.31	-0.5839	17
1210	93.12	3.38	37.03	26.87	5778.83	-0.2950	16
932	93.37	4.69	34.84	27.31	5882.01	0.2365	9
1219	94.26	4.27	42.03	29.35	6112.84	0.5396	3
802	93.42	4.62	30.43	24.98	5657.46	-0.1844	13
1222	94.23	3.62	41.56	27.76	5288.96	0.0952	10
Abanico-75-S*	93.38	3.07	41.86	21.81	5948.52	-0.6129	18
1235	93.08	4.77	39.43	28.4	5880.92	0.5722	1
Abanico-75-F**	88.45	6.18	10.01	12.68	3818.87	-1.3925	20
786	93.93	4.47	38.9	27.8	4405.45	0.3631	5
954	93.31	3.77	38.38	27.8	5915.85	0.0193	11
1215	93.41	3.22	41.07	25.94	5926.01	-0.2543	15
Mean	93.5	4.13	36.91	26.34	5659.46		
LSD (5%)	0.89	0.47	4	2.678	408.34		
CV %	1.45	17.45	19.26	15.41	10.93		

* Whole seed meal made from the fruit of cultivar Abanico-75 (reference). ** Defatted seed meal made from the fruit of cultivar Abanico-75 (reference).

Of the studied squash introductions, 70% presented an above-average CP content in the seeds (average = 26.34%) (Tab. 3). The CP values were similar to or higher than those for peanut (*Arachis hypogea*), 26.0%; Canavalia grain (*Canavalia ensiformis*), 16-23%; cotton seed (*Gossypium* spp.), 12-22%; and Nima bean (*Phaseolus vulgaris*), 16-20%. For the seed CE, 65% of the introductions presented above-average values (5659.46kcal kg^{-1}), surpassing that of sunflower seed (5,353 kcal kg^{-1}) (Arija *et al.,* 1999) (Tab. 3).

The WSI for the nutritional value of the squash seeds showed that 57% of the introductions were above-average in several of the studied variables, with 1235, 1200, 1219 and 1201 ranking first (Tab. 3).

Of the introductions included in this study, 57% presented above-average CP values (43.5%) in the DSM, presenting higher values than palm kernel cakes (14%), cotton (29.5%), rapeseed (34.5%), copra (21%) (Chatterjee and Walli, 2002) and *Jatropha curcas* fruits (Rodriguez *et al*., 2016). In addition, the CP value in the DSM of introductions 1205 (46.16%), 1229 (52.48%) and 1222 (52.22%) as well as that of cultivar Abanico-75 (51.33%) was higher than that of soybean meal (46%) (Tab. 4).

For the CE in the DSM, 52% of the introductions presented above-average values (4,078 cal g^{-1}). Introduction 1201 presented the highest energy content in the WSM (6,523.15 cal g^{-1}) and introduction 1202

Table 4. Nutritional value and weighted selection indexes (WSI) for defatted seed meal of 19 squash introductions and cultivar Abanico-75 (the latter used as the reference).

Introduction	Dry matter (%)	Ash (%)	Crude protein (%)	Energy (cal g^{-1})	WSI	Ranking
1205	89.91	5.36	46.16	3828.14	-0.5603	19
1207	91.64	5.63	41.31	4107.12	0.1055	7
1202	90.1	5.2	45.82	4290.07	0.6107	4
1213	90.21	5.53	42.76	4035.63	-0.0683	11
1206	90.41	3.6	40.63	4134.69	-0.5465	18
1229	87.08	5.36	52.84	4195.82	0.6674	3
1201	89.95	5.76	39.81	4092.93	0.0580	8
1200	89.98	5.05	40.48	4197.76	0.1181	6
419	90.56	4.73	37.61	4167.96	-0.1762	15
1210	91.66	4.59	39.77	4053.16	-0.4542	17
932	91.78	5.68	44.37	3935.31	-0.2272	16
1219	90.1	5.51	44.8	4053.37	0.0462	9
802	90.2	6.41	38.96	3954.64	-0.1190	13
1222	91.43	4.47	52.22	4149.74	0.2139	5
Abanico-75-S*	91.84	4.03	51.33	4129.52	-0.0245	10
1235	90.17	6.82	49.82	4129.76	0.8853	1
Abanico-75-F**	89.73	7.62	11.16	3825.62	-1.0532	20
786	89.75	5.97	49.78	4220.64	0.8339	2
954	90.2	4.62	51.89	3996.41	-0.1573	14
1215	89.92	4.38	49.73	4074.61	-0.1087	12
Mean	90.33	5.31	43.56	4078.64		
LSD (5%)	0.6	0.63	6.01	81.18		
CV%	1.16	17.97	20.92	3.017		

* Whole seed meal made from the fruit of cultivar Abanico-75 (reference). ** Defatted seed meal made from the fruit of cultivar Abanico-75 (reference).

presented the highest energy content in the DSM (4,90.07 cal g^{-1}) (Tab. 4).

Introductions 1235, 786, 1229 and 1202 ranked first based on the WSI, presenting outstanding nutritional values (Tab. 4).

Based on the data collected in this study, all of the WSMs and DSMs presented higher nutritional values than the raw materials on the market. This study aimed to determine which introductions could serve as potential parents in future breeding efforts and selection processes conducted by the university's Vegetable Research Program. Based on the WSI, those introductions presenting the best proximate performance in terms of WSM were 1235, 1200, 1219, 1201, 954 and 786; in terms of the DSM, introductions 1235, 786, 1229, 1202 and 1222 had the best performance. Likewise, introductions 1235 and 786 ranked first in both the WSM and DSM, based on the comprehensive weighted value.

Fiber quality of whole seed and seed meal of squash introductions

Both food and animal feed industries require raw material with minimal values of NDF, ADF and lignin, particularly in the case of animal nutrition, where the high digestibility of nutrients in ruminants and monogastric animals that present enzymatic digestive processes is associated with a low NDF and ADF with respect to total fiber content. The RFV assigned to the WSM and DSM in Tab. 5 and 6 assumed that the high RFVs mean that these introductions have a high biological value. Based on the foregoing, the best introductions in terms of RFV for the WSM were 1229, 1200, 1201, 1219 and 1206 (Tab. 5).

Table 5. Relative feed value (RFV) of whole seeds of 19 squash introductions and cultivar Abanico-75 (the latter used as the reference).

Introduction	Neutral detergent fiber (%)	Acid detergent fiber (%)	Dry matter consumption[1] (% liveweight)	Digestible dry matter[2] (%)	RFV[3]	Ranking
1205	25.6	18.46	4.69	74.52	270.78	12
1207	23.16	17.39	5.18	88.76	356.53	7
1202	38.23	27.03	3.14	88.69	215.80	16
1213	22.75	15.46	5.27	88.78	363.01	6
1206	21.94	17.83	5.47	88.76	376.34	5
1229	18.76	11.82	6.40	88.81	440.36	1
1201	20.17	15.75	5.95	88.78	409.44	3
1200	19.92	15.43	6.02	88.78	414.59	2
419	31.31	23.77	3.83	88.71	263.58	13
1210	26.59	17.08	4.51	88.77	310.54	9
932	28.71	22.09	4.18	88.73	287.49	10
1219	21.03	13.53	5.71	88.79	392.77	4
802	39.22	31.5	3.06	88.65	210.27	19
1222	38.45	30.01	3.12	88.67	214.51	18
Abanico-75-S*	29.75	13.74	4.03	78.20	244.51	14
1235	33.58	27.45	3.57	67.52	187.03	20
786	30.59	13.7	3.92	78.23	237.89	15
954	25.16	18.46	4.77	74.52	275.52	11
Abanico-75-F**	22.71	6.64	5.28	83.73	342.96	8
1215	30.59	23.22	3.92	70.81	215.34	17
Mean	27.41	19.01	4.60	84.06	301.46	
LSD 5%	4.23	4.27	0.67	4.75	52.55	
CV %	23.43	34.06	22.37	8.56	26.42	

[1] Estimated as 120 / (% neutral detergent fiber). [2] Estimated as 88.9 – (0.779 x % acid detergent fiber). [3] Estimated as (digestible dry matter x dry matter intake) / 1.29. * Whole seed meal made from the fruit of cultivar Abanico-75 (reference). ** Defatted seed meal made from the fruit of cultivar Abanico-75 (reference).

As indicated above, after the seed oil extraction, the DSM acquired a special biologic value because of its high protein content. However, what determines whether the RFV of the DSM is apt for cattle nutrition is the level of fiber (NDF or ADF). Introductions 1229, 932, 1200, 786 and 954 ranked first for this variable (Tab. 6).

Based on the selected introductions, the recommendation is to identify *C. moschata* parental materials with both a general combining ability and a specific combining ability for EE and CP in the WSM and for a high RFV in both the WSM and DSM (Ortiz *et al.,* 2013).

A crossbreeding process should be carried out with *C. sororia* introductions 1202 and 954 to obtain superior F_2 segregants for oleaginous and protein grain (Ortiz *et al.* 2013).

CONCLUSIONS

The squash WSM and the DSM meal derived thereof presented a high nutritional value with the potential to replace protein and oleaginous grains in ruminant feed.

Of the introductions submitted to proximate analysis to determine nutritional value, 10% of the *C. sororia* introductions (954 and 1215) and 26% of the *C. moschata* introductions (786, 1200, 1219, 1229 and 1235) ranked high in terms of quality.

Based on the RFV, introductions 1229, 1200, 1201, 1219 and 1206 were selected for the WSM, and 1206, 1229, 932, 1200, 786 and 954 were selected for the DSM.

In the case of *C. moschata* introductions 1200, 1201, 1206, 1213, 1219 and 1229, parents with both general

Table 6. Relative feed value (RFV) of defatted seed meal made from 19 squash introductions and cultivar Abanico-75 (the latter used as the reference).

Introduction	NDF (%)	ADF (%)	Dry matter consumption[1] (% liveweight)	DDM[2] (%)	RFV[3]	Ranking
1205	18.95	17.72	6.33	75.10	368.64	11
1207	22.46	13.99	5.34	78.00	323.06	18
1202	35.25	25.26	3.40	69.22	182.68	20
1213	20.7	10.53	5.80	80.70	362.64	12
1206	19.68	15.67	6.10	76.69	362.51	13
1229	13.58	8.38	8.84	82.37	564.25	2
1201	19.97	10.85	6.01	80.45	374.74	9
1200	17.16	9.73	6.99	81.32	440.83	4
419	21.36	12.6	5.62	79.08	344.42	15
1210	20.51	16.35	5.85	76.16	345.44	14
932	16.21	10.23	7.40	80.93	464.43	3
1219	20.1	7.37	5.97	83.16	384.86	7
802	29.26	14.9	4.10	77.29	245.73	19
1222	21.86	13.01	5.49	78.77	335.18	16
Abanico-75-S*	19.55	11.87	6.14	79.65	379.01	8
1235	19.69	12.46	6.09	79.19	374.14	10
786	16.84	19.29	7.13	73.87	408.07	5
954	18.78	10.51	6.39	80.71	399.80	6
Abanico-75-F**	12.33	5.4	9.73	84.69	638.97	1
1215	22.59	13.13	5.31	78.67	323.96	17
Mean	20.34	12.96	6.20	78.80	381.16	
LSD 5%	3.28	2.96	0.92	2.30	64.49	
CV %	24.45	34.63	22.63	4.43	25.65	

[1] Estimated as 120 / (% neutral detergent fiber). [2] Estimated as 88.9 - (0.779 x % acid detergent fiber).

[3] Estimated as (digestible dry matter x dry matter intake) / 1.29. * Whole seed meal made from the fruit of cultivar Abanico-75 (reference). ** Defatted seed meal made from the fruit of cultivar Abanico-75 (reference). NDF, neutral detergent fiber. ADF, acid detergent fiber. DDM, Digestible dry matter.

and specific combining abilities for oil and CP contents in the WSM and for high RFV in both the WSM and DSM should be identified.

A crossbreeding process should be carried out with *C. sororia* introductions 1202 and 954 to obtain F_2 segregants for seeds with a high oil value in the WSM, as well as for a high RFV in the DSM.

Conflict of interests: this manuscript was prepared and reviewed with the participation of al authors, who declare that there exists no conflict of interest that puts at risk the validity of the presented results.

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