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RESEARCH ARTICLE

Effect of canning on the canning attributes and proximate composition of Bruchid Resistant, Maz-type common bean Lines

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Abstract: Screening of bean lines for canning attributes and proximate composition is an important input for the food industry, bean researchers, and other end users. The objective of this study was to evaluate Maz-Lines common beans for their canning quality and proximate composition. Three Maz-type common bean lines were subjected to nine different canning treatments. Canning attributes and proximate composition of those maz-type canned common beans were evaluated using standard official methods. The result showed that maz-type common bean lines and the canning process significantly affected canning attributes. Consequently, the percentage of washed-drained weight ranged from 64.80 to 73.17% and 67.23 to 70.97% due to the effects of different canning treatments and maz-common bean lines, respectively. The result indicated the hydration coefficient varied from 1.03 to 1.05. The degree of clumping, appearance, splitting degree, and starchiness were also determined by the visual rating procedure. The result of those visual ratings of all three Maz-type common beans revealed promising canning quality traits. Good canning quality was obtained in a sample soaked for 40 minutes at ambient temperature, followed by blanching for 40 minutes at 75 oc. The canning process caused an increase in crude protein, crude fat, total carbohydrate, and energy values in canned beans. However, the moisture and crude fiber contents of canned beans decreased as a result of varied canning treatments. It can be concluded that canning attributes and some proximate composition of the Maz-type common bean line were improved by the canning process.
Keywords: Blanching, Canning, Soaking, Protein, hydration coefficient.

INTRODUCTION

Common beans are the most important gluten free food ingredients used in many food products and rich source of protein, amino acids, carbohydrates, dietary fiber, vitamins and anti-oxidants (Kan *et al*., 2018; Carbas *et al*., 2020). It also contains some anti-nutrients that affect nutrient digestibility and bio accessibility in human body (Wang *et al*., 2010; Kumar *et al*., 2022). In contrast, those anti-nutritional compounds have a role in preventing coronary heart disease, diabetes, digestive tract disease, cancer and obesity (Barman *et al*., 2018). Each bean type has also unique minor chemical profiles and affects their functional food outcomes. Some common beans type contains non- nutritive proteins that displays insecticidal properties against bean bruchids.

Bruchids are small beetle and major post-harvest pest of stored legumes that can caused significant post-harvest losses (Castro *et al*., 2013). Maz-type common beans have remarkable Bruchids resistant properties and have been used as breeding materials to generate multipurpose common beans. Those beans type is might be used for income generation and human consumption.

Common beans must be processed prior to consumption. Canning is among conventional food processing and preserving method in which the food product is sterilized by heat after placed in hermetically sealed containers (De Lima Sampaio *et al*., 2022). This process includes soaking, blanching and autoclave cooking operation. These unit operations have contribution to some improvements in nutritional profile, enhance flavors to beans, reduce heat-labile anti-nutrients, and elongate storage life of canned beans. Various common beans with outstanding grain yields and agronomic performance have been identified as Bruchid-resistant lines through the low land pulse breeding program at Melkassa Agricultural Research Center (Tigist *et al*., 2018). In addition, many maz-type bean lines were developed for canning purposes; however, their canning attributes and proximate composition were not investigated after canning. Therefore, the objective of this study was to evaluate the canning attributes and proximate composition of Maz-type canned common beans.

MATERIALS AND METHODS

SAMPLE COLLECTION AND PREPARATION

Common beans of MAZ types, a total of 5 lines were collected from melkassa agricultural research center and transported to food science and nutrition research laboratory. The sample was cleaned, washed, and sorted manually to remove all extraneous materials. Then, the cleaned all maz-type common beans were subjected to the same steps of canning procedure for screening based on the canning attributes. Consequently, three lines with best canning attributes of Maz-type of common beans were selected from 5 Lines based on preliminary screening trial. The selected three maz-lines were tested under different canning steps as shown in Table 1 and evaluated for their proximate composition and canning attributes. The proximate composition of raw maz- lines were evaluated and used for comparison

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Table1: Treatment combination of an experiment

Treatments	Soaking and blanching time in minutes	Blanching temperature in °C	Thermal processing (temperature °C *time in minutes)
1	20	60	121*30
2	20	75	121*30
3	20	88	121*30
4	30	60	121*30
5	30	75	121*30
6	30	88	121*30
7	40	60	121*30
8	40	75	121*30
9	40	88	121*30

CANNING PROCEDURE

Seed samples of MAZ-type common bean lines were hand cleaned and sorted manually to remove the under sized and broken seeds. The cleaned and sorted seed samples of each bean lines were stored in separate airtight containers until analyzed for their physico-chemical and canning attributes. Cleaned seed samples were subjected to the modified laboratory canning procedure described by (Balasubramanian, 1998). About 96 g of Maz- type common beans were weighed in clean plate and transferred to mesh bags. Those weighted seeds were soaked in distilled water (1:3 gram to millilitre(mL)) for different time at room temperature.

Then, blanched for above set time and temperature combination in water containing 10 mg Ca2+ kg–1 (10 ppm), as calcium chloride dihydrate. The seed samples in the bag were cooled in cold water, drained and weighed. The weight gained by imbibitions during soaking was used to calculate the hydration coefficient. Weighed, the seed sample from each mesh bag was transferred to bottle cans. The cans were filled with brine (prepared using deionized water with a calcium level the same as that of used during soaking and blanching) containing 1.3% (wt/vol) NaCl and 1.6% (wt/vol) sugar, sealed, and cooked in retort autoclave using steam at 121°C for 30 minutes and then cooled in water at 20°C for 20 minutes.

PHYSICAL AND CANNING ATTRIBUTES EVALUATION

Seed weight : Weigh 100 randomly selected dry seeds using electronic balance. Seed Size: seed size was measured using calliper. cooking time was determined using matson cooking techniques, Hydration coefficient (HC) was obtained by dividing the weight of soaked bean seeds to the weight of dry bean seeds. Washed drained weight (WDWT) was the weight of rinsed bean seeds drained for five minutes on a 8-mesh screen (Tyler series) positioned at a 15° angle. Percentage washed drained weight (PWDWT) was equivalent to washed drained weight *100/ Weight of can contents

Canning attributes: Attributes like degree of clumping, appearance, splitting degree and starchiness were evaluated based visual observation rate for canned beans. Three-point scale were used for Degree of clumping (1 = beans clumped solidly in the bottom of the can; 2 = beans clumped, but easily decanted; and 3 = no clumping).

Five point scale were used for appearance (1 = seeds blown apart, free seed coats present; 2 = seeds split badly, but holding together and no free seed coats; 3 = 60–69% of seeds intact and no free seed coats; 4 = 70–89% of seeds intact and no free seed coats; and 5 = 90% of seeds intact and no free seed coats). Splitting degree were evaluated based on ten rating scale (0 = splitted Extremely, 1 = splitted very much, 2 = splitted moderately, 3 = splitted slightly, 4 = Either splitted or completely unsplitted 5 = neither splitted nor unsplitted, 6 = unsplitted slightly, 7 = unsplitted moderately, 8 = unsplitted very much, 9 = completely unsplitted). Five point hedonic scale was used for evaluating starchiness/viscosity of canned beans (1 = Very clear, 2 = moderately clear, 3 = slightly clear, 4 = moderately cloudy, 5 = Extremely Cloudy)

PROXIMATE COMPOSITION

Proximate compositions of raw and canned maz-type common beans were determined using official methods. Moisture content, ash value and crude fat were determined according to the method of AOAC, (2005) while Crude protein and fiber were determined according to the procedure described by AOAC, (2000). Total carbohydrate content was estimated by subtracting the sum of percentages of moisture, crude fat, crude protein and ash contents from 100 (Joshi *et al.*, 2015) . Total Carbohydrate(%) = 100 -(Moisture (%) + Crude Protein (%) + Crude Fat (%) + Ash (%)) .Energy value was calculated from crude fat, crude protein and carbohydrate contents using At water's conversation factors; 16.7 kJ/g (4 kcal/g) for protein,37.4 kJ/g (9 kcal/g) for Fat and 16.7 kJ/g (4 kcal/g) for carbohydrates (Guyot *et al.*, 2007). 1kJ/100g = 4.18 kcal/100g.

STATISTICAL DATA ANALYSIS

The collected data was analyzed using SAS Statistical software and subjected to two way analysis of variance (ANOVA). The critical difference at $P < 0.05$ was estimated and used to find the significant difference. Least significant difference (LSD) test was used to separate the means.

RESULTS AND DISCUSSIONS

Table 2: Effects of main factors (canning and varieties) on PWDWT of MAZ-type common beans

Varieties	Weight of drained sample	Percentage of drained weight
Maz-23	234.14[a]	67.23[b]
Maz-153	231.11[b]	70.97[a]
Maz-200	223.98[c]	67.49[b]
CV	1.21	1.85
LSD	1.51	0.69

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Treatments	ST and BT in minutes	Blanching temperature in °c	Weight of drained sample	Percentage of drained weight
1	20	60	233.74[bc]	73.17[a]
2	20	75	234.70[b]	70.06[c]
3	20	88	239.33[a]	71.32[b]
4	30	60	232.51[bc]	69.94[c]
5	30	75	225.11[d]	68.31[d]
6	30	88	231.59[c]	68.32[d]
7	40	60	222.69[d]	65.58[e]
8	40	75	224.42[d]	65.58[e]
9	40	88	223.58[d]	64.80[e]
CV			1.21	1.85
LSD			2.62	1.20

Note: CV=Coeffient of variation, LSD =Least significant difference, ST= Soaking time, BT= Blanching time, means within same column followed by the same letters are not significantly different; ($P > 0.05$)

Effects of canning process and varieties on percentage of washed drained weight and weight of drained sample were presented in Table 2. Drained weight related to amount of final yield obtained after beans subjected to different canning process and if it records a high drained weight, less amount of beans is needed to fill the can when compared to those having lower drained weight (Varner and Uebersax, 1995). Weight of drained sample of maz-type common bean was statistically varied from the highest value 234.14 for maz-23 followed 231.11 for maz-153 to the least value of 223.98 for maz-200. Canning process brought significant difference for weight of drained sample.

Correspondingly, the highest value 239.33 recorded for maz-type common bean sample soaked for 20 minutes at room temperature and blanched at 88 oc for similar minutes. Washed Drained Weight was negatively correlated with firmness of beans after processing, which means beans genotypes having higher and lower washed drained weight values were softer and harder, respectively (Khanal et al., 2014). The average current results of washed drained weight were in the acceptable range for good canning attributes. On the other hands the highest Percentage of washed drained weight 70.97% were noted for maz-153 regardless of canning process.

Results of percentage of washed drained weight affected by canning process was ranged from 64.80% to 73.17% for maz-type common bean samples autoclaved at 121°C for 30 minutes after soaked at ambient temperature for 40 and 20 minutes followed blanching at a temperature of 88oc and 60 oc under the same minutes of soaking, respectively. The result obtained for percentage of washed drained weight in the present study was higher than that of reported by Vander Merwe et al. (2006); Derese and Shimelis, (2012) for beans canned in tomato sauce. The higher percentage of washed drained weight revealed good swelling capacity of the beans (Hosfield,1991).

The current results of percentage of washed drained weight were greater than 60% which was reported as optimum value for percentage of washed drained weight in canning process (Balasubramanian, 1999). Research finding reported by Balasubramanian et al. (2000) stated that addition of calcium in dry beans during modified laboratory canning process contributed to reduction of percentage washed drained weight.

Table 3: Effects of main factors (canning and varieties) on canning attributes of MAZ-type common beans

Varieties			Degree of clumping	appearance	Splitting degree	Starchness
Maz-23			2.58[a]	3.26[a]	4.78[a]	2.50[b]
Maz-153			2.36[b]	3.32[a]	4.64[a]	2.95[a]
Maz-200			2.31[b]	2.48[b]	3.95[b]	2.87[a]
CV			15.16	11.75	12.30	15.91
LSD			0.20	0.19	0.30	0.24
Treatments	**ST and BT in minutes**	**Blanching temperature in °c**	**Degree of clumping**	**appearance**	**Splitting degree**	**Starchness**
1	20	60	2.37[ab]	2.49[c]	4.49[bcd]	2.97[ab]
2	20	75	2.41[ab]	2.54[c]	3.36[e]	2.79[abc]
3	20	88	2.35[ab]	2.93[b]	4.10[d]	2.67[abc]
4	30	60	2.37[ab]	3.06[b]	4.86[ab]	2.49[c]
5	30	75	2.46[ab]	3.51[a]	4.67[abc]	2.58[bc]
6	30	88	2.28[b]	2.94[b]	4.64[abc]	2.68[abc]
7	40	60	2.42[ab]	2.42[c]	4.22[cd]	2.87[abc]
8	40	75	2.65[a]	3.68[a]	4.71[abc]	3.07[a]
9	40	88	2.44[ab]	3.58[a]	5.09[a]	2.83[abc]
CV			15.16	11.75	12.30	15.91
LSD			0.35	0.34	0.52	0.41

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CV=Coeffient of variation, LSD =Least significant difference, ST= Soaking time, BT= Blanching time, means within same column followed by the same letters are not significantly different; (P > 0.05)

Canning attributes of maz-type common beans were presented in Table 3. Degree of clumping associates with leaching of starches from granules and caused an increment of canned medium viscosity. The result indicated in table 3 reflected that the highest degree of clumping was noted in maz-23 common bean types. Statistically, non-significant p>0.05 was observed for degree of clumping in all sample canned under different canning process. The result of degree of clumping obtained in the present study revealed that all maz-type common beans type used in this experiment were in acceptable degree of clumping.

In similar manner appearance attributes of canned beans recorded in the current study was varied from 2.48 to 3.26 for maz-200 and maz-23, respectively. The values close to one indicated good record for appearance attributes while the values closed to five showed poor in appearance. Thus maz-200 common beans type was preferred in appearance as compared to other types. Good in appearance attributes for canned beans as influenced by canning treatments was recorded for canned maz type common samples soaked for 40 minutes and blanched at 60°C.

Splitting degree (0-9) ranged from 3.95 to 4.78 for bean lines and ranged from 3.36 to 5.09 as affected by canning treatments. starchiness (1-5) varied from 2.50 to 2.95 as influenced by bean lines and ranged from 2.49 to 3.07 due to variation in applied canning procedures. The starchiness values obtained in the present study for all samples were failed in the acceptable level.

Table 4: Physical properties of maz-type beans lines

Varieties	100 seed weight (g)	Seed size (mm)	Cooking time (minutes)	Hydration coefficient
Maz-23	41.85ab	14.07a	31.33a	1.0364b
Maz-153	37.90c	9.873b	29.33a	1.0476a
Maz-200	42.33a	15.39a	28.33a	1.0380b
CV	3.36	5.48	9.06	0.48
LSD	2.55	1.36	3.28	0.0048

CV=Coeffient of variation, LSD =Least significant difference, ST= Soaking time, BT= Blanching time, means within same column followed by the same letters are not significantly different; (P > 0.05)

Physical properties (100 seed weight, cooking time, hydration coefficient and seed size) for all maz-type common beans sample were presented in Table 4. Accordingly, the highest value for 100 seed weight and seed size were recorded in Maz-200 while the lowest values were noted in Maz-153 common beans sample. The cooking time of Maz-type common beans were presented in Table 4. Cooking time of all three Maz-types common beans ranged between 28.33 to 31.33 minutes. Moreover, hydration coefficient (HC) measures the water-uptake during soaking. The values of hydration coefficient for soaked Maz-type common beans were ranged from 1.03 to 1.04 in the present study. The result of hydration coefficient obtained in this study was lower than the hydration coefficient of small white types of beans which varied from 1.73 and 1.81 as reported by Daleen *et al*. (2006) and lower than the considered optimum hydration coefficient (1.8) stated by (Hosfield 1991). To increase the value of hydration coefficient, dry beans could be soaked under extended the soaking time at ambient temperature.

Effects of main factors (canning and varieties) on proximate composition of MAZ-type common beans

Table 5: Effects of main factors (canning and varieties) on proximate composition of MAZ-type common beans

Varieties			Moisture (%)	Ash (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Carbohydrate (%)	Energy (kcal/100g)
Maz-23			7.64b	4.07a	22.23b	8.71a	2.04a	55.30b	328.53b
Maz-153			7.59b	3.80b	22.51b	7.51b	1.57c	56.98a	332.12a
Maz-200			7.86a	3.99a	23.11a	7.81b	1.72b	55.50b	329.91b
CV			3.52	3.62	2.52	10.50	8.84	1.93	1.22
LSD			0.14	0.07	0.29	0.43	0.08	0.56	2.09
Treatments	**ST and BT in minutes**	**Blanching temperature in °c**	**Moisture (%)**	**Ash (%)**	**Crude protein (%)**	**Crude fiber (%)**	**Crude fat (%)**	**Carbohydrate (%)**	**Energy (kcal/100g)**
1	20	60	7.48cd	4.36a	22.27de	9.48a	1.70d	54.70d	323.22e
2	20	75	7.65c	4.09bc	22.96bc	8.39bc	1.72cd	55.21cd	328.19d
3	20	88	7.22e	3.96cd	21.96e	8.20bc	1.97b	56.68ab	332.32bc
4	30	60	7.25de	4.14b	22.28de	8.09c	1.73cd	56.41ab	330.40cd
5	30	75	7.54c	3.94d	22.35de	7.75cd	2.22a	56.19bc	334.16abc
6	30	88	7.56c	3.73e	22.76cd	6.77e	1.86cd	57.34a	337.13a
7	40	60	7.64c	3.78e	23.02bc	7.65cd	1.77cd	56.14bc	332.63bc
8	40	75	7.04e	3.67e	23.89a	7.80cd	1.65d	55.96bc	334.23ab
9	40	88	7.96b	3.72e	23.44ab	7.12de	1.69d	56.07bc	333.20bc
0	Raw		9.64a	4.18b	21.25f	8.88ab	1.44e	54.60d	316.37f
CV			3.52	3.62	2.52	10.50	8.84	1.93	1.22
LSD			0.26	0.14	0.54	0.79	0.15	1.02	3.81

Note: CV=Coefficient of variation, LSD =Least significant difference, ST= Soaking time, BT= Blanching time, Means within same column followed by the same letters are not significantly different; (P > 0.05)

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PROXIMATE COMPOSITION

Proximate composition of MAZ-type common beans was presented in Table 5. Moisture content of maz-type common bean recorded in the current study was below 10 which indicated good for sample shelf stability (Alozie *et al*., 2009; Dabel *et al*., 2016). Moisture content of canned Maz type common bean flour was significantly lower than that of raw Maz type common bean flour. Reduction of moisture content noted in maz-type common bean due to canning process in the present study was in agreement with Afoakwa *et al*. (2006).

Ash value refers to total mineral content present in any given food samples. As can be referred from the Table 5, the total ash content of the maz type common bean ranged from 3.80 to 4.36% for Maz-153 and Maz-23 flour, respectively. In this study the highest total ash content (4.36%) was recorded for canned common bean type while the lowest was recorded in raw maz-type common bean sample (4.18%). The highest total ash value (4.36%) was noted in canned common bean sample canned after soaked at ambient temperature for 20 minutes and blanched at 60^0c for 20 minutes. This might be attributed to the greater leaching of some mineral elements in to soaking water as soaking duration increased (Elmaki *et al*., 2007).

Crude protein varied from 22.23% (Maz-23) to 23.11% (Maz-200) in maz- common bean type. Protein content of the canned Maz- type common bean in the present study was significantly increased comparative to raw Maz -type common bean flour as shown in Table 5. Similar increment of protein content in canned beans was reported by Pedrosa *et al*., (2015) for Spanish common dry beans. Moreover, protein content of Maz type canned bean ranged from 21.96 to 23.89% in the present study. Crude fiber content (8.71%) of Maz-23 was statistically ($P<0.05$), the highest from the remaining.

The result showed in the Table 5 revealed that canning caused significant ($P<0.05$) change in the crude fiber. Consequently, the highest (9.48%) crude fiber recorded in the canned common bean sample soaked at room temperature for 20 minutes followed blanched at 60^0c for 20 minutes while the lowest value (6.77%) noted for the sample canned after blanched at 88^0c for 30 minutes. The result of all most crude fiber content (6.77-9.48%) obtained in the present study was slightly greater than crude fiber content varied between 4.07 to 7.33% reported by Minuye and Bajo, (2021) for various common bean cultivars grown in central rift valley of Ethiopia. This revealed that varietal difference and canning treatments might be contributed to the significant variation of crude fiber contents in maz-type common bean samples.

The highest crude fat value 2.04% was noted for maz-23 common bean type while the lowest value 1.57% recorded in maz-153 common beans type. The result shown in Table 5 revealed that a significant increased ($P <0.05$) in crude fat content was observed in all canned maz-type common beans when compared to raw flour. The highest mean value of crude fat content of maz -type canned common beans flour as affected by canning procedure was 2.22% for sample canned at 121^0c for 30 minutes after soaked for 30 minutes and blanched at 75℃, while the lowest mean value of 1.44% was noted for raw common beans flour.

Carbohydrate content of maz-type common bean varied from 55.30 % for maz- 23 to 56.98% for maz-153. Canning caused increment of carbohydrate from 54.60% of raw maz-type common bean flour to 57.34% for maz-type common bean canned under 121℃ for 30 minutes after soaked at room temperature for 30 minutes and blanched at 88^0c. The results of energy contents for both main factors (Maz lines and canning process) were presented in Table 5 and there were significant differences ($P<0.05$) in energy contents due to Maz lines and canning treatments.
Among maz-type common bean varieties the highest energy value (332.12 kcal/100g) was recorded in maz-153 relative to maz-23 and maz-200. On the other hand energy value of canned common bean type was ranged from 323.22 kcal/100g to 337.13 kcal/100g.The present energy value recorded for canned maz-type common beans was closely related to the energy value reported for defatted soyabean flour by Serrem, (2011). The energy value of maz-type common beans sample was increased due to different canning treatments applied on it. This might contributed from considerable increment of crude protein, crude fat and carbohydrate content in all canned maz- common bean types.

CONCLUSIONS

The results demonstrated that the proximate composition and canning features of maz-type bean samples were significantly influenced by different canning techniques as well as maz-type common bean lines. Maz-type common bean lines exhibit potential canning characteristics. When compared to raw flour, certain of the canned beans' proximate composition, such as their crude protein, crude fat, carbohydrates, and energy value were increased.

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CONFLICTS OF INTEREST

"The authors declare no conflict of interest".