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Breeding Common Bean (*Phaseolus vulgaris* L.) for Canning Quality Traits: A Review

Habtamu Alemu*

Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center, Assosa, Ethiopia

***Corresponding author:** Alemu H, Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center, Assosa, Ethiopia, Tel: +251577752552; E-mail: halemu2017@gmail.com

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Abstract

Common bean or haricot bean (*Phaseolus vulgaris* L.) plays a paramount role in human nutrition and market economies in the world. Common bean is the most important food legume either as a source of protein for local consumption as dry seeds, green pods (as in snap beans), and green-shelled seed and in some tropical areas, bean leaves are cooked eaten like spinach and young leaves used in salads, or as an export crop for generating foreign currency in Ethiopia. This paper has the objective of reviewing the quality parameters for canning quality of common beans and the works done so far on breeding of the common bean for canning quality. Canning quality in dry bean is determined by a complex of traits, such as hydration coefficient (HC), washed drained weight (WDWT), percent washed drained weight (PWDWT – WDWT expressed as percentage by weight of the can contents), texture (TEXT), clumping (CL), appearance (AP), and color of dry seed, processed seed and cooked liquid. Several processing factors like genotype (G), environment (E) and G × E interactions influenced Canning quality traits of common bean. The canning quality in Common bean can be measured by Physico-chemical Properties of the crop, Proximate Composition of Common Bean Seeds, Bioavailability of Micronutrients in bean seeds and Phytochemical Compositions in the seed.

Keywords: Common bean; Canning quality; *Phaseolus vulgaris* L.; Physico-chemical properties; Proximate composition

Introduction

Common bean or haricot bean (*Phaseolus vulgaris* L.) is the most important food legume either as a source of protein for local consumption or as an export crop for generating foreign currency in Ethiopia [1]. This crop was introduced to the northern parts of the country around the 16th century [2]. The common bean plays a paramount role in human nutrition and market economies in the world. World common bean production can be conveniently grouped into twelve regions, the most important of which are Brazil, Mexico and Eastern African highlands. Beans are a major staple in these regions, which together contribute to half of the world's production. Latin America, the center of origin for the common bean is the leading bean producer in the world [3]. *Phaseolus vulgaris* became established as a food crop in Africa before the Colonial era [4].

The common bean is cultivated primarily for its dry seeds, green pods (as in snap beans), and green-shelled seed and in some tropical areas, bean leaves are cooked eaten like spinach and young leaves used in salads. Dried beans that do not meet human food quality standards are used as feed for livestock. Post-harvest plant remains are also used as feed for domesticated animals and Young tender leaves and flowers are also used as fresh vegetables in some Central and Eastern African, and in Latin America countries [5].

Common bean is a major legume crop with significant nutritional importance. It is a major source of calories and protein source in many developing countries throughout the world [6]. Common bean is a rich source of zinc and iron, two micronutrients depleted from individuals with AIDS [7]. Diets containing foods rich in these micronutrients are suggested to benefit the health status of HIV infected patients [6,8]. Common bean also contains a protein that inhibits the HIV-1 reverse transcriptase, these proteins known as Lectin [9]. Collectively, these features support the importance of common bean as one of the many factors that can address the AIDs problem through improved nutrition [10].

Common bean has a wide range of adaptation and its production is very heterogeneous in terms of ecology, cropping system and agronomic performance. It is one of the most important grain legumes grown in the low lands of Ethiopia particularly in the Central Rift Valley of Ethiopia. In these areas, smallholder farmers grow white pea beans for export and food type colored beans for house hold consumption. Ethiopia, endowed with varied agro-ecological zones and diversified natural resources, has been known as the homeland and domestication of several crop plants.

Common beans are important components of crop production in Ethiopia's smallholders' agriculture, providing an economic advantage to smallholder farmers as an alternative source of protein, cash income, and food security. Previously, the aim and goal of Ethiopian agricultural research centers were only to release improved bean varieties in terms of high yield or productivity per hectare, and drought and disease resistance from their plant breeding and crop protection perspectives. Very little was known about the canning quality of common bean varieties. Due to unavailability of canning quality laboratory in Ethiopia, up to now canning analysis is done in South Africa and some genetically potential bean varieties for canning may be copied. This gap did not allow intensive utilization of different common bean varieties as a value-added product efficiently [11].

Canning quality of dry beans can be determined by using various canning quality parameters [12,13]. Analysis of variance proved to be

useful in interpreting the different canning parameters separately but does not indicate the grouping of variates. Canonical variate analysis indicates both the grouping of variates and the most important parameters to discriminate between them [12]. Van Lill et al. used principal component analysis to group the bread baking and yield characteristics of wheat, while canonical variate analysis was used by Osborne et al. to discriminate between quality types in wheat breeding lines [14,15]. Canning quality in dry bean is determined by a complex of traits, viz., hydration coefficient (HC), washed drained weight (WDWT), percent washed drained weight (PWDWT – WDWT expressed as percentage by weight of the can contents), texture (TEXT), clumping (CL), appearance (AP), and color of dry seed, processed seed and cooked liquid. Evaluation of these traits (except PWDWT) was discussed by Hosfield and Uebersax, Canning quality traits are influenced by several processing factors, genotype (G), environment (E) and G × E interactions. Consumers view quality as a function of those attributes they can easily measure: clumping, appearance, flavor, color of the processed seed, and appearance of the brine. These traits have no legal requirement or industry standard. All other traits have either an industry standard (HC and TEXT) or a legal requirement (PWDWT) that should be met within given tolerances or limits [16-18].

Many methods are being used to evaluate the canning quality of common bean. So, the objective of this paper is:

To review those quality parameters for canning quality of common beans and the works done so far on breeding of the common bean for canning quality.

Breeding Common Bean for Canning Quality Traits

Description of the crop

Common bean (*Phaseolus vulgaris* L.), also referred to as dry bean, is an annual leguminous plant that belongs to the genus, *Phaseolus*, with pinnately compound trifoliate large leaves [19]. Cultivated forms are herbaceous annuals, which are determinate or indeterminate in growth habit. On germination, the plant is initially tap-rooted, but adventitious roots emerge soon thereafter, and dominate the tap root which remains 10-15 cm in length [20].

Origin, distribution and genetic diversity: Common bean originated in Latin America where its wild progenitor (*Phaseolus vulgaris*) has a wide distribution ranging from northern Mexico to northwestern Argentina. Large germplasm collections of domesticated and wild forms are located at CIAT, Cali, Colombia and USDA, Pullman, Washington, USA. The reference collection of Phaseolinae is located at the National Botanical Garden, Meise, Belgiumn. Common bean belongs to Native American traditionally grew bean with maize (corn) and squash [21].

Genetic diversity refers to the variation of genes within populations/species, making it possible to develop new breeds of crop plants and allowing species in the wild to adapt to the changing conditions. In crop plants, genetic diversity arises as consequences of interplay of evolutionary forces (mutation, selection and random genetic drift) and the influence of humans through domestication and selection [22].

Morphology and botanical characteristics of the crop: Most beans are herbaceous annuals, although, under tropical conditions, some beans (such as large limas) may behave as short-lived perennials. Seeds are non-endospermic and vary greatly in size and colour from the small black wild type to the large white, brown, red, black or mottled seeds of cultivars, which are 7-16 mm long [23]. The common bean flower has an elongated twisted keel containing the style and ten stamens. Inside the flower the anthers drop pollen on to the style in the evening before it opens. Seeds may be round, elliptical, somewhat flattened or rounded elongate in shape and a rich assortment of coat colours and pattern exists. Common bean shows variation in growth habits from determinate bush to indeterminate, extreme climbing types. The bushy type bean is the most predominant type grown in Africa [24]. The style leaves pollen at the opening of the keel. Cross-pollination is possible if the stigma contacts a pollen-coated bee when it is extended. Otherwise the stigma will be self-pollinated when it retracts and contacts its own pollen at the opening of the keel. Self-pollination is thus the norm in the common bean, and it probably occurs automatically at or before the flower opens in the morning. However, it takes 8-9 hours for the pollen tube to grow and fertilize the ovules, during which time honey bees and bumble bees can visit the flower and cross-pollinate it. Tubes of foreign pollen probably grow faster than the plant's own pollen, so crossing is likely when the plant is cross-pollinated [25].

Canning quality of common bean

Acceptable canning quality in dry bean is required by consumers, processors, and plant breeders, but what constitute "acceptable" can vary with different end users. In cultivars for canning process, seed coat integrity and blanching treatment affect the quality of bean regeneration. Seed coat integrity has an influence on water uptake into dry bean. Damaged seed coats are usually lost when absorption of water and swelling cause the skins to separate from the slower hydrating cotyledons. The thermal process greatly enhances the palatability of the edible dry beans, inactivates toxic factors, and increases the nutritional availability and digestibility of different nutrients [26]. Current research also shows that thermal treatment can reduce heat-labile antinutritional factors and increase the digestibility of protein and amino acid in raw edible beans (*Phaseolus vulgaris* L.), therefore the nutritive value of beans is improved [27].

Measures of canning quality of common bean

Physico-chemical properties: Generally cooking quality is the aggregate of properties perceived as influencing consumer preferences and overall acceptability. Seed coat to the whole seed ratio of common bean varieties ranged from 8.42 to 9.66% [11]. Beninger and Hosfield reported that seed coat to whole seed ratio range from 6.5% to 9.8% for eight common bean varieties. Bassinello et al. on their research work entitled canning quality and common bean preference in Brazil showed that the seed coat to the whole seed ratio for eleven common bean varieties were between 7.87 and 11.29% [28].

Proximate composition of common bean seeds: According to the report of research done by Derese, Moisture content concentration varied from 10.13 to 10.27 [11]. The crude protein varied from 22.15 to 26.97 whereas crude fat varied from 0.56 to 1.65. Crude fiber varied from 4.86 to 7.01. This result indicates that proximate composition varied from variety to variety.

Bioavailability of micronutrients: The mineral content of legumes is generally high, but the bioavailability is poor due to the presence of phytate, which is a main inhibitor of Fe and Zn absorption. The phytate/Fe molar ratio has been used as an indicator of iron bioavailability in beans [29]. Growth depressing effects due to zinc

bioavailability based on PA × (Ca per Zn) molar ratio are severe when the ratio exceeds 3.5 [30].

Phytochemical composition: Phytochemicals can reduce the nutritional values of beans by limiting the digestibility of proteins and carbohydrates (e.g., enzyme inhibitors, lectins and tannins) or by reducing the biological availability of minerals [31]. Derese reported that the phytate composition of the five common bean varieties ranged from 13.51 to 23.76 mg g-1. The highest value of phytate was observed for Awash-1 followed by Argene, Awash Melka, Chercher and Omer, respectively [11].

Canning Quality Evaluation of Common Bean Varieties

Drained weight of common beans relates to "processors yield" [32], as it would require fewer beans with a high washed drained weight to fill a can compared to the case of beans with low washed drained weight. According to the Canadian government regulations for canned beans, the percentage washed drained weight of common beans should be at least 60% [33]. In the Ethiopian context, yet there are no approved quality standards/regulations for quality evaluation of canned common beans and bean-based products. For that reason, the Canadian quality assessment procedure/regulation was used as a benchmark to evaluate the Ethiopian bean-based products. Calcium chloride is used in the canning industries to enhance the firmness of canned vegetables/pulses. In canned beans, the formation of metal-pectin complex may contribute to the toughening of seed coat and the turgidity of cell walls of the cotyledon tissue [34,35]. According to the research finding reported by Balasubramanian et al. addition of calcium reduces the hydration coefficient; percentage washed drained weight and splits during canning [34].

Effect of canning process on the reduction of phytochemicals: Many treatments are convenient to remove or inactivate phytochemicals in legume seeds [31]. Beans are generally soaked and cooked to render the seeds palatable, inactivate heat labile phytochemicals, and permit the digestion and assimilation of protein and starch [36].

The Importance of Canned Bean Product Quality

Dry packaged kidney beans are available for consumers. Canned products from kidney bean, such as refried beans, soups and baked beans, are also common retail forms. Canners are often very particular about specific qualities of the beans. They look for beans with rapid expansion ability, higher drained weight, ease in cooking, and uniformity after the thermal process Organoleptic properties within the final canned products are one of the major quality evaluation standards. However, not all the cultivars are blessed with equally acceptable quality. The problems affecting consumers are often related to the occurrence of bean discoloration, hardness of the beans and breakage of the seed coat after the canning process [37].

Standards for Canned Beans Quality

Generally, the standard for kidney beans canning quality includes two categories. The first category involves USDA's specifications for dried bean grades. Beans are classified by moisture content, broken seeds, uniformity of size, color and status of foreign matter [38,39]. Grade A beans are usually preferred by canners. The second category involves post-canning quality in which several parameters are examined carefully. These parameters include the appearance of the canned beans, consistency of the canned products, and the flavor [39,40]. Seed integrity after canning is one of the specifications used in evaluation. Grade A canned beans are required to be free from defects. These defects are referred to as vegetable material, loose skin, broken and mashed beans and blemished beans [40]. The USDA's consumer guidelines states, a top-quality canned bean should have seed coats without separation or breakage from the cotyledon [41].

Summary and Conclusion

Quality is an inherent characteristic of the produce which is required by the producers, consumers or other stakeholders. Different stakeholders have different quality traits to look for and have different understanding as well as different definition for quality. Common bean can be bred for traits like yield, micronutrient content, canning quality, disease resistance quality, a biotic stress resistance quality and some other quality.

Canning quality of dry beans can be determined by using various canning quality factors such as canning process, seed coat integrity and blanching treatment affect the quality of bean regeneration. Like other quality traits, canning quality traits are influenced by several processing factors, genotype (G), environment (E) and G × E interactions. Consumers view quality as a function of those attributes they can easily measure: clumping, appearance, flavor, color of the processed seed, and appearance of the brine. Canning quality of common bean can be measured by using different techniques including Physico-chemical Properties of bean crop, Proximate Composition of Common Bean Seeds, Bioavailability of Micronutrients and Phytochemical Composition.

References

1. Tefera T (2006) Yield of common bean cultivars under semi-arid conditions in eastern Ethiopia. J Trop Sci 46: 155-159.
2. Shimelis EA, Rakshit SK (2005) Proximate composition and physico-chemical properties of improved dry bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. LWT-Food Science and Technology 38: 331-338.
3. Pachico D (1989) Trends in world common bean production. Bean production problems in the tropics 10: 1.
4. Allen DJ, Dessert M, Trutmann P, Voss J (1989) Common beans in Africa and their constraints. Bean production problems in the tropics. CIAT, Cali, Colombia, pp: 9-31.
5. Broughton WJ, Hernandez G, Blair M, Beebe S, Gepts P, et al. (2003) Beans (Phaseolus spp.) – model food legumes. Plant and Soil 252: 55-128.
6. Fields-Gardner C, Fergusson P (2004) Position of the American Dietetic Association and Dietitians of Canada: nutrition intervention in the care of persons with human immunodeficiency virus infection. J Am Diet Assoc 104: 1425-1441.
7. Buys H, Hendricks M, Eley B, Hussey G (2002) The role of nutrition and micronutrients in pediatric HIV infrection. SADJ 57: 454-456.
8. Kruzich LA, Marquis GS, Carriguiry AL, Wilson CM, Stephensen CB (2004) US youths in the early stages of HIV disease has low intakes of some micronutrients important for optimal immune function. J Am Diet Assoc 104: 1095-1101.
9. Wong JH, Zhang XQ, Wang HX, Ng TB (2006) A mitogenic defensin from white cloud bean (Phaseolus vulgaris). Peptides 27: 2075-2081.
10. Hamid R, Masood A, Wani IH, Rafiq S (2013) Lectins: Proteins with Diverse Applications. J App Pharm Sci 3: S93-S103.
11. Mekonen D, Admasu S (2012) Canning quality evaluation of common bean (Phaseolus vulgaris L.) varieties grown in the central rift valley of Ethiopia. East African Journal of Sciences 6: 65-78.

12. De Lange A, Labuschagne M (2001) Multivariate assessment of canning quality, chemical characteristics and yield of small white canning beans (Phaseolus vulgaris L) in South Africa. J Sci Food Agric 81: 30-35.
13. Van Der Merwe D, Osthoff G, Pretorius AJ (2006) Evaluation and standardization of smallscale canning methods for small white beans (Phaseolus vulgaris L.) canned in tomato sauce. J Sci Food Agric 86: 1115-1124.
14. Van Lili D, Purchase JL, Smith MF, Agenbag GA, De Villiers OT (1995) Multivariate assessment of environmental effects on hard red winter wheat. I. Principal-components analysis of yield and bread-making characteristics. South Afr J Plant Soil 12: 158-163.
15. Osborne BG, Salmon S, Curtis PS (1993) Quality assessment of new wheat varieties. In: Taylor JRN, Randall PG, Viljoen JH (eds.). Selected papers from the ICC International Symposium, CSIR, Pretoria, South Africa.
16. Hosfield GL, Uebersax MA (1980) Variability in physico-chemical properties and nutritional components of tropical and domestic dry bean germplasm. J Amer Soc Hort Sci 105: 246-252.
17. Uebersax MA, Bedford CL (1980) Navy bean processing: Effect of storage and soaking methods on quality of canned beans. Research report 410, Agricultural Experiment Station, Michigan State University, East Lansing, MI.
18. Ghaderi A, Hosfield GL, Adams MW, Uebersax MA (1984) Variability in culinary quality, component interrelationships, and breeding implications in navy and pinto beans. J Am Soc Hortic Sci 109: 85-90.
19. Katungi E, Farrow A, Chianu J, Sperling L, Beebe S (2009) Common bean in Eastern and Southern Africa: a situation and outlook analysis. International Centre for Tropical Agriculture, p: 61.
20. Duke JA (1981) Handbook of Legumes of World Economic Importance. Plenum Press, New York, p: 345.
21. Gepts P, Osborn TC, Rashka K, Bliss FA (1986) Phaseolin-protein variability in wild forms and landraces of the common bean (Phaseolus vulgaris): evidence for multiple centers of domestication. Economic Botany 40: 451-468.
22. Centro Internacional de Agricultura Tropical (CIAT), World Factbook (2011) Uganda country profile. Accessed August 3rd, 2011 from experimental Designs. John Wiley and Sons Inc, New York, 2nd edn.
23. Cobley LS (1976) An introduction to the botany of tropical crops. Longman Group Limited.
24. Buruchara R (2007) Background information on common bean (Phaseolus vulgaris L.).
25. Free JB (1993) Insect pollination of crops. 2nd edn. Academic Press, Harcourt Brace Jovanoich, Publishers. London, San Diego, New York, Boston, Sydney, Tokyo, Toronto, pp: 371-381.
26. Uebersax MA, Reungsakulrach S, Occena, LG (1991) Strategies and procedures for processing dry beans. Food Technol 45: 104-111.
27. Wu W, Williams WP, Kunkel ME, Acton JC, Wardlaw FB, et al. (1994) Thermal effects on in vitro protein quality of red kidney bean (Phaseolus vulgaris L.). J Food Sci 59: 1187-1191.
28. Bassinello PZ, De COliveira MG, De O Da Silva L, Del Peloso MJ, Soares DM (2005) Canning Quality and Common Bean Preference in Brazil. Annual Report-Bean Improvement Cooperative 48: 46.
29. Ariza-Nieto M, Blair MW, Welch RM, Glahn RP (2007) Screening of iron bioavailability patterns in eight bean (Phaseolus vulgaris L.) genotypes using the Caco-2 cell in vitro model. J Agri Food Chem 55: 7950-7956.
30. Fordyce EJ, Forbes RM, Robbins KR, Erdman JW (1987) Phytate × calcium/zinc molar ratios: are they predictive of zinc bioavailability? J Food Sci 52: 440-444.
31. Admassu Shimelis E, Kumar Rakshit S (2005) Antinutritional factors and in vitro protein digestibility of improved haricot bean (Phaseolus vulgaris L.) varieties grown in Ethiopia. International Journal of Food Sciences and Nutrition 56: 377-387.
32. Varner GV, Uebersax MA (1995) Research Report. Michigan Dry Bean Digest 19: 22-23.
33. Balasubramanian P, Slinkard A, Tyler R, Vandenberg A (1999) Genotype and environment effect on canning quality of dry bean grown in Saskatchewan. Can J Plant Sci 79: 335-342.
34. Balasubramanian P, Slinkard A, Tyler R, Vandenberg A (2000) A modified laboratory canning protocol for quality evaluation of dry bean (Phaseolus vulgaris L.). J Sci Food Agri 80: 732-738.
35. Lange AD, Labuschagne M (2000) Multivariate assessment of canning quality, chemical characteristics and yield of small white canning beans (Phaseolus vulgaris L.) in South Africa. J Sci Food Agri 81: 30-35.
36. Deshpande SS, Cheryan M (1983) Changes in phytic acid, tannins, and trypsin inhibitory activity on soaking of dry beans (Phaseolus vulgaris L.). Nutr Rep Int 27: 371-377.
37. Wassimi NN, Hosfield GL, Uebersax MA (1990) Inheritance of physico-chemical seed characters related to culinary quality in dry bean. J Am Soc Horti Sci 115: 492-499.
38. Chambers W (1999) Role of traditional Ag markets: The dry edible bean industry. Agricultural Outlook.
39. Belshe D, Boland M, Daniel S, Obrien D (2001) Economic issues with dry-edible beans.
40. US Department of Agriculture (1976) United States standards for grades of canned dried beans, canned pork and beans, canned baked beans (USDA Publication No. 41-FR-32222, 3rd edn). Washington, DC: US Department of Agriculture.
41. US Agricultural Marketing Service (1994) How to buy canned and frozen vegetables. In USDA, Home and Garden Bulletin (No. 259).