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THE CULINARY TRAITS: COOKING TIME AND CANNING QUALITY OF PULSES

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ABSTRACT
Pulses are one of the most important plant proteins and they contribute to food and nutrition security. Their long cooking time is a major factor that has rendered these pulses underutilized because high amount of energy is required to make them palatable. This report highlights two major culinary qualities (cooking time and canning quality) of some pulses with the aim of identifying their cooking time and canning quality methodology. It presents different reports on the cooking time and canning quality of pulses published from 2005 to 2021 for cooking time and from 1996 to 2021 for canning quality. Nineteen journals were selected for cooking time and canning quality. Google scholar served as main source of data. Key words such as determination of cooking time, and canning quality of pulses were used. This report showed that cooking methods of pulses were mainly sensory analysis, tactile, Mattson cooker, pressure cooker, VIS/NIR spectroscopy, solid loss, glass slide, and hyperspectral imaging. While canning quality parameter identified include: wash drain weight and percentage drain weight, firmness splitting, texture, visual appearance, colour, hydration coefficient, overall acceptance. The report also showed that 5% yellow pea, 5% lentil, 5% dolichos, 33% cowpea, 5% chickpea, 47% common bean were the pulses identified for cooking time. While canning quality is 6%, runner bean, 19% cowpea 75%, common bean 75%. We suggested that breeding should be focused on canning quality and shorter cooking time to enhance the utilization of these pulses. This result therefore provides information for researchers, pulse breeders, producers and agronomists in Nigeria and Africa.

Key words: cooking time, canning quality, legumes

INTRODUCTION
The attention of stake holders across nations, research organizations, the general public, academic institutions and policy makers are being drawn to food and nutrition security that has become part of livelihood as a result of the upturn in global population. The estimate of the global population is about 7 billion (UNICEF, 2020; Shitta *et al.*, 2021); by 2050 however the population is expected to reach 9.3 billion (Ray, 2013; FAO, 2017). In spite of this, upscaling the adoption and use of sustainable crops offer reasonable possibilities in increasing food production in the mist of the rising challenges (Shitta, 2021). Pulses are one of the useful crops for improving the nutritional security worldwide especially in Nigeria. The world edible pulses production is up to 60 Mt (~22 billion USD), while its international trade is close to 7 billion USD (Best, 2013; Elsayed et al., 2018). One importance of pulses over other crops is their sustainability and ability to strive under unfavorable environmental condition. After cereals they are the second highest essential food for humans (Okeke *et al.*, 2008; Singh, 2017, Akah *et al.*, 2021). Pulses are cheap product of plant protein, dietary fibre, minerals, B-vitamins with low fat, ability to reduce cholesterol in the body, and regulate blood glucose as they have low glycemic index (Akah *et al.*, 2021). Hence, they play important role in healthy living as well as food and nutrition security. Examples of pulses of global importance include pigeon pea (*C. cajan*), common bean (*P. vulgaris* L.), faba bean (*V. faba* L.), Chickpea (*C. arietinum* L.), mung bean (*V. aradiata* L.), cowpea and black-eyed pea (*V. unguiculata* L.), and lentil (*L. culinaris* Medik) (FAO, 2016). They are from the family Fabaceae, have nitrogen fixing ability and can be intercropped (Cazzato *et al.*, 2012; Ezeaku *et al.*, 2012; Ntatsi *et al.*, 2018; Maitra and Banerjee, 2020). Irrespective of the economic importance of pulses, their utilization is hampered compared to other crops due to their prolonged preparation or cooking time required for their palatability. This limits their utilization by modern consumers (Hamid *et al.*, 2014; Obasi *et al.*, 2014; Owusu *et al.*, 2018; Angelis *et al.*, 2021; Odogwu *et al.*, 2021) who prefer to save time and energy in their choices of meals. The two principal qualities when selecting pulses for utilization are cooking time and sensory quality but have generally been flouted by breeders to favor other traits like yield and early maturity. The prolonged cooking time of pulses has been associated with a phenomenon well-known as hard-to-cook (HTC) (Cichy *et al.*, 2019) which is caused by high temperature of storage and humidity over a long period of time (Liu and Bourne 1995; Reyes-Moreno *et al.*, 2000). Several factors

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contribute to this defect (HTC) such as size of the seed, degree of ripening, heritable factor and environmental conditions. However environmental factor has greater impact on the storage after harvesting (Coelho *et al*., 2007; Prihayati *et al*., 2011; Schoeninger *et al*., 2014; Mendoza *et al*., 2018; Cichy *et al*., 2019). Long cooking time negatively affects the nutritional quality in addition to the high energy needed leading to their underutilization by consumers (Tuan and Phillips 1992; Ruiz-Ruiz *et al*., 2012).

Diverse processing methods that make pulses easily accessible has been gradually developed by various researchers (Afoakwa *et al*., 2006; Trust, 2012). The traditional and modern food processing technologies has also improved the consumption of the foodstuffs by converting them into ready products with better quality. Ready-to-eat cooked pulses has increased consumption especially in modern society as they are inexpensive and quick to prepare (Pedrosa *et al*., 2015). Pulses are canned by processors as ready to use with longer shelf life thereby increasing demand (Warsame and Kimani, 2014; Singh, 2017). In most developed countries pulses are pre-cooked, packaged and canned. The traditional method of drying may be cheaper however, canning has been proven to reduce the energy needed for cooking, it has increased the nutrient retention, raised the shelf life and reduced the post-harvest storage losses and paved way for the international markets (Amonsou *et al*., 2010; Sasikala *et al*., 2011; Cavalcante *et al*., 2017). Information on the culinary quality (cooking time and canning quality) of pulses would help in the breeding of improved varieties based on cooking time and canning quality thus enhancing the utilization of the crop. Hence this report highlights the culinary quality-cooking time and canning quality of pulses. This work would be relevant to researchers, pulse breeders, producers and agronomist in Nigeria and Africa.

METHODS AND LIMITATIONS

Different reports on the cooking time and canning quality of pulses published from 2005 to 2021 for cooking time and from 1996 to 2021 for canning quality were sourced from online database. Nineteen journals were selected for cooking time while 15 journals were selected for canning quality. The journals selected from online databases focusing on cooking time and canning quality of pulses. Google Scholar served as central source of data. The first key words were "determination of cooking time of pulses", and the second were "canning quality of pulses". The selected articles were then summarized by the authors for the cooking time and canning quality of pulses. Summary was focused on the type of pulse, methods and summary of findings. The results of the report were then organized and used as resources for the summary of the cooking time and canning quality of pulses.

RESULTS AND DISCUSSION

Overall information (References, pulse type or cooking method and summary) obtained from 19 scientific articles are presented in Table 1. Identification of the general data (References, pulse type or canning method and summary) from 15 scientific articles obtained are presented in Table 2.

Cooking Time

Cooking of pulses is the process of hydration and heating (Owusu *et al*., 2018). It makes pulses edible by guaranteeing acceptable sensory properties and it is also an indication of cooking quality which is one of the most important factors responsible for consumer's choice for a particular food (Hamid *et al.*, 2014; Owusu *et al*., 2018). Cooking also deactivates or decreases the anti-nutrient contents in pulses such as trypsin inhibitors and flatulence-causing oligosaccharides, which leads to better nutritional quality (Wang *et al*., 2008). Apart from cooking time, the evaluation of texture is also crucial in the determination of cooking quality and influences consumer acceptance of cooked pulses (Pathak and Kulshrestha, 2017). The following cooking time methodology was identified in this study:

Sensory analysis: This requires mouth feel and can detect parameters of food texture having high sensitivity by sensory panels. Descriptors in a scale of 1-5 were applied such as "cooked," "done," "soft," and "texture" in a scale of 1-5 (Yeung *et al.,* 2009), or observed for the absence of negative descriptors such as "chewiness," "hardness," and "grittiness." (Wood, 2016).

Tactile (forefinger and thumb): This involves boiling seeds in excess water and testing for softness of seeds at intervals (Wood, 2016). Here cooked seeds are usually squeezed between the forefinger and thumb (Wang and Daun, 2005). Cooking time is determined when seeds are soft (Wani and Daun, 2005; Yeung, 2007; Obasi *et al*., 2014; Wani *et al*., 2014; Ngure *et al.,* 2021).

Mattson bean cooker: This is one of the standard methods of determining cooking time in pulses (Shitta *et al*., 2021). Mattson (1946) developed the Mattson cooker which could hold up to100 seeds but was later modified by Jackson and Varratno-Martson to hold up to 25 seeds (Wang and Daun, 2005). The equipment is simple to use, cost-effective, and produces unbiased data unlike other procedures. It necessitates, continuous, attentive-ness of the operator to detect the movement of the plungers in the cooking process. The hollow plunger rests on each seed which is then subjected to boiling water and a timer is started. As seeds soften the plunger penetrates through the seed at the time taken is recorded (Wang and Duan, 2005; Yueng, 2007; Cichy *et al*., 2015; Silvia *et al.,* 2017, Mendoza *et al*., 2018; Cichy *et al*., 2019; Bassett *et al*., 2021; Diaz *et al*., 2021; Wiesinger *et al*., 2021).

Table 1: List of articles published on cooking time of legumes

References	Pulse type	Methods	Summary
Wang and Daun (2005)	Yellow peas, lentils, chickpeas and navy beans	Soaking was for 34 hours. Samples were cooked using Mattson cooker, automated Mattson cooker and tactile texture.	There was significant association between the tactile and Mattson cooker when 80% of the seeds were penetrated using the automated Mattson cooker. The more objective, easier to handle and cost-effective method is the automated Mattson cooker in the determination of cooking times of pulses compared to tactile method.
Adebooye and Singh (2007)	Cowpea	Samples were cooked with moderate amount of water both whole and decortication using glass side method.	Both the decorticated and whole grain of the small variety cooked faster than the big grain variety. Significant losses in tannins, phenolics and phytate content as a result of decortication and cooking were identified. Decortication led to significant losses in mineral nutrients. Cooking has no effect on the mineral content. Arachidic was absent in the decorticated grains both varieties of cowpea.
Mwangwela *et al.* (2007)	Cowpea	A Mattson bean cooker (custom made) as was used to evaluate the cooking time of micronised (41% moisture, 130, 153 and 170°C) and unmicronised cowpea samples.	Micronisation reduced the cooking time significantly. Micronisation of cowpea conditioned in 41% moisture to 170°C however reduced the pasting attributes of the cowpea flour. As a result of these changes, M-170°C cowpea seeds needed a higher cooking time than the other two micronized cowpea samples conditioned under moisture. Therefore, flour from cowpeas treated at M-170°C possessed lower starch functionality.
Yeung (2007)	Cowpea	Samples were Soaked for 16 h. An efficient and cheap method to analyze cooking quality qualities was developed using metal container. Tactile texture and Mattson cooker were also used.	There were significant correlations among cooking properties, but there was no correlation with intact seed size and colour. Genetics and environment significantly affected cooked doneness and tactile texture. Compression force significantly correlated with doneness and tactile texture. There was significant correlation between doneness and tactile texture of the cooking time from the MBC (Mattson bean cooker). The subjective evaluations of the cooked doneness and tactile texture was validation of MBC and texture analyzer. The refractometer used to assess solid loss, saved time and has potential for use in sample evaluations. The rapid cooking method is efficient, repeatable and inexpensive compared to the TA and MBC.
Prihayati *et al.* (2014)	Cowpea	Four different cooking methods were used: cooking with regular pan without prior soaking in water; cooking with regular pan with prior soaking in water; pressure cooking without prior soaking in water; and pressure cooking with prior soaking in water.	Iron and zinc contents of the samples were not affected by cooking. BRS Araceˆ cultivar cooked using regular pan with previous soaking had the best retention of iron. Sample prepared with pressure cooker had the highest zinc retention compared to BRS Xiquexique, BRS Tumucuma- que, and BRS Araceˆ cultivars prepared with the regular panBRS Tumucumaque cultivar cooked in the pressure cooker without previous soaking had the best zinc retention. Cowpea cooked with or without previous soaking in a regular or pressure cooker were success for optimum retention of zinc and iron.
Wani *et al.* (2014)	Kidney bean	Samples were unsoaked and soaked 6 and 12 h. Cooking was carried in a beaker of boiling distilled water pressing between finger and thumb.	There wassignificant difference in composition and colour values. There was also significant difference among cultivars in Seed dimensions sphericity, bulk density, angle of repose and surface area. Master Bean cultivar had better cooking qualities than other cultivars. There were no significant differences in textural properties of cooked samples among the cultivars, to show that they have been cooked to the same level. Cooking time was significantly effective with swelling capacity, fat content and porosity.
Hamid *et al.* (2014)	Cowpea	Cooking time was evaluated using the method of Wani *et al.* (2013).	Both the Red and Black cowpea cultivars had high proteins and carbohydrates content. There were significant differences insurface area, sphericity, angle of repose and bulk density among the two cowpea cultivars. Black cowpea cooked for 29.77 min. shorter than red cowpea with cooking time of 64.67 min.
Obasi *et al.* (2014)	Cowpea	Sample were cooked with a pot of boiling water. Toasted and raw cowpea samples were handled separately (thumb and index fingers).	There was significant reduction in cooking time of brown beans and oloka cowpea upon toasting, while that of IAR48 and IT89KD-288 cowpea varieties were high. There was significant correlation between the amount of water absorbed by cowpea and their cooking time.
Cichy *et al.* (2015)	Dry bean	Soaking was for 12 h, Seeds were cooked using Mattson cooker in boiling distilled water.	There was wide variation in cooking time within dry beans most from Andean. Five of the accessions cooked in < 27 min. across 2 years, with average cooking time of 37 min. There was close phylogenetic relationship among four of the five accessions. Vis/NIR spectroscopy was able to predict cooking time. GWAS identified location on Pv01, Pv03, Pv06, and Pv07 associated with water uptake during soaking and locations on Pv02, Pv03, and Pv06 associated with cooking time.
Silva *et al.* (2017)	Cowpea	Samples were cooked using Mattson cooker	The line PC950409D02E showed shortest cooking time of 9.6 min., and C3Q showed the highest time of 16.6 min. protein content, cooking time and mineral contents are influenced by genotype; the calcium, iron and zinc contents in cowpea were reduced by cooking; after cooking CPCR3F6L17 attained a high grain yield, including protein, iron, potassium, and zinc contents.
Pathak and Kulshrestha (2017)	Kidney beans	Cooking time before and after soaking for a duration of 12 h was determined using pressure cooker and tactile method.	Soaking reduced the total phenols contents and tannins for both small red kidney beans and local cultivar. Significant difference was observed between total phenols and tannins in both the kidney beans. Soaking also reduced the cooking time of both the kidney beans. Size and colour had impact on the anti-nutritional content and cooking time of both the kidney beans.

Buzera *et al.* (2018)	Common beans	Overnight 16 h soaking in distilled water and 0.025N Na_2CO_3, followed by cooking on a hot place in a beaker at 96°C.	Soaking in water and Na_2CO_3 reduced the cooking time but Na_2CO_3 significantly reduced the cooking time than the unsoaked. Namulenga had higher hydration coefficient (HC) and the swelling capacity than HM21_7. Soaked beans in water were lighter as a result of pigment leaching whereas beans soaked in Na_2CO_3 were darker coloured but was effective in reducing cooking. HM21-7 had the harder beans and Namulenga had the softer.
Owusu *et al.* (2018)	Lima beans	Seeds were cooked at 65°C with 550 ml using of distilled water.	There was no significant difference in the cooking time of all 5 lima bean accessions excluding. for BC02. There was no statistical differencewith regard to of water uptake ratio and cooked length-breadth. Hydration index and hydration capacity were not significant save for OMC05 relating to hydration capacity. Also, swelling capacity and swelling showed no significant difference.
Mendoza *et al.* (2018)	Dry bean	Seeds were soaked for 12 h. Cooking was carried out using pin drop Mattson cooking device and cooking time from dry bean samples using the hyperspectral imaging method.	Prediction of soaked bean cooking time was effective. For unsoaked beans the cooking time were less vigorous and accurate. Hyper-spectral imaging technique has the ability to offer a non-destructive, easy, fast, and cheap means for determining the water absorption and cooking time of dry bean. The partial least squares model mainly an independent set of 110 similar dry bean seeds verified the suitability of the method for the prediction of cooking time of soaked beans.
Cichy *et al.* (2019)	Dry bean	Samples were pre-soaked and unsoaked. Cooking time was measured using a Mattson pin drop.	Cooking times of the 14 presoaked dry bean genotypes was 16-156 min. (mean, 86 min) across the 15 production environments. The 14 unsoaked dry bean genotypes had cooking time of 77-381 min. (mean, 113 min). There was high heritability for the pre-soaked cooking time and moderately. The heritability of the presoaked cooking time was very high and relatively high for the unsoaked cooking time. There was stability on the genotypic cooking time across environments. Positive correlations existed amongst soaked and pre-soaked cooking times. When pre-soaked, two of the shortest cooking genotypes also cooked fast when unsoaked, Cebo, G1, yellow bean and G4, Cranberry, G23086, bean.
Diaz *et al.* (2021)	Common bean	Soaking in water was for 12 h. Samples were cooked using Mattson cooker. Mattson cooker was modified to become partially automated using an embedded system for obtained data from individual seed.	Cooking time was associated with seed coat colour, the white-coloured bean had the shortest cooking time. Ten QTL were identified. There was an inverse correlation of cooking time and WAC and a QTL on Pv03 controlling cooking time inversely and WAC (CKT3.2/WAC3.1) in populations with Andean origin. WAC7.1 was present in both Mesoamerican germplasm. There was variation in GP accuracies for CKT ranging from good results for the MAGIC panel to lower accuracies in the MIP ppopulations.
Wiesinger *et al.* (2021)	Pinto beans	Sample were not soaked cooking was carried using Mattson pin drop cooking device.	SD pinto beans cooked faster and provided more bioavailable iron compared RD pinto beans. There was no correlation between iron bioavailability, iron and phytate concentrations among the pinto beans. Pinto beans, however, was correlated with procyanidin concentrations and cooking times, and improved iron bioavailability.
Ngure *et al.* (2021)	Dolichos	Cooking was in Saucepans. Heating system used was charcoal. Seed were pressed with fingers.	Cooking time and sensory attributes showed significant difference between the six newly developed genotypes and the two checks. Seeds were cooked between 87 to 159 min, with M5 genotype having the shortest time (87 min) and the local variety with the longest cookingtime (159 min). G2, G1, B1, and M5 genotypes were highly rated in overall acceptability, due of their short cooking time and acceptable organoleptic characteristics.
Bassett *et al.* (2021)	Dry bean	Seeds were soaked and cooked with Mattson cooker.	Cooking time was between 19-34 min. and high broad-sense heritability was observed. There were significant differences among RILs in Sensory traits intensities, broad-sense heritability was however low, while the highest was observed in beany and total flavor. Linkage map of 870 single SNPs markers across 11 chromosomes developed for (QTL) mappingshowed QTL for water uptake (3), cooking time (6), colour (13), sensory features intensities (28), seed-coat postharvest non-darkening (1), seed yield (2) and seed weight (5), identified from data across 2 years. Co-localization was observed for starchy, sweet, and seed-coat perception on Pv01; for total flavor, beany, earthy, starchy, sweet, bitter, seed-coat perception, cotyledon texture, and colour on Pv03; water uptake and colour on Pv04; total flavor, vegetative, sweet, and cotyledon texture on Pv07; cooking time, starchy, sweet, and colour on Pv08; and water uptake, cooking time, total flavor, beany, starchy, bitter, seed-coat perception, cotyledon texture, colour, and seed-coat postharvest non-darkening on Pv10.

Pressure cooker: In recent times researchers have been improvising cheaper and easier methods of cooking time determination. One of these methods is the use of pressure cooker (Pathak and Kulshrestha, 2017). This method would serve in Nigeria and other parts of Africa where the Mattson cooker is not readily available. Pathak and Kulshrestha (2017) evaluated 100 seeds of each sample with 300 ml water using pressure cooker (Hawkins). Cooking time were recorded as steams were observed from the vent. Using the tactile method, softness and percentage of cooked samples were counted.

Table 2: List of articles on the canning quality of legumes

References	Legume type	Methods	Summary
Chang *et al.* (1996)	Navy bean	Canned bean properties, such as drained weight, clumping, splitting, overall appearance, colour, firmness, and viscosity of canned bean liquid were determined according to Lu and Chang (1996).	There was significant correlation of pasting viscosity of navy bean flour with washed drained weight and firmness of canned beans. There was significant correlation between the extract viscosity of the bean flour with a pH 10 sodium carbonate buffer with washed drained weight, firmness, split, viscosity of canned bean medium, and overall acceptance. Correlation also existed between RVA pasting viscosity and pH 10 buffer extract viscosity. These physical tests are simple, fast, and economical.
Taiwo *et al.* (1997)	Cowpea	Samples were subjected to different treatments, soaking and unsoaked. Tomato sauce was added to the pre-treated seeds in medium can sizes and processed at 120.6°C for different sterilization times of 30, 45, 60 and 75 min.	The medium can size needed a longer process time to reach the retort temperature than the small can size. The lethal effect of sterilizing at 120.6°C showed a lower D-value, higher sterilizing value (F_0), and higher safety ratio (a/b) than at 114.5°C. The final F_0 at the end of processing was higher than the targeted F_0 (11 min) from the 5D value, which suggests that the processing time is suitable for safe food production. Semi-dry processed cowpeas had high consumer acceptance than dry seeds, and acceptable canning qualities like those of the imported baked beans.
Loggerenberg (2004)	White beans	Three canning techniques were used, viz laboratory canning-(LCT), industrial canning - (ICT) and modified canning technique (MCT). For the LCT, samples were blanched; tomato sauce of 876 g tomato puree, 246 g white sugar, 118 g brown sugar, 65 g salt and 325 g water (distilled water supplemented with 10 ppm $CaCl_2.2H_2O$) were added and sealed with a Dixie Automatic Can Sealer. This was heat sterilized in a Huxley vertical autoclave at 121.1°C for 50 min. Distilled water with added calcium chloride dihydrate was used both for blanching and in the canning medium. For the ICT, samples were soaked. Distilled water with the same levels of $CaCl_2.2H_2O$ was used as in LCT, After blanching, $CaCl_2.2H_2O$ and tomato sauce were added. Each can was filled with 210 *g* blanched beans and 200 *g* tomato sauce, and sealed. The sealed cans were heat sterilized in a vertical autoclave at 127 °C for 32 min. For the MCT Samples were soaked and blanched. The soaked and blanched beans were transferred to cans filled to a mass of 410 *g* with tomato sauce and sealed as in LCT. The sealed cans were heat sterilized in a vertical autoclave at 121.1°C for 30 min.	LCT and MCT evaluation procedures, HC, percentage washed drained weight, visual appearance, splits, texture, size, clumping, L-values, aL-values and bL-values were identified as suitable canning parameters for small scale evaluation of beans. Beans canned with the MCT were also canned and evaluated industrially and results compared. Canonical variate analysis indicated the same groupings for cultivars according to choose and standard grade canning quality for LCT and ICT beans. LCT evaluation could be used in the evaluation of the canning quality of beans intended for industrial canning. Cultivars with acceptable and unacceptable canning quality were identified using laboratory evaluation and CVA. The CVA for environments identified differences in the canning quality of beans from different regions, while also indicating seasonal differences. The CVA and the model identified the same entries from breeding trials over localities which were not significantly different from Teebus in canning quality, but were unable to group cultivars statistically correct according to choose grade. The model was however capable of grouping standard and choice grade cultivars separately.
Afoakwa *et al.* (2006)	Cowpea	Central Composite Rotatable Design (CCRD) and Response Surface Methodology (RSM). Cowpea was treated with $(NaPO3)_6$. Concentrations of 0%, 0.2%, 0.5%, 0.8% and 1%, then soaked in the $(NaPO3)_6$solution respectively for 0, 5, 12, 19 and 20 h. Blanching was done at 0, 2, 5, 8 and 10 min. The samples were then processed in a vertical retort for 20 min at 121°C.	Soaking time, blanching time and salt concentration had significant effect on most of the quality indices of the canned cowpeas. Increasing salt concentration had a significant effect on the physical characteristics on the cowpea variety. The optimal pre-processing conditions required to achieve the optimum quality of the newly developed cowpea were blanching time of 5.
Wright and Kelly (2011)	Black bean	Canning was done according to the modified methods of (Hosfield *et al.* 1984) and evaluated for canned bean quality.	The linkage map spanned 15 linkage groups (LG) or 4600 cm of the bean genome. Four QTL for yield and colour retention in four environments were identified by composite interval mapping on six linkage groups. QTL $SY10.2^{J115}$ for seed yield was identified on LG B10 with other QTL on B3, B5, and B11. Colour retention was linked to loci on B1, B3, B5, B8, and B11. 115M had positive alleles for yield, but negative alleles for colour retention. Other QTL for agronomic and canning quality traits were detected.

Thapa (2012)	Red kidney beans or common bean	Soaking, blanching and canning, and brine. The cans were sealed in Dixie automatic can sealer (Dixie Canner Co, Athens, GA, USA).	Phytic acid and tannins in dark red kidney beans ranged from 12.37 to 23.60 mg g^{-1} and from 0.11 to 28.78 mg g^{-1}. Out of 12 different treatment conditions used in canning process of beans, the 12 h tempering-soaking-blanching-canning process was the most effective in reducing phytic acid and tannins. The percentage split of beans obtained from the tempered canned beans was lower than the commercially soaked and processed canned beans.
Gathu *et al.* (2012)	Common bean	Parameters involves seed size, water uptake bulk density leaching characteristics.	Results showed the eight new advanced drought tolerant variety of dry bean are suitable for use in canning process.
Teshome and Emire (2012)	Common bean	Soaking, blanching, addition of brine and canning. Three different canning mediums; brine solution, brine solution together with about 10 mg kg^{-1} of calcium chloride and tomato sauce were used. The cans were retorted by Dixons instruments autoclave (model ST18, 2005, England).	In the three canning mediums, there were significant differences in their canning quality traits. Percentage washed drained weight were in the ranges of 55.05-62.66, 53.44-60.78, 51.34-56.77 for beans canned in brine, brine with 10 mg kg^{-1} CaCl2 and tomato sauce, respectively. The optimum HC value for all common bean varieties was 1.8. Awash-1, Awash Melka and Argene bean varieties has promising potentials for canning, and have the ability to be used as a raw material for the bean canning industry. However, Chercher and Omer bean varieties were not good enough for canning purpose.
Rocha-Guzman *et al.* (2013)	Common bean	Samples were soaked for 1 hour and blanched. Thermal processing was by sterilization (canning), and open pan cooking.	The crude (raw) Mexican common bean cultivars had highest polyphenolic content and antioxidant activity. The most suitable cultivar for canning process was Bayo Victoria due to higher values for integrity, total phenolic content and antioxidant capacity measured by the DPPH method after the canning process. Black beans had highest antioxidant capacity for open pan cooking.
Pedrosa *et al.* (2015)	Spanish common dry beans	Seeds were soaked in decalcified water for 12-14 h and 16-18 h, respectively and blanched. Then the seeds were canned and cooked at 116° C for 42 min, salt (16.00 *g* L^{-1}) and ascorbic acid (1.50 *g* L^{-1}) were added to the canning liquid. Cans were introduced in a vertical retort.	The main difference in the raw beans corresponded to the lectin: a higher content was found in raw Curruquilla beans compared with raw Almonga beans. Industrial canning significantly increased the protein and dietary fibre contents of both bean varieties. The minerals, total α-galactosides and inositol phosphates contents however were reduced in both canned seeds. The trypsin inhibitors content was almost eliminated by canning, there was no lectins in any of the canned samples. There was a decrease in antioxidant activity in canned Curruquilla. They showed adequate nutritive profiles. They also had bioactive components content that are appropriate for creating a healthy lifestyle.
Mendoza *et al.* (2017)	Black bean	Samples were soaked in distilled water with 0.03% CaCl for 1 h and canned withbrine of 1.5% sucrose, 1.2% NaCl, and 0.03% CaCl., sealed, and cooked in a for 45 min at 116°C and 10.40 × 10^4 Pa (15 psi). A laboratory Vis/NIR spectrophotometer was used to acquire reflectance spectra from intact dry beans in the range of 400-2,498 nm.	Result showed VIS/NIRS and HYPERS have the potential in predicting texture of canned beans using intact dry seeds. Results using the combination of the three-season data sets based on the two-band ratios showed that VIS/NIRS models were consistently effective in predicting texture over a wide range of measurements.
Njau (2016)	Runner *Phaseolus coccineus* L.), and snap bean (*Phaseolus vulgaris* L.)	Soaking, blanching cans (73 × 110 mm); then hot brine (90°C) with concentration of 1.9% NaCl and sealed with 185 automatic can sealers. The seed cans were heat-sterilized in an automatic retort.	Canning quality tests showed that 35 grain type runner bean lines met the industrial canning standards. The best performers at Kabete were KAB-RB13-327-92/1, KAB-RB13-326-207/1B and KAB-RB13-326-207/1B. The best performers among lines grown at Ol-Joro-Orok lines were KAB-RB13-471-117/1, SUB-OL-RB13-275-248/3 and KAB-RB13-310-161/5. The KAB-RB13-338-41/1 had the highest proportion of clumps (3). The reference variety had low PWDWT and brine pH before and after incubation. Twenty snap bean lines met the industrial canning standards. Among the best performers were KSB22-147-2M/1, KSB22-147-2M/2 and KSB52-2M. The reference variety, Julia had low HC of 1.10 and high fiber content (20%).
Moutaleb *et al.* (2019)	Cowpea	Samples were soaked in sodium hexametaphosphate solution concentration (0%, 0.25%, 0.5% and 0.84% (w/v)) respectively for 8, 10, 12 and 13 h. Cowpeas were blanched for 5, 7, 10 and 13 min. The samples were processed in the autoclave under different time (15, 17, 20 and 23 min) and temperature (106, 110, 112, 115 and 118°C).	Response surface methodology has the potential to optimize the pre-processing and processing conditions of TN 5-78 cowpea. The data analysis showed that factors considered in have a significant effect on the most qualitative parameters of the product. The optimum conditions obtained led to an end product with the acceptable quality parameters that were cooking time of 12 hours, salt concentration of 0.5%, blanching time of 5 min, processing temperature of 110°C and cooking time of 15 min.

Gelete *et al.* (2021)	Common bean Cooking time was conducted objectively using automated Mattson bean cooker apparatus	Samples were soaked for 30 min. and blanched for 30 min at 88°C. Tin cans were filled with soaked and blanched samples and boiling brine (15.60 *g* sucrose and 12.40 *g* salt 1.00 kg^{-1} of tap water). The tin cans were then sealed using automatic can seamer and cooked in horizontal automatic retort for 1 h at 120°C and 10.40 × 10^4 Pa.	All the tested genotypes had better canning and cook quality except for HC of canned beans, soaked for 30 min., and blanched for 30 min. at 88°C, which varied from 1.32 to 1.62. Strong considerable impact of genotype-by-environment interaction on bean canning properties was observed, indicating that genotypes reacted differently to the variable test sites. Geno-types were genetically different for all of the quality traits varied from 42.30 to 57.40 min. for cooking time and 260.40-278.60 *g* for washed drained weight. Percent washed drained weight of all the tested genotypes was > 60%, as required by processors. The HC was below the desired optimum level of 1.80, from moderate to no clumping, and from moderately clear to clear brine were observed for canned beans. Generally, the newly developed genotypes had better canning and cooking quality except for HC. However, GEI exerted considerable effect on the quality traits especially cooking time. The interaction effect shared nearly three times greater effect than genotype and environment; hence highly determined the cooking time (Gelete *et al.*, 2021).
Minuye and Bajo (2021)	Common bean	Soaking was for 30 min., blanching was for 30 mins., brine of $CaCl_2$ solution.	There were significant differences in their physical parameters, proximate composition, mineral content, canning qualities, and phytate values. Some of the common bean varieties however showed high protein, fiber, micro, and macronutrient contents and has a better canning quality than others. PAN-182, Awash-2, G-4445, G-2816, Batu, and Roba has a better nutritional value.

Glass slides: This method involves a combination of tactile and ungelatinized core method of evaluation of cooking time used mostly for dhal. This is done by squeezing a dhal between two glass slides at regular intervals while cooking (Adebooye and Singh, 2007).

Solids loss: This is the quantity of soluble materials that are leached in to the boiling water during cooking. To measure solid loss, cooking broth are evaporated to dryness in an air oven. New method involves the use of refractometer (Yeung, 2007; Wood, 2016). Longer cooking times may result to more solid loss (Hentges *et al*., 1991; Black *et al*., 1998). This method however is not highly adopted.

VIS/NIR spectroscopy: A new model of cooking time and quality characteristics prediction in beans depending on their chemical composition exists which is an automated nondestructive VIS/NIR spectroscopy. This method has been used by Cichy *et al*. (2015) to predict the cooking time from scans of intact raw samples. The calibration explained 68% of the phenotypic variation in cooking time using a Mattson cooker across the market classes (Wood, 2016). The seed coat of pulse has a phenolic compound called anthocyanin which is associated with their cooking time. The 520 nm spectral band is in the visible range (i.e., colour related) and is commonly used to detect anthocyanin content (Welch *et al*., 2008). Similarly, Mendoza *et al*. (2018) results showed that the texture and hardness of canned black beans can be predicted from intact dry seeds by using VIS/NIR spectroscopy. Since the end-use texture quality of dry beans is directly related to their hydration and cooking properties, these sensing technologies could help predict the cooking time properties of different bean seed genotypes, thus rapidly increasing the efficiency of screening.

Hyperspectral imaging: This is a more advanced method applied by Mendoza *et al*. (2018). Hyper-spectral imaging detects spectral signals in a series of continuous channels with a narrow spectral bandwidth; therefore, it can capture fine-scale spectral features of targets that otherwise could be comprom hyperspectral images with hundreds of bands can capture more detailed spectral responses. Reflectance images of dry bean samples were acquired for the wavelength range of 400 to 1000 nm. In a study by Mendoza *et al*. (2018), hyperspectral images were taken from whole dry seeds, and partial least squares regression models based on the extracted hyperspectral image features were developed to predict water uptake and cooking time of soaked and unsoaked beans. This study demonstrated that hyperspectral imaging technology has potential for providing a nondestructive, simple, fast, and econo-mical means for estimating the water uptake and cooking time of dry bean (Mendoza *et al*., 2018).

From the chart, the pulses identified for cooking time analysis include common bean, cowpea, chickpea, lentil, yellow peas and Dolichos (Figure 1). Common bean has received more research attention based on cooking time followed by cowpea.

Canning Process

Canning is the heat sterilization process in which product is placed in hermetic container, heated at sufficiently high temperature for an ample length of time to destroy all microbial and enzyme activity (Loggerenberg, 2004). Properly sealed and heated canned foods are expected to be stable and indefinitely unspoiled in the absence of refrigeration. The sealing step is critical and heat is applied under pressure for a specific temperature-time combination. The latter is determined by the type of food, pH, container size and consistency or bulkiness of the food, but heating

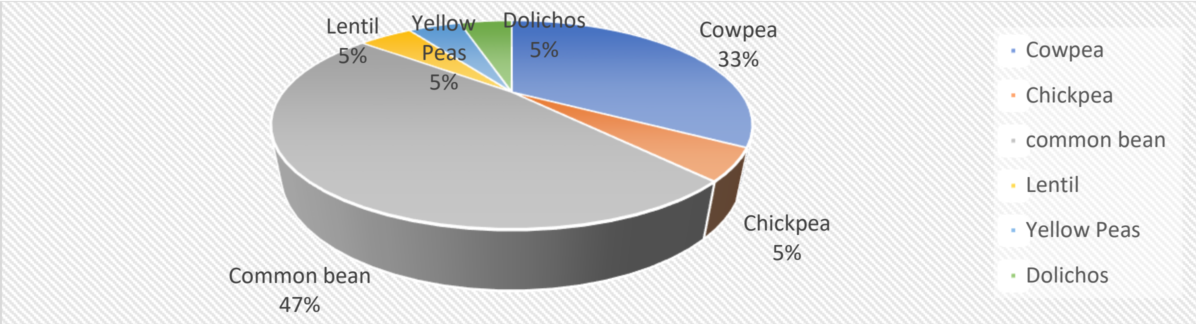

Figure 1: Pulses analyzed for cooking time

of food for longer than necessary is undesirable, as the nutritional and sensory quality of food are affected negatively by prolonged heating (Brock *et al*., 1994). There are many ways of adding value to pulses through several processing technologies such as frozen, canning and precooked, flours, protein concentrates extruded beans. Canning of pulse is convenient as they are easy to prepare compared to cooking of dry pulses (Zanovec *et al*., 2011) which consumes time while cooking (Bassinello, 2008). Pulse consumers prefers to save time while cooking especially in this era where there is increase in profession, social and financial demands (Zanovec *et al*., 2011). Canned pulses are hence an alternative for most consumers. The main aim of canning is for preservation, to inhibit chemical activities, enzymatic reactions and growth of microorganism. Canned pulses are widely accepted worldwide (Zanovec *et al*., 2011), they are however not popular in Nigeria. For instance, despite the fact that Nigeria is the highest producer of cowpea only imported products are available and it is expensive.

Canned Beans Quality Parameters

The quality of canned beans is measured in physical, nutritional, chemical and sensory parameters. The first to be evaluated includes physical and sensory parameters followed by some chemical parameters. The physical parameters to be assessed during processing includes water absorption, hydration coefficient (HC), and damage level after hydration. The following parameters were identified for canning quality (Hosfield *et al*., 1984; Loggerenberg, 2004; White and Howard, 2013).

Washed drained weight (WDWT) and percentage washed drained weight (PWDWT): This is the mass of washed beans drained for 2 min. on a 8-mesh screen at angle 15° (Thapa, 2012). While Percentage washed drained weight is calculated as PWDWT = (WDWT (*g*) × 100/mass of can contents (*g*) × 100 (Loggerenberg, 2004; Thapa, 2012), percentage washed drained weight, (Teshome and Emire, 2012; Njau, 2016). WDWT is basically dependent on the MC of soaked beans, the fill weight and the brine in that it is the function of the equilibrium of the can medium (beans and brine) in the can. Drain weight relates to processors yield as it requires fewer beans with a WDWT to fill a can than beans with low WDWT. PWDWT of dry beans is about 60%. WDWT is a possible indication of excessive solid loss during processing, while a high WDWT indicates large swelling capacities (Hosfield, 1991; Gelete *et al*., 2021). In a study by Teshome and Emire (2012) in the three canning mediums, there were significant differences in their canning quality traits. Percentage washed drained weight ranged between 55.05-62.66, 53.44-60.78, 51.34-56.77 for beans canned in brine, brine with 10.00 mg kg^{-1} $CaCl_2$ and tomato sauce, respectively. The optimum hydration coefficient (HC) value for all common bean varieties was 1.80. Awash-1, Awash Melka and Argene bean varieties has promising potentials for canning. However, Chercher and Omer bean varieties were not good enough for canning purpose. Similarly, Gelete *et al*. (2021) observed that Genotypes were genetically different ($p \leq 0.01$) for all of the quality traits varied from 42.30 to 57.40 min. for cooking time and 260.40-278.60 *g* for washed drained weight. Percent washed drained weight of all the tested genotypes was > 60%, as required by processors. The HC was below the desired optimum level of 1.8, from moderate to no clumping, and from moderately clear to clear brine were observed for canned beans (Gelete *et al*., 2021).

Split: In canned bean splitting is a factor that determines the intactness of cooked beans and this is carried out subjectively (Hosfield, 1991; Loggerenberg, 2004; Thapa, 2012). Raw intact beans may split when subjected to retort processing thus leading to reduction in price. Splitting also causes leaching of samples into the canning medium and could also lead to clumping. The addition of $CaCl_2$ to the brine reduces splitting and clumping of canned navy and pinto beans (Loggerenberg, 2004). Not only would splitting of canned beans result in the exudation of starch into canning medium, causing graininess of the sauce, but could also lead to clumping of individual beans (Lu and Chang, 1996). The percentage split of beans obtained from the tempered canned beans was lower than the commercially soaked and processed canned beans.

Hydration coefficient (HC): The optimum and good hydration ranges between 1.80 and 2.00 (Balasubramanian *et al*., 2000). The reference variety, Julia had low HC (1.10) and high fiber content (20%) (Gelete *et al*., 2012). A higher HC improve the yield of the canning. A large quantity of beans is required to fill a can volume when the ration is low. Water absorption is evaluated after the hydration stage and is measured as the product of the mass. With this value the initial product permits the calculation of the HC, which relates the hydrated samples to dry samples. The optimum and good hydration ranges between 1.80 and 2.00 (Balasubramanian *et al*., 2000).

Visual appearance (VA): This is the determination of general acceptance or suitability of the canned bean for commercial processing. Beans are evaluated for intactness, splits, free seed coats and brine consistency (Loggerenberg, 2004).

Colour: This one of the properties of beans that consumers preferences about**.** Colour is as a result of the absorption of more wavelengths by pigments. It is usually measured with a HunterLab colour meter. Colour can be assessed using a colorimeter. Two sample of each package are collected and reading is taken twice for each sample to ensure accuracy (Hosfield *et al*., 1984; White and Howard, 2013). Wright and Kelly (2011) showed that the linkage map spanned 15 linkage groups (LG) or 460 cM of the bean genome. Four QTL for yield and colour retention in four environments were identified by composite interval mapping on six linkage groups. QTL SY10.2^{J115} for seed yield was identified on LG B10 with other QTL on B3, B5, and B11. Colour retention was linked to loci on B1, B3, B5, B8, and B11. 115M had positive alleles for yield, but negative alleles for colour retention.

Texture and firmness: Texture is the effort required to chew and the mouthfeel, is an important attribute of canned beans and has been commonly used as an indicator of the acceptability of canned whole bean products. VIS/NIRS and HYPERS have the potential in predicting texture of canned beans using intact dry seeds (Mendoza *et al.,* 2018). Results from using the combination of the three-season data sets based on the two-band ratios showed that VIS/NIRS models were consistently effective in predicting texture over a wide range of measurements (Mendoza *et al,* 2018). Texture is influenced by the temperature of samples. samples should be softened to a certain limit during its processing to maintain its individual integrities that help to increase the product quality (Loggerenberg, 2004). While firmness is the part of texture usually measured in canned beans and is on a spectrum from too firm ('tough beans') to too soft 'mushy beans' (Mendoza *et al*., 2017).

The degree of clumping: This is also one of the parameters measured in canned bean (Njau, 2016). One of the factors determining the intactness. The degree of packing indicates the degree of clumping that would occur after processing, which might lead to cultivar rejection by the processor. Intact beans will undergo little bean breakdown during canning, while excessive bean breakage during cooking would result in starch exudation into the canning medium, with consequential clumping of individual beans. Softening of beans while processing is thus important, but beans must still maintain their individual integrity. Njau's (2016) results showed the best performers among lines grown at Ol-Joro-Orok lines were KAB-RB13-471-117/1, SUB-OL-RB13-275-248/3 and KAB-RB13-310-161/5. KAB-RB13-338-41/1 had the highest proportion of clumps (3). The reference variety had low PWDWT and brine pH before and after incubation. Twenty snap bean lines met the industrial canning standards. Among the best performers were KSB22-147-2M/1, KSB22-147-2M/2 and KSB52-2M. The reference variety, Julia had low HC (1.10) and high fiber content (20%) (Njau, 2016).

Soluble solid loss: This is done by direct reading of the brix level of the broth with either a portable device or a workbench device called refractometer. The broth consistency is the final aspect that is important. This is evaluated using a viscometer (White and Howard, 2013). From Figure 2, the pulses identified for canning quality include common bean, cowpea, and Runner bean. Common bean has received more attention than other pulses.

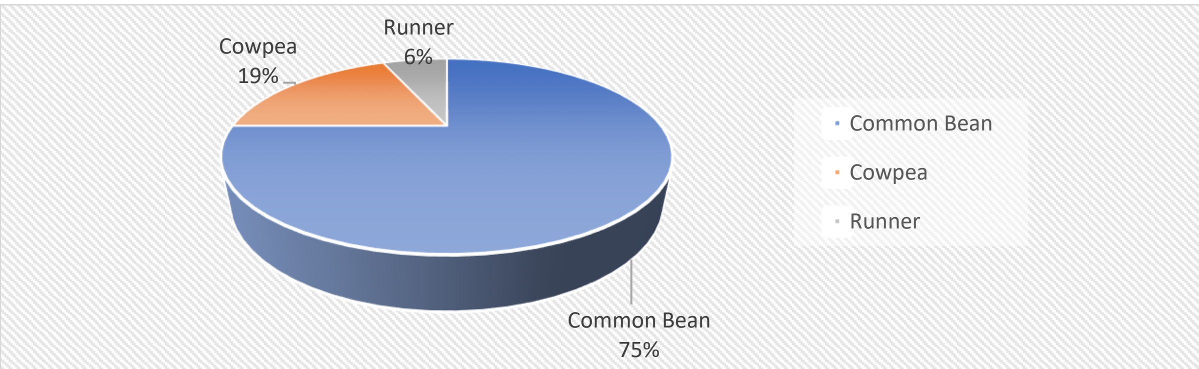

Figure 2: Pulses analysed for canning quality

CONCLUSION

Pulses are contributing to foods and nutrition sustainability across the world and in Africa. Reducing the cooking time and improving the canning quality of the pulse will enhance the utilization of the grains and create rooms for the international market. Our report showed that cooking time determination methodology for pulses were mainly sensory analysis, tactile, Mattson cooker, pressure cooker, VIS/NIR spectroscopy, solid loss, glass slide, hyperspectral imaging. While canning quality parameter identified include; wash drain weight and percentage drain weight, firmness splitting, texture, visual appearance, colour, hydration coefficient, overall acceptance. Results also showed that 5% yellow pea, 5% lentil, 5% dolichos, 33% cowpea, 5% chickpea, 47% common bean. While that of canning quality is 6%, runner bean, 19% cowpea 75%, common bean 75%. Breeding should be focused on canning quality and shorter cooking time to enhance the utilization of pulses. This result therefore provides information for researchers, pulse breeders, producers and agronomist in Nigeria and Africa.

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