

EFFECTS OF SOAKING ON THE COOKING TIME OF DIFFERENT COMMON BEAN (*PHASEOLUS VULGARIS* L.) VARIETIES GROWN IN KENYA

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Abstract

Production of common beans (*Phaseolus vulgaris* L.) in Kenya is characterized by a large variety of beans of different cooking properties. Despite the well-known nutritional and functional benefits of bean consumption, the hard-to-cook (HTC) defect continues to be a major hindrance to the widespread consumption of beans. Pre-cooking treatments can play a major role in reducing the cooking times of the beans and thus increase the acceptability and consumption of beans. This requires innovative scientific and technological approaches for altering the physico-chemical properties of the beans to meet certain functionalities. One such approach is soaking of the beans prior to cooking. The aim of this study was to provide quantitative information on the effect of soaking in different brine solutions on the cooking quality of different bean varieties grown in Kenya. During this study, four common dry bean varieties were soaked in deionised water at varying temperatures (20-50°C) to determine the optimum soaking temperature. They were also soaked in solutions containing monovalent and divalent salts, chelating agents and phytic acid. The influence of soaking solution pH (4-8.5) on the cooking time was also determined. Soaking at high temperatures increased the hydration rate and decreased soaking time to achieve equilibrium moisture content in the beans. Soaking in CaCl₂ solution and low pH solutions increased the cooking time of the beans while soaking in deionised water and high pH solutions reduced the cooking time. These results indicate that soaking has significant effects on the cooking time.

Key words: soaking, cooking time, beans, cooking properties, hard-to-cook, brine solution, soaking temperature, cooking time.

1.0 Introduction

Dry beans (*Phaseolus vulgaris* L.) are good sources of protein, carbohydrates, vitamins and minerals, and are a staple food among many communities in Sub-Saharan Africa. However, they are underutilized because of long preparation times needed to achieve required digestibility (Vindiola *et al.*, 1986; Uebersaxet *al.*, 1991). This contributes to low per capita consumption of beans, partially attributed to long cooking times and increased cost of fuel for preparation. Shorter cooking times for common bean are a characteristic desired by all. Attempts to increase the utilization of legumes in general have employed a wide range of preprocessing and processing techniques either in isolation or in combination. The preprocessing techniques include soaking, dehulling, germination, fermentation, supplementation with various chemicals and enzymes while the processing techniques include boiling, autoclaving, radiation, cooking, roasting and recently extrusion cooking (Van der Poel, 1990; Gujskaand Khan, 1991; Bishnoi and Khetarpaul, 1994; Fernandez *et al.*, 1997; Alonso *et al.*, 1998; Alonso *et al.*, 2000). Cooking is intended to render beans palatable, digestible and also to inactivate anti-nutritional factors (Taiwo *et al.*, 1997). Soaking dry beans thus forms an integral part of pre-processing methods and its main purpose is to facilitate faster cooking though it also reduces anti-nutritional factors (Abu-Ghannam and McKenna, 1997). Soaking and cooking of beans are two separate processes that may or may not be performed simultaneously (Taiwo *et al.*, 1997). Soaking, however, is time consuming requiring between 12 and 24 hours at room temperature and therefore many attempts have been made to shorten it (Abu-Ghannam and McKenna, 1997). Some researchers have suggested a low cost mechanical method for shortening soaking time based on removal of the seed coat by polishing the beans in a wheat polishing machine (Konet *al.*, 1973). The peeling process has previously been applied to Sanilac and Pinto beans, and resulted in considerable reduction in soaking time (Abu-Ghannam and McKenna, 1997). Other studies have applied vacuum filtration techniques to accelerate soaking (Rockland and Metzler (1967) in Lima beans.

According to Abu-Ghannam and McKenna (1997), increasing the temperature of the soaking solution has been identified as the most common method for reducing the soaking time. It has also been noted that soaking at temperatures above 60°C is accompanied with an increase of three to four-fold loss in total solids, nitrogenous compounds, sugars, oligosaccharides, calcium, magnesium and water soluble vitamins (thiamine, riboflavin, and niacin) thus making it necessary to work with temperatures below 60°C in order to keep such losses to a

minimum. Previous studies have demonstrated that below the gelatinization temperature the process of water uptake is only a water transfer phenomenon (Engels et al., 1986) leading to swollen starch granules, and that above the gelatinization temperature and a starch to water ratio of above 0.75, simultaneous water transfer and starch gelatinization occurs (Lin, 1993; Hosney, 1994; Turhan and Gunesakaran, 2001).

This work focuses on providing quantitative information on the effect of soaking in different brine solutions and moisture uptake on the cooking profile of common dry bean varieties consumed in Kenya.

2.0 Materials and Methods

2.1 Plant Material

Four different varieties of beans (*Phaseolus vulgaris* L.) were purchased from Kenya Agricultural Research Institute (KARI), Thika Station. These included Rose coco (GLP 2), Red haricot (GLP 15), Canadian wonder (GLP 24) and Pinto (GLP X92) common beans.

2.2 Hard-shell Test

Samples of 100 seeds of pinto and red haricot bean varieties were weighed in triplicate and water was added to them in a ratio of 1:5. They were soaked in deionized water at 25 and 35°C for 15 hours. The seeds that did not imbibe water were counted. The hard-shell was calculated by expressing the beans that did not imbibe water as a percentage of the total number of beans soaked.

2.3 Soaking of Beans in Different Solutions

Beans were soaked in different types of solutions prior to cooking to determine the role of the brine in influencing the cooking time. This process was referred to as solvent engineering. The solutions tested included deionized water, monovalent (NaCl, NaHCO₃, Na₂CO₃) and divalent salts (CaCl₂), chelating agents (EDTA, CDTA and phytic acid), and solutions of varying pH (4, 5, 6, 8, 8.5). Acetate buffer was used at the low pH range (4, 5 and 6) while phosphate buffers were used at high pH (8 and 8.5). Soaking was done in each of the brine solutions at 25°C for 15 h followed by cooking at 96°C for 1.5 h. The cooking profiles of the different soaking solutions were determined as described in 2.5 below.

2.4 Soaking of Beans at Different Temperatures

Water absorption in Rose coco (GLP 2), Red haricot (GLP 15), Canadian wonder (GLP 24) and Pinto (GLP X92) bean samples was determined by placing a sample of approximately 10 g (weighed exactly) in a 50 ml beaker containing 40 ml of deionised water heated to the required soaking temperature (25°C, 35°C, 45°C and 55°C). The beakers were placed in different thermostated water baths (Memmert WBU-45, Germany). Water absorption was recorded every 30 min up to a total soaking time of 360 min. During the soaking regime, the beans were removed from the soaking solution at specified time intervals, drained for 2 min, blotted with tissue paper and weighed. The weight gain was calculated and the beans were returned to the soaking solution at the defined temperature. The process was continued until the difference between consecutive weights was insignificant. There was no correction for lost solids. All soaking tests were done in triplicate and average results were used to calculate the percentage moisture gain. The soaking profiles of the beans were determined.

2.5 Cooking of Soaked Beans

A sample of 100 soaked seeds of each of the four bean varieties were subjected to standard cooking at 96°C in a thermostated water bath (Memmert WBU-45, Germany) for varying time intervals. The cooked samples were withdrawn and cooled in a cold water bath for 1 min. The softness/hardness (cookability) of the beans was determined objectively using a Sun-Rheometer (Compact 100 Model CR-100, Sun Scientific Company Ltd, Tokyo, Japan) equipped with a Graphtec (Servo 150 SR 6511) recorder. The system uses a cutting probe which could measure up to a maximum force of 100 N at a speed of 100 mm min⁻¹. The maximum force registered during the cutting of the cooked beans was recorded. Every experimental value indicated the average of 10 measurements for a given time. The data obtained was used to generate cooking profiles for the different varieties.

3.0 Results and Discussion

3.1 Hard shell test

Two bean varieties (Red haricot (GLP 15) and Pinto (GLP X92)) had developed hard shells with storage as shown in Figure 1. However, the red haricot had a (Whenever “significant” is used, the p-values reflecting the significance level should be shown) higher percentage of hard shell. On increasing the temperature from 25°C

to 35°C for 15 hours the hard shell content reduced from 30% to 10% in the red haricot variety. This shows that the rate of soaking of beans is influenced by both the bean variety and the soaking temperature.

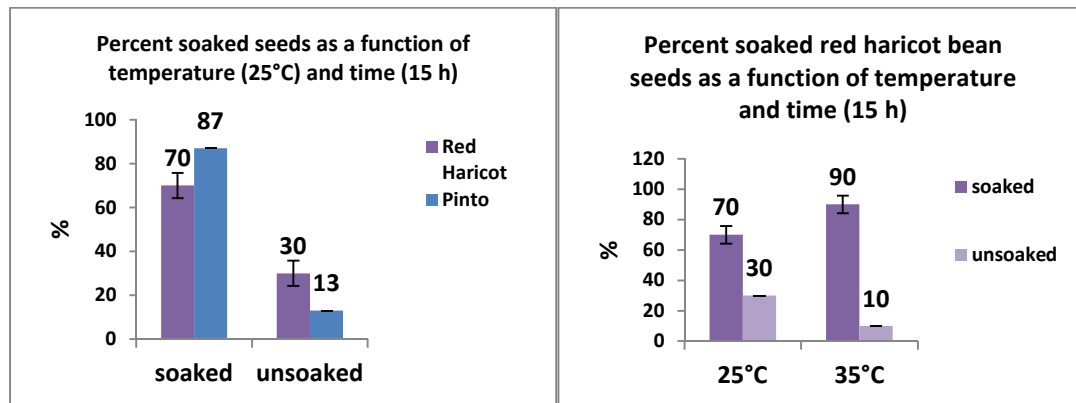


Figure 1: Percent hard shell content for Pinto and Red haricot beans and the effect of increasing the temperature of the soaking water

3.2 Effects of Soaking In Different Solutions

Beans soaked in a low pH solution cooked slower than those soaked in a high pH solution. Similarly the beans soaked in low pH also cooked slower than those beans soaked in deionized water (Figure 2). This can be associated to the β -eliminative depolymerisation of pectin, which is favored at high temperatures and alkaline pH. Due to the β -elimination of pectin, cells are more easily separated during cooking thus reducing the cooking time (Liu *et al.*, 1995). This is also in line with the hypothesis that pectin is involved in the development of the hard to cook (HTC) defect in beans (Stamboli *et al.*, 1995).

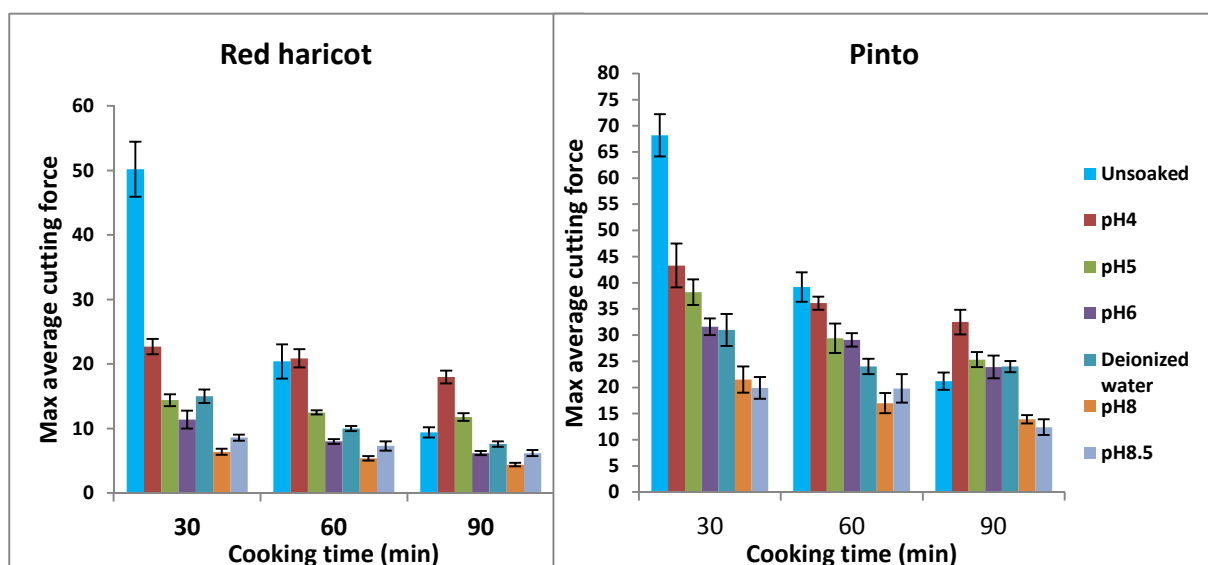


Figure 2: Effect of soaking pinto beans in different pH solutions

Soaking in distilled water significantly reduced the cooking time of the beans in comparison to the unsoaked beans. Monovalent salts, in particular Na_2CO_3 and NaHCO_3 had a more pronounced effect on reducing the cooking time of all the bean varieties (Figure 3). Soaking in NaCl on the other hand had no significant effect on the cooking rates of all the bean varieties. The effect of the two monovalent salts (Na_2CO_3 and NaHCO_3) could be related to their alkaline nature which increases the pH of the solutions thus encouraging β -elimination of pectin. Conversely, soaking in CaCl_2 resulted in a longer cooking time as the CaCl_2 had a hardening effect on the beans, attributed to cross-linking of pectin with calcium ions to form insoluble pectates. As the cooking time increased from 30 min to 90 min, the effect of CaCl_2 was manifested more clearly. After 90 minutes, maximum average cutting force for the CaCl_2 soaked beans was much higher than the cutting force for all the other treatments.

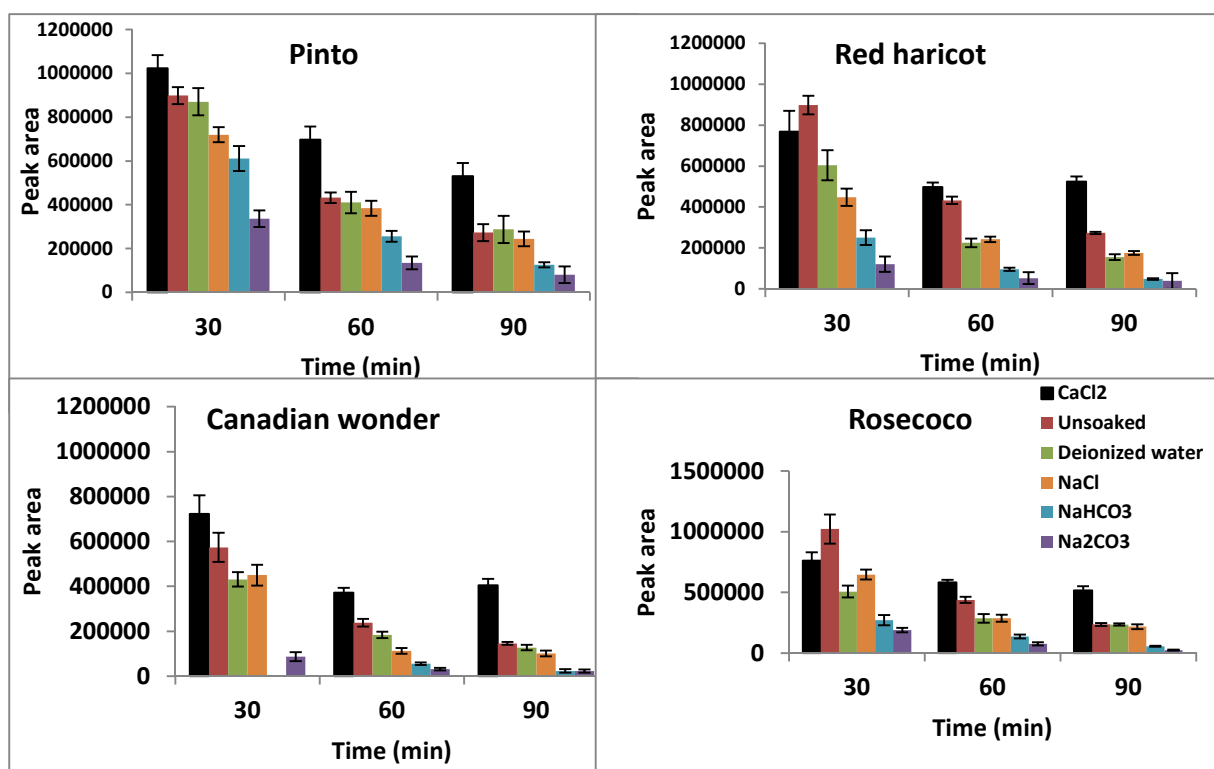


Figure 3: Effect of soaking beans in deionized water, NaCl, NaHCO₃, Na₂CO₃ and CaCl₂.

Ethylene diamine tetraacetic acid (EDTA) is a chelator and can chelate calcium thus weakening the pectin-Ca crosslinking and softening the beans. However, in this study it had no significant effect on the cookability of the beans (Figure 4). This could be due to the low levels of the chelator used (100 ppm) which are in line with the World Health Organization (WHO) maximum limits for chelating agents in foods. Phytic acid led to softening of the beans. Soaking in CDTA on the other hand led to a significant hardening of the beans which is contrary to the expectations. All these results point at the hypothesis that pectin plays a role in the development of the HTC defect in the beans.

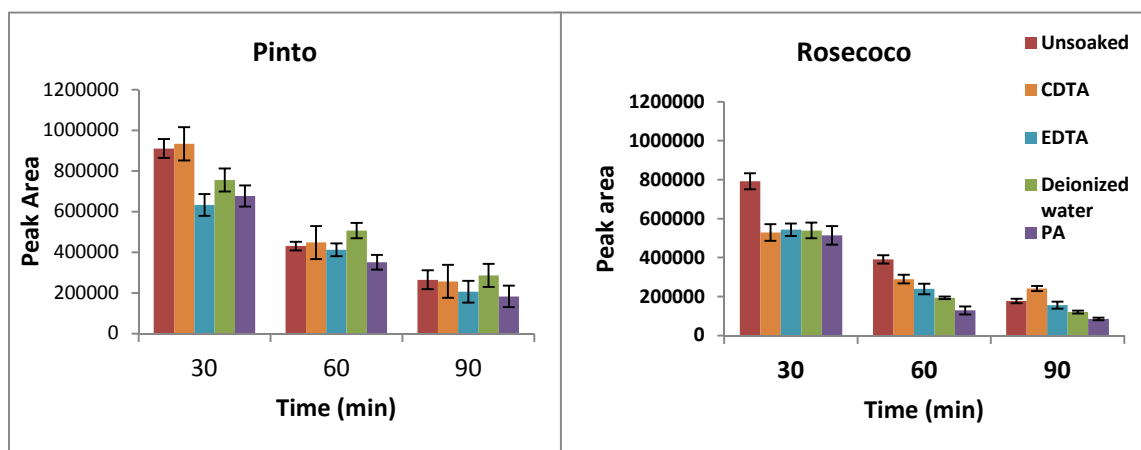
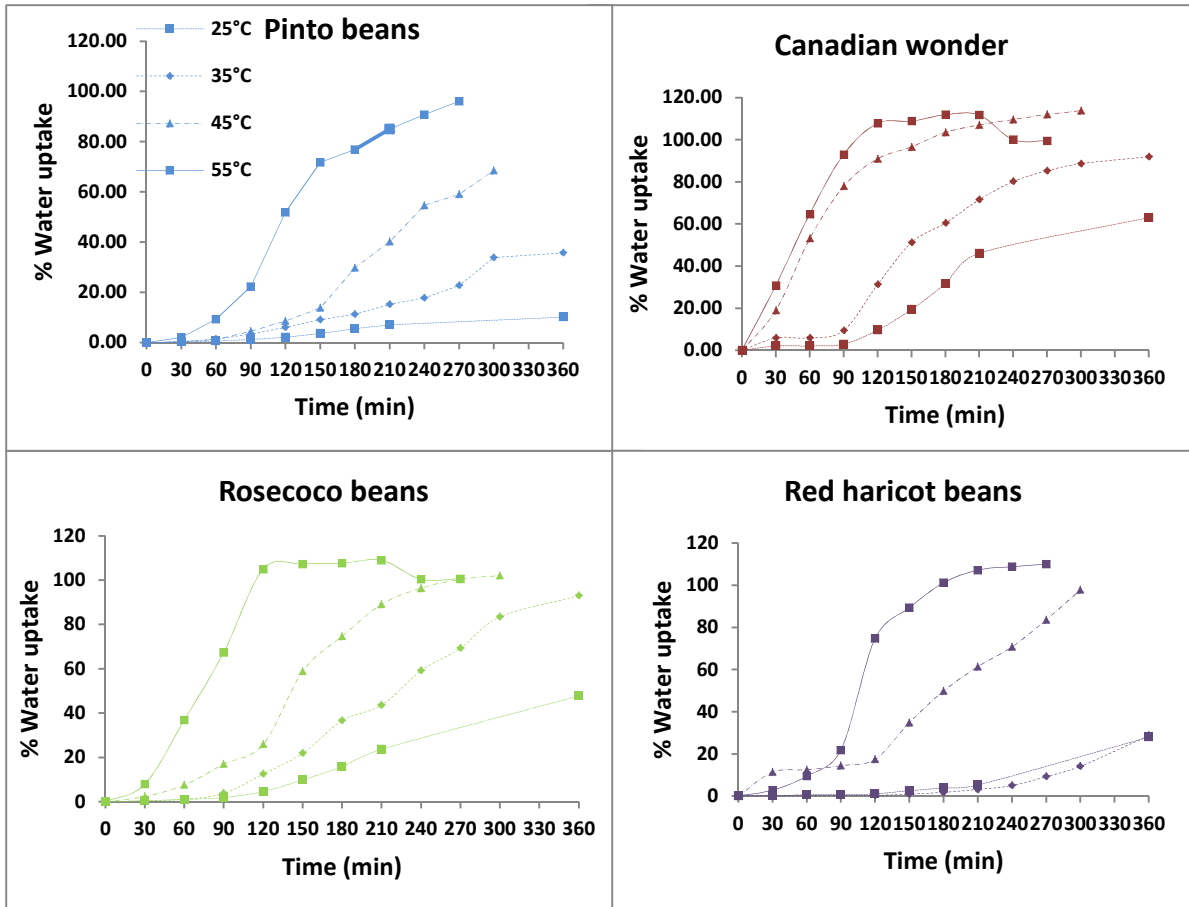


Figure 4: Effect of soaking beans in different chelating solutions

3.3 Effects of Soaking at Different Temperatures

The effect of soaking the pinto beans at different temperatures for 6 hours was determined and the results are shown in Figure 5. The beans exhibited a sorption behavior characterized by increasing rate of water uptake with increasing soaking temperatures within the time limitations of this experiment. The rate was, however, different for different bean varieties at all temperatures. This could be one of the possible reasons why different bean varieties have different cooking times. During cooking at temperatures above gelatinization temperature, starch is immediately gelatinized in the presence of sufficient moisture (ratio of 4:3) (Engels *et al.*, 1993; Hosney 1994; Turhan and Gunesakaran 2001). Therefore, the faster the moisture uptake, the higher the cooking rate. Increasing the rate of water uptake would thus be very important in reducing the cooking

time of beans (Abu-Ghannam and McKenna 1997; Rockland and Metzler 1967) and this can be achieved by increasing the soaking temperature. The cost of heating the water is lower than the cost of boiling the beans for an extended period of time.



3.4 Effects of Soaking Solutions on Cookability of Freshly Harvested Beans

The unsoaked beans took the longest to be fully cooked (Figure 6) requiring 180 minutes to be fully cooked. On the other hand, soaking in Na_2CO_3 (0.01 M) significantly reduced the cooking time of all bean varieties to between 30 and 60 minutes. Majority of beans soaked in distilled water cooked within 90 minutes and one variety cooked within 120 minutes. Soaking significantly reduces the cooking time.

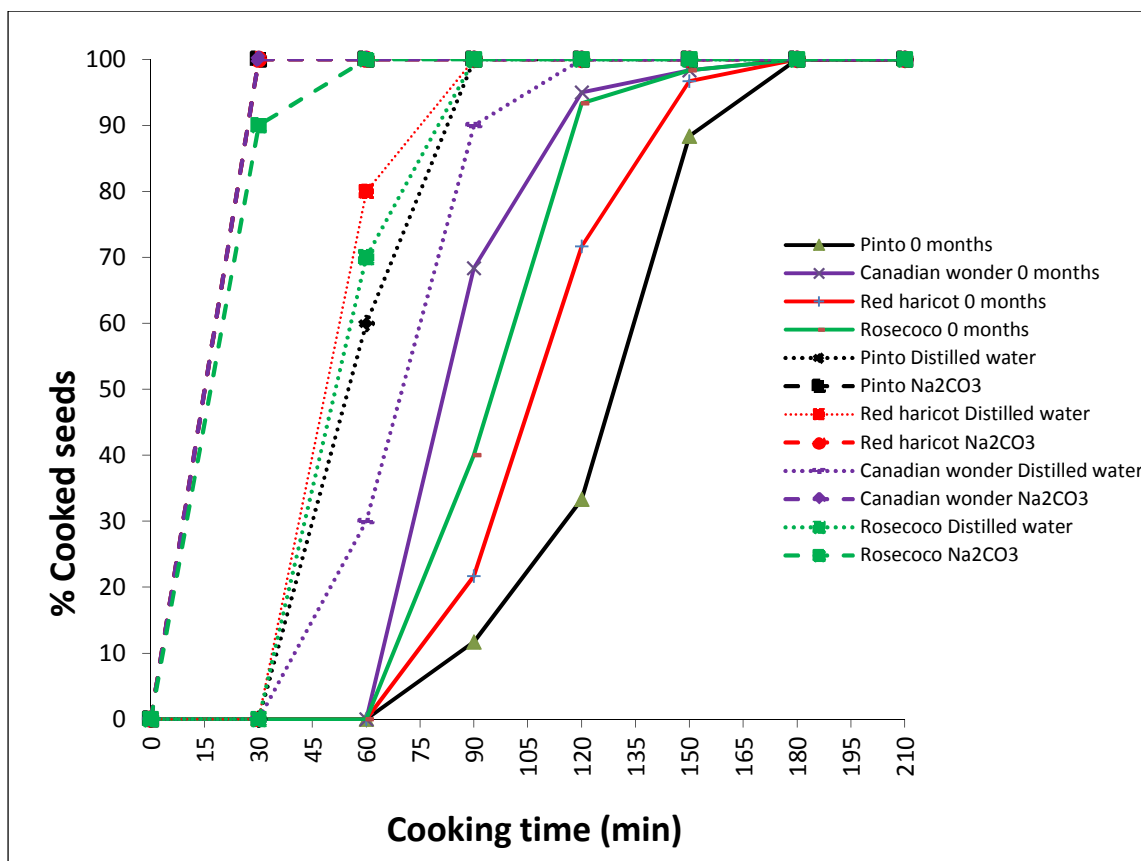


Figure 6: Cooking fingerprint of Pinto, Rosecoco, Canadian wonder and Red haricot bean varieties (*Phaseolus vulgaris*) based on the finger pressing test during cooking at 96°C with soaking pre-treatment in different solutions

4.0 Conclusions

Soaking beans in distilled water and Na_2CO_3 can be used to reduce the cooking time of the beans and that would lower the cost and time of preparing bean recipes. In contrast, soaking in CaCl_2 increases the cooking time. From these results, it can be concluded that through solvent engineering, it is possible to alter/manipulate the functional properties and the cooking time of common beans as desired.

Acknowledgements

The authors wish to acknowledge VLIR-UOS for funding this work.

References

- Abu-Ghannam, N. and McKenna, B. (1997). Hydration Kinetics of Red Kidney Beans (*Phaseolus vulgaris* L.). *Journal of Food Science*, **62**(3), pp 520 – 523.
- Alonso, R., Aguirre, A. and Marzo, F. (2000a). Effect of extrusion and traditional processing methods on anti-nutritents and in vitro digestibility of protein and starch in faba and kidney beans. *Food Chemistry*, **68**, 159–165.
- Alonso, R., Orue, E. and Marzo, F. (1998). Effects of extrusion and conventional processing methods on protein and anti-nutritional factor contents in pea seeds. *Food Chemistry*, **63**(4), pp 505–512.
- Engels, C., Hendrickx, M., De Samblanx, S., De Gryze, I. and Tobback P. (1986). Modeling water diffusion during long-grain rice soaking. *Journal of Food Engineering*, **5**, pp 55-73.
- Fernandez, M., Aranda, P., Lopez-Jurado, M., Garcia-Fuentes, M. A. and Urbano, G. (1997). Bioavailability of phytic acid phosphorus in processed *Vicia faba* L. var. Major. *Journal of Agriculture and Food Chemistry*, **45**, pp 4367–4371.
- Gujska, E. and Khan, K. (1991). Feed moisture effects on functional properties, trypsin inhibitor and hemagglutinating activities of extruded bean high starch fractions. *Journal of Food Science*, **56**, pp 443–447.
- Hoseney, R. C. (1994). Principles of cereal science and technology. 2nd Edition, pp 40-45. St. Paul, MN: AACC.
- Kon, S. (1979). Effect of soaking temperature on cooking and nutritional quality of beans. *Journal of Food Science*, **44**, pp 1329–1334, 1340.
- Lin, S. H. (1993). Water uptake and gelatinization of white rice. *Lebensmittelwissenschaft and Technologie*, **26**, pp 276-278.
- Rockland, L.B. and Metzler, E.A. (1967). Quick-cooking Lima and other dry beans. *Food Technology*, **21**, pp 344–348.
- Taiwo, K. A., Akanbi, C. and Ajibola, O. O. (1997). The effects of Soaking and cooking time on the cooking properties of two cowpeas varieties. *Journal of Food Engineering*, **33**, pp 337-346.
- Turhan, M. and Gunesakaran, S. (2002). Kinetics of in situ and in vitro gelatinization of hard and soft wheat starches during cooking in water. *Journal of Food Engineering*, **52**, pp 1-7,
- Uebersax, M.A., Ruengsakulrach, S. and Occeña, L.G. (1991). Strategies and procedures for processing dry beans. *Food Technology*, **44**, pp 104–11.
- Van der Poel, A. F. (1990). Effect of processing on antinutritional factors and protein nutritional value of dry beans (*Phaseolus vulgaris* L.). *A review of animal feed science and technology*, **29**, pp 179-208.
- Vindiola, O.L., Seib, O. A. and Hoseney, R. C. (1986). Accelerated development of hard-to-cook state in beans. *Cereal Foods World*, **31**, pp 538-552.