Evaluation of the Effect of Chemical Treatment and Soaking on the Cooking Time of African Yam Bean Seed (*Sphenostylis stencarpa*)

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Abstract

The effect of soaking African yam bean (Sphenostylis stenocarpa) seeds in water and various concentrations of trona, NaCl, $Na_2 CO_3$, $NaHCO_3$ and $CaCl_2$ on the pH and cooking time were investigated. The acceptability of the cooked African yam bean seeds was also evaluated. Maximum change in pH was detected in sample soaked with sodium carbonate, followed by that of trona, then sodium bicarbonate. The result also showed that all the chemical agents significantly reduced the cooking time when compared with the control, (cooking without salt) except for calcium chloride which rather increased the cooking time. The most effective cooking medium was found to be sodium carbonate , which was able to reduce the cooking time from 107 minutes to 61 minutes, this was followed by trona (69 minutes) then sodium bicarbonate (71 minutes) and lastly sodium chloride(81 minutes). Calcium chloride on the other hand increased the cooking time form 107 minutes to 195 minutes. The samples treated with sodium carbonate, sodium bicarbonate and sodium chloride were found to be more tender and more acceptable.

Key words: Chemical, Soaking, Ph, Cooking Time, Organoleptic

Introduction

African yam bean is among the local food resources high in protein content. Watson (1977) reported as high as 19.6% protein and 372 Kcal metabolizable energy per 100g edible portions. Although the protein level of African yam bean is lower than that of soybean which is about 38%, the amino acid profile analysis indicated that its lysine and methionine levels are equal to or better than those of soybean (Evans and Boulder, 1974).

Constraints on the use of African yam bean seeds as food especially for people of low socio -economic status, the hungry masses, have been the laborious traditional methods of preparation, long cooking times of 4 – 6 hours (Okigbo, 1973) and the presence of anti nutritional factors such as trypsin inhibitors which have been shown to be inactivated by heat treatment (Onyeike **et al**, 1991). In Nigerian homes and most African countries, the total absence of electricity or epileptic electric supply makes it apparently impossible to have a reliable electric power resource of fuel for cooking. The low socio-economic status of the people makes it also difficult for them to afford cooking gas. The use of firewood in the cooking process is again becoming increasingly very difficult to sustain due to the rapid deforestation without the corresponding aforestation, leading to dependence on the use of kerosene stoves for cooking. Going by the current pump price of kerosene, it may not be easy to carryout a cooking process that takes 4-6 hours.

The addition of salts such as sodium bicarbonate ($NaHCO_3$), sodium chloride (NaCl) and sodium carbonate(Na_2CO_3) have been shown by Varriano-Marston and De-Omuna (1979) to lower the cooking time and improve the sensory properties of black beans (*Phaseolus vulgaris*). Other salts such as calcium chloride ($CaCl_2$) and a mixture of salts of $NaHCO_3$, NaCl and Na_2CO_3 as well as traditional softening agents like trona and palm bush ash have also been proved to reduce the cooking time problems of some legumes. Morris (1963) had earlier reported that the hard to – cook phenomenon in legumes stored for long periods of time required long soaking and cooking to soften the seeds.

The objective of this investigation is to determine the effect of some selected salt solutions, and soaking on cooking time of Africa yam been seed.

Materials and Methods

The uninfected speckled (brown spotted) African yam bean seeds (*Sphenostylis stenocarpa*) used for the research were purchased from Umuahia main market, Abia State, Nigeria. In this experiment two treatment effects were studied –these were the effects of soaking and selected chemical agents in reducing the cooking time of the African yam bean.

Soaking procedure: The African yam Bean seed samples were weighed (25g) and soaked (prior to cooking) in 250 ml water (tap water) along side the following salts: trona, NaCl, Na_2CO_3, $NaHCo_3$ and $CaCl_2$ at concentrations of 0.5, 1.0.1, .5 and 2.0g per litre each. The soaking periods were 6 hr, 12 hr, 18 hr and 24 hr respectively at room temperature. The soaked samples were then drained and cooked. In the case of the un-soaked samples, solutions containing varying salt concentrations (0.5,1.0,1.5 and 2.0g/l) of trona, NaCl, Na_2CO_3 , $NaHCo_3$ and $CaCl_2$ were used as the cooking media for each fresh 25g sample of the African yam bean seeds.

Cooking of the African yam bean seeds: Each treatment sample – soaked or un-soaked African yam bean seeds along with the salts (trona, NaCl, Na_2CO_3, $NaHCo_3$ and $CaCl_2$) were cooked in kerosene stove using 2000 ml of water for every batch of 25g seeds. The cooking time was estimated as the time boiling commenced to the time doneness was observed. Doneness was ascertained when seeds pressed between two fingers has no gritty or grainy feel.

Chemical analysis and sensory evaluation:

Determination of pH: The pH was determined using a pH meter.

Proximate composition: The proximate compositions of the African yam Bean Seeds were determined according AOAC. (1975).

Sensory evaluation: The organoleptic assessment of all the cooked samples was carried out using a 10-man panel of judges. The sensory parameters evaluated include colour, texture, flavour, and general acceptability. In this scale I represents dark brown while 5 represents cream for the colour; 1 represents extremely hard while 5 represents extremely soft for texture; for flavour and general acceptability 1 represents extremely disliked while 5 represents extremely liked.

The data generated were subjected to analysis of variance (ANOVA) and the means separated using least significance difference according to Snedecor (1956)

Results

The result of the proximate analysis showed that African yam bean seed has 20% protein, 1.4% fat, 2.6% moisture, 5.2% fibre, and 10.3% moisture. This result indicates that African yam bean seed is indeed a very high protein legume and in African setting like Nigeria, where protein/energy balance is a problem it is of a great value in the menu. The impact of the salts used as cooking media and soaking on the reduction of the cooking time is given in Table 1.

Table 1: Effect of salts on the cooking time of African yam bean seed before and after soaking

Salt	Cooking Time (min) Unsoaked sample	soaked sample
Water(control)	107^{b}	82^{b}
Trona	69^{cd}	53^{cd}
Sodiun Carbonate	61^{d}	29^{e}
Sodium bicarbonate	71^{cd}	40^{de}
Sodium chloride	81^{c}	60^{c}
Calcium chloride	195^{a}	172^{a}

[abc] mean values on the same column with different superscript are significantly different ($p < 0.05$)

It is apparent from this table that all the chemical agents significantly reduced the cooking time when compared with the control, (cooking without salt) except for the calcium chloride which rather increased the cooking time. The most effective cooking medium was found to be sodium carbonate, which was able to reduce the cooking time from 107 minutes to 61 minutes, this was followed by trona(69 minutes) then sodium bicarbonates (71 minutes) and lastly sodium chloride(81 minutes). Calcium chloride on the other hand increased the cooking time from 107 minutes to 195 minutes. This result showed that sodium carbonate and trona are very effective cooking media at concentrations up to 2g/l.

When soaking was combined with the cooking salts, the cooking time became much more reduced (Table 1). Sodium carbonate and sodium bicarbonates significantly ($P \leq 0.5$) reduced the cooking time when compared with the rest. Both chemical agents were able to bring down the cooking time to 29 minutes and 40 minutes respectively. Calcium chloride still increased the cooking time to 172 minutes. This means that soaking is a very important method of reducing cooking time especially when combined with salts as cooking agents.

Further evaluation of the effectiveness of the chemical agents (salts) at different concentrations is shown in Figure 1. The result showed that the chemical agents generally became more effective at higher concentrations except for calcium chloride, which rather increased the cooking time at higher concentrations. Again it is apparent from this figure that sodium carbonate proved to be the most effective cooking medium at all concentrations than the rest, closely followed by sodium bicarbonate and trona.

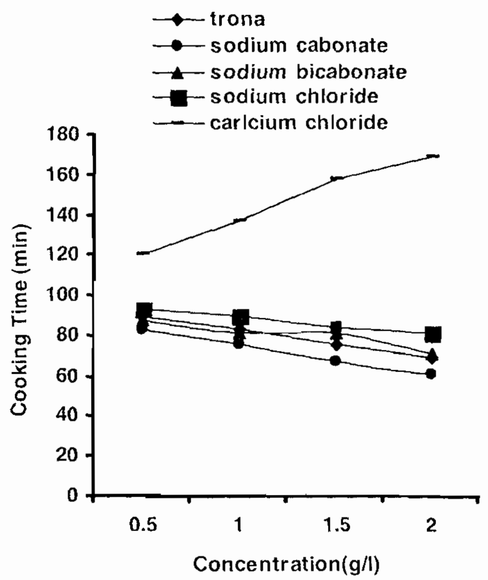

Fig.1: The Influence of the concentration of the salts on the Cooking Time

On the other hand the effectiveness of soaking at different times in reducing the cooking time is shown in Figure 2. Extending the soaking time from 6 hrs to 24 hours generally reduced the cooking time. That means that the longer the soaking time the shorter the cooking time.

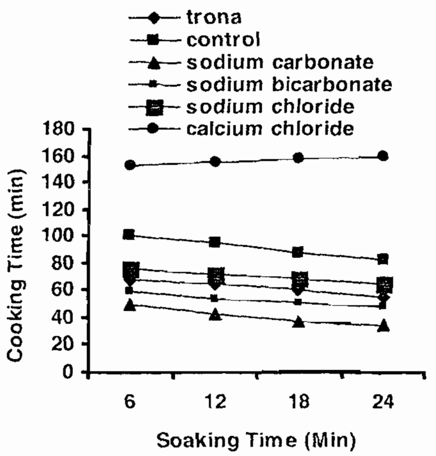

Fig. 2: The Influence of soaking with salts on the Cooking Time

The most effective once again being sodium carbonate, followed by sodium bicarbonate, trona, sodium chloride and the control (without chemical agent). Calcium chloride rather increased the cooking time and the longer the soaking time, the longer the cooking time (Fig. 2). The effect of the salts on pH of the soaked African bean seeds is shown in Table 2.

Table 2: Effect of soaking salts on the pH of African yam bean seed

Salt	Initial pH	Final pH	Decrease in pH
Water(control)	7.4 0	7.25	0.15
Trona	9.76	9.01	0.75
Sodiun Carbonate	10.52	10.18	0.80
Sodium bicarbonate	10.09	9.59	0.50
Sodium chloride	5.69	5.35	0.34
Calcium chloride	3.90	3.62	0.28

^{a}Mean pH values on the same column with different superscript are significantly different ($p < 0.05$)

Maximum change in pH was detected in the sample soaked with sodium carbonate, followed by that of trona, then sodium bicarbonate. The least reduction in pH was seen in the sample soaked without any of the salts (control), followed by the sample soaked with calcium chloride. The result of the sensory evaluation of the African bean seeds cooked with different chemical agents is presented in Table 3. In terms of colour, there was no significant difference detected amongst the samples cooked with just water, sodium chloride, trona and sodium chloride. However they all showed significantly better colour rating than those soaked with either sodium bicarbonate or sodium carbonates which were rather more brownish in colour. The sample soaked with calcium chloride was found to be hard even at the end of the cooking period (Table 3).

Table 3: The sensory evaluation of the cooked African yam bean seed treated with some salts

Salt	Colour	Texture	Flavour	General acceptability
Water(control)	4.4^{a}	3.8^{b}	3.2^{bc}	4.0^{abc}
Trona	3.5^{a}	4.0^{ab}	3.6^{bc}	3.5^{cd}
Sodiun Carbonate	1.2^{b}	4.8^{a}	3.8^{b}	4.4^{ab}
Sodium bicarbonate	1.7^{b}	4.4^{a}	3.4^{b}	3.0^{ab}
Sodium chloride	4.2^{a}	4.2^{ab}	4.8^{a}	4.6^{a}
Calcium chloride	3.5^{a}	1.9^{c}	3.0^{a}	2.1^{d}

$^{abc.}$ mean scores on the same column with different superscript are significantly different ($p < 0.05$)

The samples treated with sodium carbonate, sodium bicarbonate and sodium chloride were found to be tenderer according to the test panel evaluation. With regard to flavour, the sample treated with sodium chloride was most desirable, followed by that of sodium carbonate and trona. Calcium chloride based sample was least desirable in flavour. In terms of the general acceptability the African yam bean seeds treated with sodium chloride was most acceptable followed by that of sodium carbonate, then the control. They were significantly ($p < 0.5$) more acceptable than calcium chloride treated sample.

Discussion

In an earlier work carried out by Takahashi (1996) on the "structural weakening of skeletal muscle tissue during post-mortem ageing of meat, he showed that Desmin molecules which form intermediate filaments are fragmented by calcium ions non-enzymatically. The fragmentations of desmin-molecules suggest deploymerization of intermediate filaments under-non-physiological conditions. These facts are the basis of "the calcium theory of meat tenderization which Takahashi (1996) proposed. The structural weakening of the endomysuim and perimysium shows the effect on tenderization of extended ageing of meat, and is closely related to degradation of proteolyses which link collagen fibrils and stabilize collagen fibres. On the same basis of theory it is most probable that the capacity of the salts to reduce the cooking time of the African yam bean seeds operate largely on their ionization in solution and fragmentation of the cellular structure as well as the structural weakening of both the protein and non-protein molecules that convey strength to the seeds (Uytterhaegen et al, 1994, Takahashi, 1996, Wheeler et al, 1997, Pringles et al 1999,).

In this experiment it is worth noting that sodium carbonate, sodium bicarbonate, trona and sodium chloride have a structural weakening effect on the seed, which reduced the cooking time whereas calcium chloride seamed to have a toughening effect, which extended the cooking time.

Soaking was seen to reduce the cooking time both for the samples treated with chemical agents and control (Table 1). Hentges et al. (1991) working on the "Changes of selected physical and chemical components in the development of the hard –to-cook bean defect" highlighted on the proposed theory that hard-to-cook defect involves interactions between phytate, mineral and pectin. However, they did not eliminate possible roles of starch and protein solubility. Leaching of a number of water soluble component of the bean seed will invariably weaken the structural fabric promoting the hard–to- cook effect (Hentges et al., 1991). Sefa – Dedeh et al. (1979) showed that soaking in water produced a loss of some protein bodies in seeds of cowpeas (*Vigna unguiculata)*.

Reduction in pH could be due to the spontaneous demethylation of pectic substances or to increased activity of the amino-acid side chains – the resulting charges on the macromolecules would thus influence water absorption (varriano-marston and De- Omuna, 1979). They also showed that the pH reduction may be caused by ionization of cellular components resulting in increased levels of proton (H^+) in the soak solution. It has however, been shown in studies on pectin substances that some of these hydrogen ions (H^+) were contributed by the pectic acid which has a pka of 2.80 to 4.20 (Kertesz, 1951) . It was also demonstrated that the amount of sodium in the soak water did not significantly ($p < 0.5$) affect water absorbed by black beans; (varriano – marston and De – omuna, 1979). The fall in pH in the Na_2CO_3 – soaked sample than in the other corresponding salt solutions indicated that Na_2 Co3 is a better tenderizer since it may have caused more releases of the hydrolyzed biomolecules out of the seed into the soak solution as observed by visual inspection indicated by deep brown colour. The reduction in pH value with soaking is an indication of leaching out of acidic biomolecules from the African yam bean seeds into the soak solutions.

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