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Influence of Blanching Duration on the Hullability of Adikpo and Lafia Varieties of Grondnut Kernels (Arachis Hypogea)

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Abstract: An investigation was carried out to determine the compressive force, strain energy, elastic modulus and seed-coat adhesion as a function of blanching time for the kernels Adikpo (samnut19) and Lafia (samnut10) varieties of groundnut. Compression tests were performed at a loading rate of 2mm/min for blanching time intervals of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 minutes. Further experiments were conducted to ascertain the effect of blanching time on testa-kernel adhesion using a mixer at a speed of 4rev/min for each time interval. Results show that compressive force, strain energy and elastic modulus of both varieties decreased as blanching time increased. Contrarily, deformation for both varieties increased linearly with increase in blanching time. Also, an optimum blanching duration of 7 and 5 minutes were achieved for the effective hulling of the adikpo (samnut19) and lafia (samnut10) varieties respectively.

Keywords: Groundnut; blanching, time; compressive force; hulling.

1. Introduction

Groundnut (Arachis hypogea Linnaeus) commonly called the poor man's nut, is a grain legume containing protein in the range of 12 – 40% [1], and high-energy value of about 564 calories/100g seed. It thrives well in a sandy-loam soil in virtually every continent of the world. Groundnut has an outer woody shell which encapsulates about 1 to 3 kernels [2] These kernels are covered by a thin film called testa or hull. In the African diet, groundnut contributes about 5 percent of estimated 58.9g of crude protein available per capita per day [3]. However, Shafig and Din [4] reported that about 99% of oil is stored naturally in groundnut kernels, leaving the testa with just 1% oil. Most processors therefore regard the testa as an impurity to groundnut products, hence decortications is a necessity for premium quality products such as groundnut oil, butter, groundnut milk and fried nuts to be obtained.

Hulling or decortications as a unit operation is preferably executed after blanching, which is a heat treatment process in which the kernels are plunged into a boiling water and then removed after a predetermined time. It is an effective method of loosening the testa from the nuts before hulling [5].

Presently, the wet hulling process is solely a manual operation at domestic and semi-industrial levels, which leaves proc-

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essors with some long lasting health problem such as numbness, pains and development of whitlows in the active fingers. This of course, is due to the paucity of information on the cellular integrity of the groundnut testa during blanching which could aid in the design of process machines. It is therefore the objective of this work to investigate the strength properties of some groundnut varieties (samnut 19 and samnut 10) as a function of blanching time.

2. Materials and Methods

Forty kilograms of each of the two varieties of groundnut kernel (Adikpo and Lafia), otherwise referred to as samnut 19 and samnut 10 varieties respectively, were procured from Mile 1 market in Port Harcourt, Nigerian. Samples were prepared as recommended by ASAE S368 [6] and as was applied by Khazaei and Mann [7] and Burubai et al [8]. Clean undamaged kernels of both varieties were sealed separately in black polyethylene bags at 0^oC for 5 days to ensure uniform distribution of moisture. Thereafter, kernels were removed from the sealed bags and allowed to warm up to room temperature for about 3 – 4 hours in separate porches as was used by Misra and Young [9]. The time-temperature dependence in the blanching process and how these can affect the mechanical behaviour of the two varieties of groundnut was investigated at a temperature of 100^oC (boiling water) at blanching time intervals of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 minutes respectively. Heating was accomplished by means of a 1000w ring-type heater immersed in 5 litres of tap water in a 10 litre plastic bucket in an autoclave. Samples were put in a stainless steel sieve and dipped into the boiling water, and the autoclave immediately closed for the required duration so as to maintain the 100^oC. At the expiration of each blanching time, water was drained and kernels allowed to cool to a temperature of 50^oC with running tap water before testing for the different properties.

The uniaxial compression tests were performed with the Universal Testing Machine (UTM, Series M922934A910 -03, UK) at the National Centre for Agricultural Machnization (NCAM) in Ilorin, Nigeria. Following the method used by Silberstein and Rao [10] and Burubai et al [8], the machine was fitted with a compression cage made of two parallel stainless steel plates. The Kernels were selected at random and compressed (with testa in place) in a direction perpendicular to the longitudinal and split axis. The compression tests were run at a slow speed of 2mm/min. This allowed the kernels to be compressed for a reasonably long period of time before failure. For each blanching time, 10 replications of the compression tests were performed until failure point which was indicated in the force – displacement graph by a sudden drop in force. As recommended by ASAE standard [6], data obtained from the deformation curve were used for calculating the elastic modulus of the blanched groundnut kernels using the modified Hertz's equation (for symmetrical halves of the kernels) given as follows.

$$E = \frac{0.531}{D^{3/2}} F\left(1-\mu^2\right)\left[2\left(\frac{1}{R_1}+\frac{1}{R_2}\right)^{1/3}\right]^{1/2}$$

Where

E = Elastic modulus, N/mm^2

F = Compressive force (average load at failure), N

μ = Poisson's ratio

D = Deformation, mm

R_1R_2= adii of curvature, mm A Poisson's ratio value of 0.4 was adopted for all calculations.

A graph of modulus of elasticity (E) was plotted against duration of blanching and a curve of best fit drawn. A model equation was then generated which characterized the behaviour of the modulus of elasticity of the groundnut kernels at different periods of blanching using statistic analysis. Other strength properties were obtained directly from the UTM integrator.

Furthermore, to ascertain the effect of blanching time on testa-kernel adhesion, 200g of the samples were mixed vigorously after each blanching time in a Kenwood Mixer (MS0/423033778) at a speed of 45rev/min for five minutes for each replication. The hulled/decorticated kernels were then sorted into Categories A, B and C. Category A is comprised of whole and undecorticated kernels. Category B is comprised whole and decorticated, while Category C is comprised of split or broken cotyledons. The sorted categories were statistically analysed to ascertain the optimum blanching time for effective decortications.

Statistical Analysis

For the distribution x, for a given number of experimental test replications n, following statistical formulae were used.

Arithmetic mean, $\bar{x} = \frac{\sum x}{n}$

Standard deviation, S = $\sqrt{\frac{\sum x - \bar{x}}{n}}$

Experimental results were further analyzed, using one-way analysis of variance (ANOVA) and comparisons of means made to ascertain whether the differences in the mean values are significant or not.

Results and Discussions

Compressive force:

The compressive force necessary to effect the desired seed coat or testa rupture for both varieties (Adikpo and Lafia) are presented in Tables 1. For Adikpo variety, at 1 min of blanching, a mean compressive force of 40.50N was recorded. This value decreased to 27.79N at a blanching time of 10 min. Similarly, for the Lafia variety, at 1 min of blanching, a compressive load of 42.03N was obtained, which then declined to 20.56N at 10 min of blanching. This negative trend is in conformity with, the findings of Burubai et al [8, 11] and Vincent [12]. It was observed however, that the compressive force at failure for the lafia variety was slightly higher than that of adikpo variety. This could be attributed to the fact that the lafia variety is comparatively bigger in size. The correlation between blanching times and compressive force for both varieties are shown in Figure 1.

Deformation:

Information on deformation of the groundnut kernel testa as a function of blanching time were obtained from the integrator of the instron testing machine and presented in Table 1. Results reveal that deformation increased positively with increase in blanching time. At 1min of blanching, a deformation of 1.79mm was noticed on the adikpo variety. This increased to 3.04mm at 10 min. In the same vein, a deformation value of 1.73 mm was observed at 1min of blanching for the lafia variety. It then increased to 4.85mm at 10min of pre-treating.

Table 1. Effect of Blanching Time on Some Strength Properties of Adikpo/lafia Varieties

Blanching Time (min.)	Strength Properties	Range		Mean		Standard Deviation	
		Adikpo	**Lafia**	**Adikpo**	**Lafia**	**Adikpo**	**Lafia**
1.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{2-}	52.60 - 23.70 3.07 – 1.314 0.052 – 0.013 69.7 – 15.3	(69.5 – 17.3) (3.45 – 1.11) (0.109 – 0.010) (40.23 – 11.51)	40.50 1,796 0.031 20.27	(42.03) (1.73) (0.044) (14.21)	7.957 0.542 0.011 6.52	(16.93) (0.81) (0.030) (7.52)
2.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	50.00 – 15.30 2.077 – 1.067 0.042 – 0.008 65.3 – 15.0	(37.60 – 18.80) (3.57 – 1.22) (0.091 – 0.016) (34.53 – 8.35)	34.08 1.389 0.027 10.72	(36.15) (2.11) (0.042) (11.12)	11.69 0.336 0.012 5.87	(13.31) (0.86) (0.028) (5.47)
3.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	49.10 – 17.40 2.38 – 0.85 0.038 – 0.012 62.4 – 17.5	(53.5 – 19.4) (3.32 – 1.04) (0.063 – 0.011) (30.15 – 7.89)	33.55 1.76 0.025 18.38	(31.4) (2.15) (0.04) (20.34)	9.11 0.39 0.01 5.84	(9.42) (0.68) (0.025) (8.55)
4.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	44.50 – 26.60 2.13 – 1.09 0.041 – 0.014 62.5 – 16.9	(69.6 – 12.4) (2.49 – 0.986) (0.090 – 0.008) (30.33 – 8.53)	32.31 2.42 0.024 18.08	(30.3) (2.62) (0.036) (9.13)	6.71 0.36 0.008 11.12	(10.62) (0.500) (0.026) (10.11)
5.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	42.30 – 22.40 2.80 – 1.07 0.039 – 0 011 53.1 – 14.7	(50.50 – 13.30) (4.47 – 1.21) (0.098 –0.0084) (27.50 – 6.99)	31.08 2.49 0.021 16.13	(30.00) (3.22) (0.034) (8.68)	8.94 0.45 0.01 9.57	(12.33) (1.04) (0.029) (5.33)
6.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	40.40 – 22.60 3.05 – 1.28 0.035 – 0.015 49.8 – 14.2	(48.30 – 14.12) (4.63 – 1.20) (0.082– 0.0053) (25.55 – 6.12)	30.34 2.69 0.020 15.49	(27.51) (3.42) (0.031) (7.96)	7.41 0.25 0.01 6.35	(11.53) (1.32) (0.03) (9.50)
7.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	38.70 – 17.00 3.61 – 0.98 0.039 – 0.009 45.4 – 13.6	(47.32 – 13.58) (5.83 – 3.56) (0.080 – 0.0051) (24.90 – 6.88)	29.17 2.73 0.019 14.59	(25.94) (3.86) (0.028) (7.96)	8.12 0.32 0.009 12.34	(10.94) (5.42) (0.03) (7.54)
8.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	37.51 – 17.00 3.82.1.25 0.043 – 0.011 40.2 – 11.4	(51.50 – 21.40) (4.59 – 2.17) (0.051 – 0.012) (24.51 – 5.98)	28.92 2.76 0.10 13.95	(25.21) (3.98) (0.025) (6.93)	8.04 0.247 0.010 8.72	(9.25) (0.78) (0.014) (9.03)
9.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	36.50 – 21.30 3.55 – 1.13 0.025 – 0.11 38.3 – 12.4	(50.32 – 14.30) (5.67 – 3.52) (0.075 – 0.011) (21.53 – 5.22)	28.01 3.03 0.016 14.09	(23.48) (4.04) (0.022) (6.78)	6.04 0.158 0.0047 6.39	(7.53) (0.75) (0.022) (10.51)
10.0	Compressive Load (N) Deformation (mm) Strain Energy (Nmm) Elastic Modulus (Nmm^{-2}	36.01 – 6.00 3.39 – 0.98 0.039 – 0.006 40.4 – 11.6	(36.70 – 13.80) (5.23 – 1.98) (0.070 – 0.010) (20.98 – 4.85)	27.79 3.04 0.015 13.39	(20.56) (4.85) (0.020) (6.36)	12.75 0.37 0.010 5.78	(8.81) (2.51) (0.03) (5.37)

NB:data in perenthesis( ) is for lafia variety.

This positive correlation shows that the strength and cellular integrity of the sample is reduced as blanching time increases. These results agree with those of Burubai et al [11], and Khazaei and Mann [7], and Bourne [13] who opined that pre-heating time of biomaterials generally has a positive relationship with deformation. Furthermore, comparison of means showed that the deformation at failure differ significantly ($P > 0.05$) for both varieties. Figure 2 below, shows the regression relationship between deformation and blanching time.

Strain Energy (Toughness)

Strain energy otherwise called toughness is the energy absorbed prior to failure per unit of seed volume.

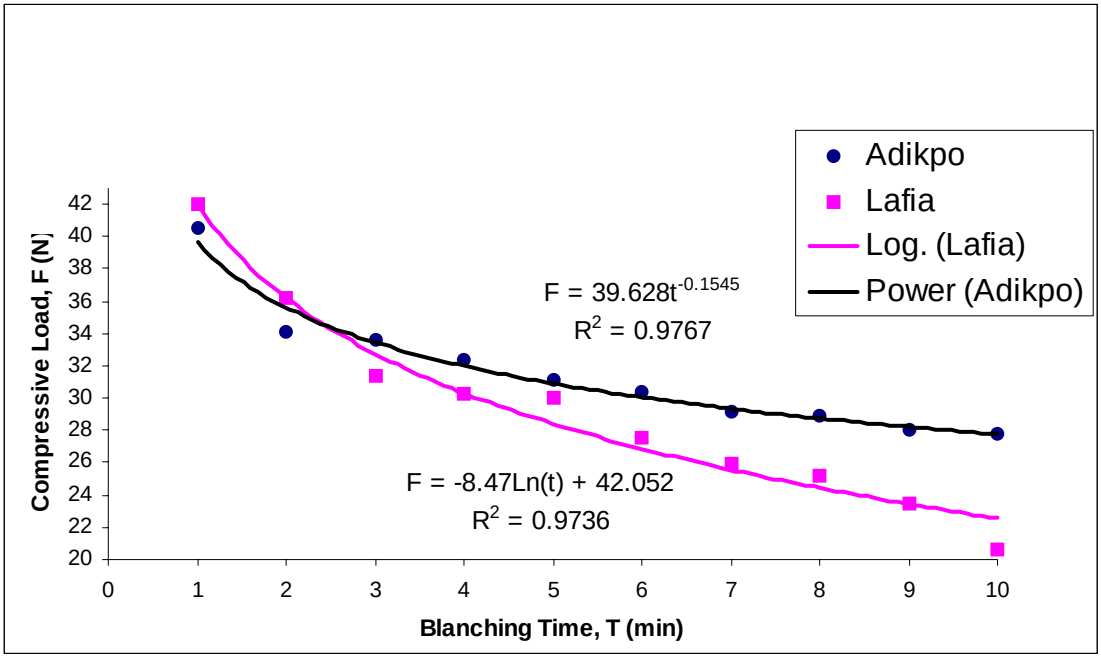

Figure 1. Effect of Blanching Time on Compressive Load (Adikpo and Lafia variety)

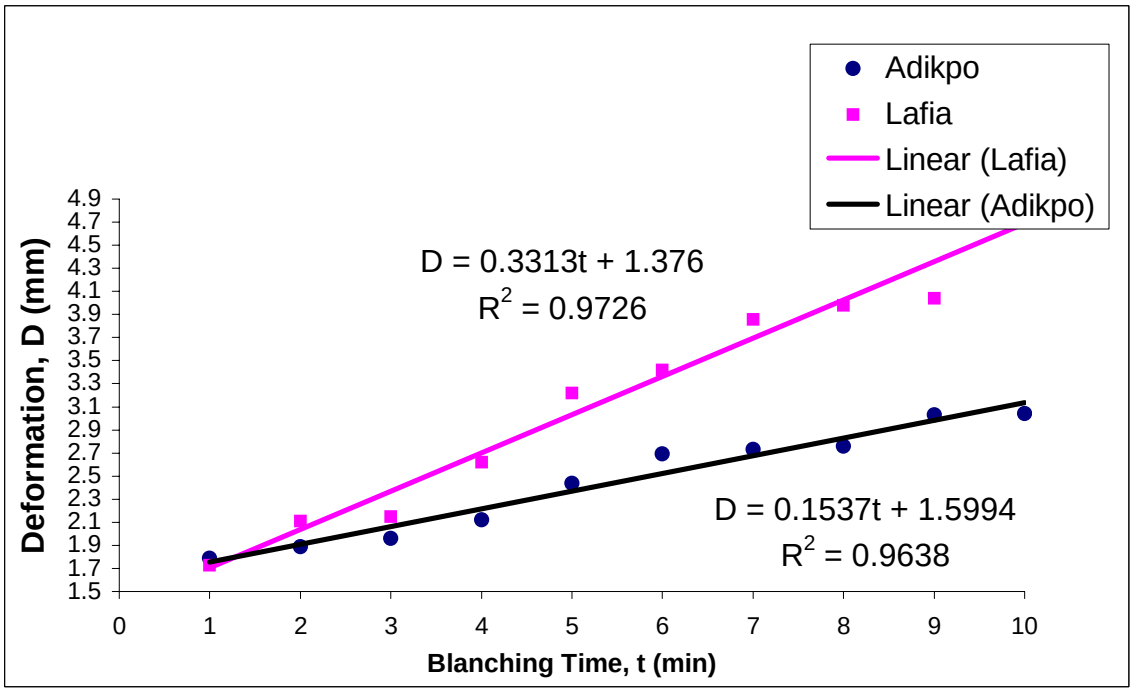

Figure 2. Effect of Blanching Time on Deformation (Adikpo and Lafia varieties)

Data on strain energy as a function of blanching time on both varieties are shown in Table 1. Generally, strain energy tends to decrease with increasing blanching time for both varieties. An average of 0.031 Nmm was noticed at 1

minute and 0.011 N mm at 10 minutes of blanching for the adikpo variety. Similarly, strain energy values of 0.044 N mm and 0.020Nmm were recorded at blanching time intervals of 1 minute and 10 minutes respectively for the Lafia variety. This trend, reveals the inability of groundnut kernel (including testa) to absorb energy at prolonged blanching time, thus confirming the works of Burubai et al [11] on African nutmeg kernels and Shomer [14] on potatoes. The LSD conducted on the mean shows a significant difference (P > 0.05). However, higher values of strain energy were recorded for the lafia variety as against the adikpo variety. Once again, this increase could be attributed to the larger characteristic dimensions of the lafia variety. Figure 3 below reveal the regression relationship between strain energy and blanching time.

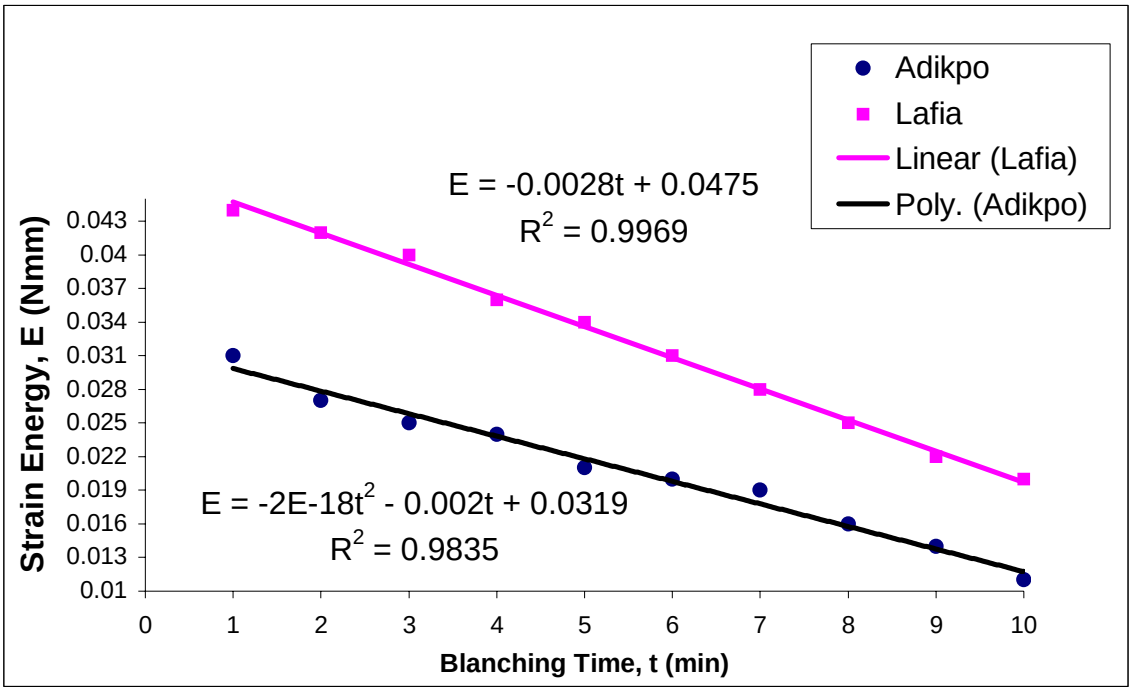

Figure 3. Effect of Blanching Time on Strain Energy (Adikpo and Lafia Varieties)

Elastic Modulus

Otherwise called firmness, elastic modulus is a measure of how easily the seed kernel can fail. For biological material, this fundamental property could be affected by heat (temperature) and moisture. Therefore, the effect of blanching time on elastic modulus of groundnut is shown in Table 1. Results reveal that elastic modulus generally has a negative trend with blanching time. Average values of 20.27N/mm^2 and 13.39 N/mm^2 were recorded at blanching time intervals of 1 minutes and 10 minutes respectively for the adikpo variety. A similar trend was also observed for Lafia variety as values of elastic modulus declined from 14.21 N/mm^2 to 6.36 N/mm^2 at blanching time intervals of 1 minutes and 10 minutes respectively. This implies that, as blanching time increases cellular integrity of the sample is lost, thus, confirming the investigations of Ramana et al. [15]. Figure 4

below show the regression relation between modulus of elasticity and blanching time.

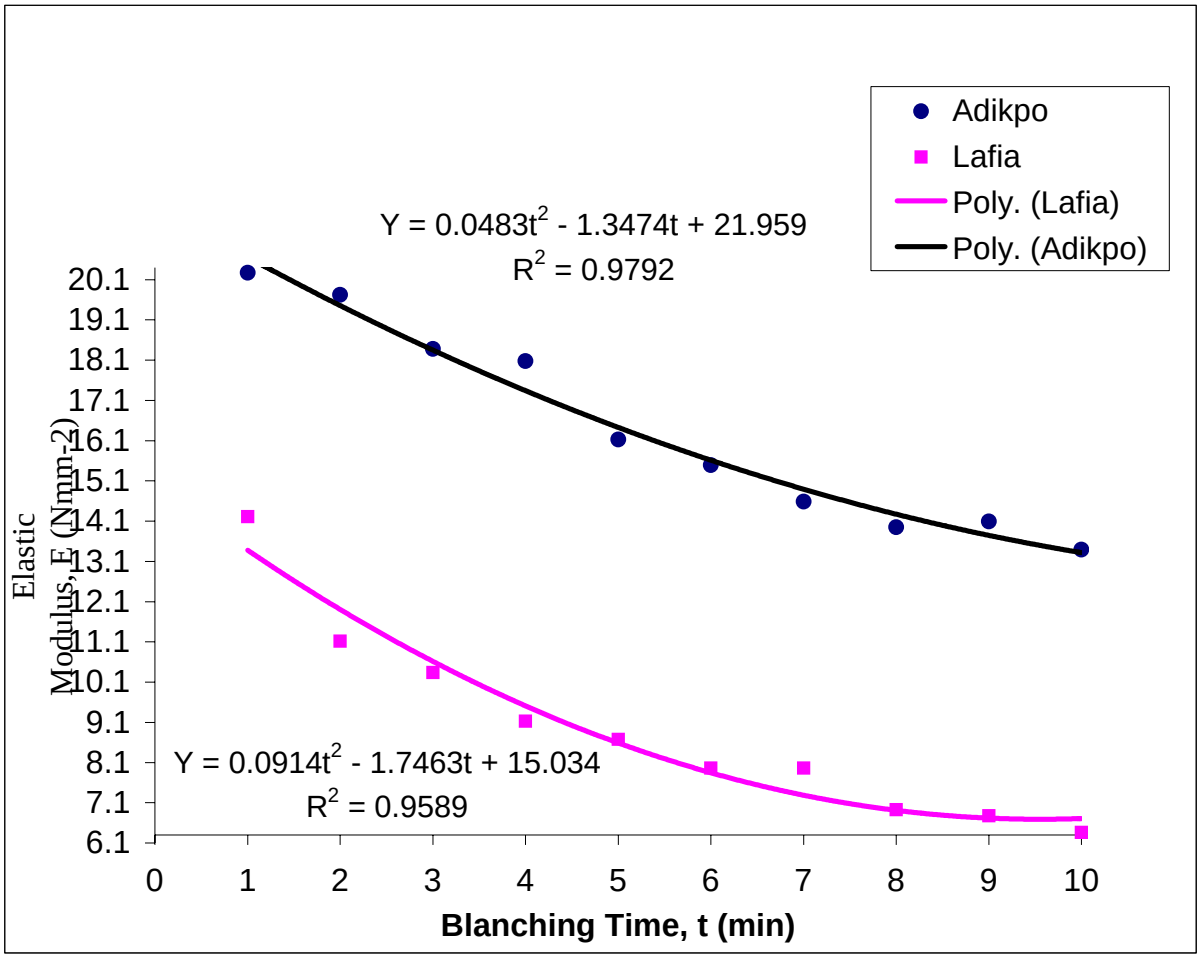

Figure 4. Effect of Blanching Time on Eastic Modulus (Adikpo and Lafia Varieties)

Effect of Blanching Time on Seed-Coat Adhesion:

Results of the analysis of the effect of blanching time on seedcoat adhesion for both varieties are presented in Table 2. Generally, the percentages of kernel decorticated whole (category B) and split or broken (category C) were observed to increase as the duration of blanching time increases for both varieties.

For the Adikpo variety, the increment in the mean values of category B was found to be significant at ($P > 0.01$) from one to seven minutes of blanching time. However, blanching time intervals from seventh to tenth minutes were not significant ($P < 0.01$). For category C, increment of mean values were not significant within the first seven minutes of blanching ($P < 0.01$), but became significant at ($P > 0.01$) between the seventh to the tenth minutes of blanching. These results suggest seven minutes as the optimum blanching time for the Adikpo variety for affective decortications.

Table 2. Results of statistical analysis of groundnut kernel samples subjected to decortication after different duration of blanching.

Duration of Blanching (min)	*Adikpo* variety			*Lafia* veriety		
	* Category A (%)	* Category B (%)	* Category C (%)	* Category A (%)	* Category B (%)	* Category C (%)
1	90.65	6.04 (5.547)	3.33 (0.836)	88.01	8.79 (1.438)	3.20 (0.964)
2	89.43	6.74 (1.334)	3.61 (0.901)	86.29	10.32 (1.341)	3.39 (1.008)
3	88.43	7.88 (1.422)	3.69 (0.944)	84.28	11.97 (1.334)	3.75 (0.748)
4	86.38	9.97 (1.544)	3.65 (0.722)	82.43	13.38 (1.551)	4.19 (0.943)
5	85.09	11.09 (1.241)	3.82 (0.977)	80.60	14.82 (1.440)	4.58 (1.141)
6	82.47	12.77 (1.333)	4.76 (1.109)	79.22	15.29 (1.829)	5.49 (0.836)
7	80.96	14.12 (1.638)	4.92 (0.806)	77.67	15.96 (1.633)	6.37 (1.216)
8	79.84	15.43 (1.837)	5.73 (1.044)	76.49	16.04 (1.139)	7.47 (0.886)
9	77.61	15.95 (1.429)	6.44 (0.869)	75.50	16.53 (1.129)	7.97 (0.913)
10	76.32	16.04 (1.946)	7.64 (0.948)	74.37	16.91 (1.901)	8.72 (1.244)

Each value is a mean of three measurements. The standard deviation is given in parenthesis
Category A: Whole and undecorticated kernels; Category B: Whole and decorticated kernels.
Category C: Split and/or broken kernels

A similar behavioural trend was also observed for the Lafia variety. But in this case, the increment in Category B was non-significant at ($P < 0.01$) from the fifth to the tenth minute of blanching. For category C, the increments became significant at ($P > 0.01$) from the fifth to tenth minute of blanching. Again, this result suggests a blanching duration of five minute as the optimum blanching time for the lafia variety.

Conclusion

1. From the investigation, it can be concluded that the strength properties of blanched groundnut kernel such as compressive force, deformation, strain energy and elastic modulus all decreased significantly as the duration of blanching increases.
2. Optimum blanching time of 7 and 5 minutes has been established for the effective decortications or hulling of the Adikpo and Lafia varieties respectively.
3. Findings from this work may now be used in the design of machine for the hulling of blanched groundnut kernels of the

Adikpo(samnut 19) and Lafia(samnut10) varieties, to reduce the health hazards and drudgeries encountered by local processors.

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