American Journal of Food Technology

ISSN 1557-4571

Academic Journals Inc.

www.academicjournals.com

American Journal of Food Technology 3 (4): 257-263, 2008
ISSN 1557-4571

Starch Gelatinization, Total Bacterial Counts and Sensory Evaluation of Deep Fried Cassava Balls (Akara-Akpu)

[1]C.E. Chinma and [2]M.A. Igyor
[1]Department of Food Science and Nutrition,
Federal University of Technology, Minna, Niger State, Nigeria
[2]Department of Food Science and Technology,
Federal University of Agriculture, Makurdi, Nigeria

Abstract: Two frying variables (Oil temperature and frying time) at three levels each, were studied to determine effects on degree of starch gelatinization, consumer response and microbial quality of fried cassava balls (Akara-akpu). Results showed that the degree of starch gelatinization of Akara-akpu increased with increasing oil temperature (°C), time and moisture content of Akara-akpu paste. Optimum starch gelatinization value of 29.62-34.41% was established for Akara-akpu samples. Based on consumer panel results, oil temperature of 160°C at 5 min and 180°C at 4 min should be used to produce acceptable Akara-akpu. It was evident that higher sensory scores in terms of crunchiness, overall quality and willingness to purchase were obtained at the established optimum gelatinization range.

Key words: Akara-akpu, fried cassava balls, degree of starch gelatinization, consumer response, microbial quality

INTRODUCTION

It is now a common practice within the food industry to utilize processing operations as an approach to enhance the physical and sensory characteristics as well as microbiological stability to extend the shelf-life of the product.

Deep-fat frying is an important unit operation in the catering and food processing industries (Tan *et al*., 1995). Deep-fat frying can produce foods for immediate consumption or for additional processing (Blumenthal and Stier, 1991). Although, fried foods have high acceptability by the public, poor preparation of deep-fat fried products is widespread. The common mistakes or mishandling practices which contribute to low quality of fried foods include: In correct temperatures and frying time as well as use of deteriorated fats. These variability in frying conditions may affect some chemical, sensory and microbiological quality of fried foods.

In the presence of moisture, starch undergoes at elevated temperatures a process known as gelatinization. Upon cooling, concentrated solutions of starch form gels. During the gelatinization process, starch granules lose enzyme attack, solubility and viscosity of starch solutions increases (Wootton and Munk, 1971). Gelatinized starch plays an important role in determining the structural and textural properties of many food products (Wootton and Munk, 1971).

Cassava food recipes form major part of the diet consumed by both adults and children among the Igbo people and some people from Nigeria as well as in other developing countries (Chinma *et al*., 2007). Akara-akpu is a deep fried product from sweet cassava (*Manihot escluenta* Crantz) variety.

Research studies have been carried out to enhance the sensory and chemical compositions of Akara-akpu as well as their storage stability when packaged in polyethylene bags under ambient condition (Chinma *et al*., 2005, 2007, 2008).

Corresponding Author: C.E. Chinma, Department of Food Science and Nutrition, Federal University of Technology, Minna, Niger State, Nigeria Tel: +2348058229289 Fax: +23466221101

This study is a continuation of the efforts to upgrade the quality of this food product through process standardization/optimization.

The objective of this study was to evaluate the effect of frying temperature and duration of frying Akara-akpu on the degree of starch gelatinization, consumer acceptability and microbiological quality of Akara-akpu.

MATERIALS AND METHODS

Sources of Raw Materials

Freshly harvested mature cassava root (*Manihot escluenta* Crantz) variety TMS 30470, soybean (*Glycine max*) variety TGX 1448-2 E were obtained from the University farm; University of Agriculture, Makurdi, Nigeria. Melon (*Colocynthis citrullus* Linn.), pepper, onions and salt were purchased from a local market in Minna Niger State, Nigeria. Palm Oil (1.5% moisture and 0.02% oleic acides) was purchased from Nigerian Institute for Oil Research, Benin, Nigeria.

Preparation of Flour and Paste

Five kilograms of soybean and dehulled melon seeds were used, respectively. Soybean seeds were boiled for 20 min while dehulled melon seeds were blanched in a basket exposed to saturated steam of 90-95°C for 5 min. The oil seeds were dried separately in an air draft oven (model T12 h, Genlab, Widnes, Cheshire, UK at 60°C for 5 h. The method of Ihekoronye and Ngoddy (1985) was used for the preparation of soybean and melon flour while the method of Fasina and Ajibola (1989) was adopted for preparation of defatted soybean and melon flours. The method of Chinma *et al.* (2007) was used in the preparation of cassava mash

Formulation of Blends

Table 1 presents formulation of blends used for Akara-akpu, which was based on the recommendations of earlier investigations (Chinma *et al*., 2005).

Ingredients Proportion

The ingredients proportion for the preparation of Akara-akpu was based on the recommendations of earlier investigations (Chinma *et al*., 2007) as shown in Table 2.

Preparation of Akara-Akpu

Flour blends and ingredients were mixed in a blender (Philips, model HR 1702, England) at setting 6 for 2 min followed by the addition of 50 mL of tap water. this was blended at the same setting for additional 5 min. Twenty grams of the paste were deep fried in palm oil at 140, 160 and 180°C for

Table 1: Formulation of blends

Cassava mash (g)	Cassava flour (g)	Defatted soybean flour (g)	Defatted melon flour (g)
100 (Control)	-	-	-
	100	-	-
	80	20	-
	70	-	30

Source: Chinma *et al.* (2005)

Table 2: Ingredients proportion for Akara-akpu preparation

Ingredients	Proportion
Flour/mash	100.0 g
Pepper	5.0 g
Onions	5.0 g
Salt	2.5 g
Palm oil	10.0 mL

Source: Chinma *et al.* (2007)

3, 4 and 5 min, respectively, using a deep fryer (Philips). The Akara-akpu balls were removed and excess oil was drained off on absorbent paper.

Chemical Analysis

Determination of degree of starch gelatinization of Akara-akpu was determined by the method of Wootton and Munk (1971). Two grams of the sample was macerated with 100 mL distilled water in a Warring blender. The suspension was centrifuged at 500 rpm for 10 min and duplicate aliquots (1 mL) were diluted with water to 10 mL and treated with 0.1 mL iodine solution. The absorbance of these samples were read at 600 nm with spectrophometer (Model 2903, Perkin-Elmer Co. Ltd.), against a reagent blank. A further suspension of the product (2 g) was prepared in 95 mL distilled water (instead of 100 mL distilled water) as described earlier. To this suspension, 5 mL of 10 M aqueous solution of potassium hydroxide was added and the mixture was allowed to stand for 5 min with gentle agitation. The alkaline suspension was centrifuged and 1 mL of duplicate aliquots was treated with 1 mL of 0.5 m hydrochloric acid and diluted with water to iodine solution (0.1 mL) and their absorbances were measured as described earlier. The degree of starch gelatinization was calculated as:

$$\text{Degree of gelatinization (\%)} = \frac{A_1}{A_2} \times 100$$

Where:

A_1 and A_2 = Absorbance of the iodine complex prepared from the aqueous suspension before and after alkali solubilization

Consumer Evaluation of Akara-Akpu

Twenty consumers consisting of staff and students from Department of Food Science and Technology, University of Agriculture Makurdi, Nigeria were recruited to evaluate coded Akara-akpu samples wrapped in transparent polyethylene bags (2 mm thick) were presented to panelists. In order to prevent sensory fatigue, panelists were advised to take a bite of each sample, taste and then expectorate it. They were instructed to eat a piece of cabin biscuit and rinse their mouths between samples. Panelists were asked to taste Akara-akpu and rate their degree of like or dislike on a 9-point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). These attributes evaluated were crunchiness, texture, oiliness, willingness to purchase and overall acceptability. Oiliness, from extremely oily (rating = 1) to extremely dry (rating = 9) and willingness to purchase (yes or no) were also assessed for each sample.

Statistical Analysis

All analytical determinations were conducted in triplicates. The means and standard deviations were calculated, data were subjected to analysis of variance (ANOVA) (Steele and Torrie, 1980). Where significant difference existed, Tukey's test was used in separating the means as described by Ihekoronye and Ngoddy (1985).

RESULTS AND DISCUSSION

High moisture content of cassava paste caused an increased value on the degree of starch gelatinization of Akara-akpu samples as the oil temperature and frying time increases. This is because starch gelatinization requires heat and adequate amount of water to take place. 100% cassava mash had the highest degree of starch gelatinization value of 50.45% at 180°C for 5 min, while sample B showed low gelatinization value at various frying conditions examined when compared to other samples (Fig. 1).

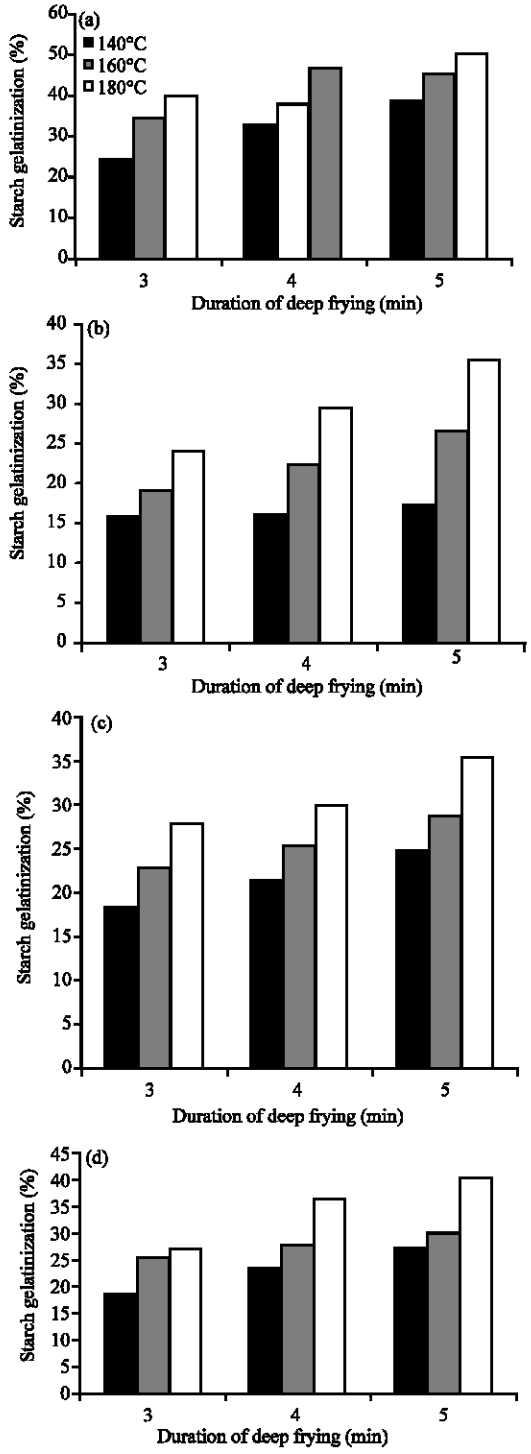

Fig. 1: The effect of the temperature and duration of deep frying on starch gelatinization of akara-akpu prepared from (a) cassava mash, (b) cassava flour, (c) blend of cassava-soy bean and (d) blend of cassava -melon

Table 3: Sensory attribute scoring of 36 akara-akpu products prepared by deep frying of formulas based on cassava roots

Formula cassava paste*	Frying temperature (°C)								
	140			160			180		
	Duration of frying (min)			Duration of frying (min)			Duration of frying (min)		
	3	4	5	3	4	5	3	4	5
Acceptability									
A	5.0	5.2	5.2	5.6	5.6	5.8	7.7	8.0	7.6
B	4.2	4.6	4.8	4.5	4.6	5.4	7.6	8.2	7.9
C	5.6	5.6	6.0	4.7	5.6	6.0	5.1	7.6	8.1
D	3.4	4.6	4.8	4.3	4.7	5.2	7.0	7.8	7.9
Crunchiness									
A	4.8	5.2	5.6	4.0	4.2	4.7	6.0	6.8	7.3
B	4.5	4.7	4.9	5.3	5.7	6.0	7.3	7.8	7.4
C	4.6	5.4	5.9	6.0	6.5	6.8	6.9	7.1	7.2
D	4.3	4.5	4.8	5.3	5.7	6.0	6.3	7.7	7.5
Crust colour									
A	5.1	5.3	5.3	5.7	6.2	6.8	5.6	7.6	7.9
B	5.0	5.3	5.8	6.1	6.4	6.6	7.3	7.8	8.1
C	4.5	6.0	6.0	6.3	6.8	7.4	8.0	8.2	7.9
D	4.8	5.3	5.3	6.5	6.6	7.2	7.0	7.3	7.9
Flavour									
A	4.7	4.8	5.3	6.2	6.6	6.9	7.3	7.6	7.7
B	5.1	5.4	5.7	5.2	6.5	6.8	5.0	6.3	7.5
C	4.1	4.2	5.3	4.7	5.3	5.9	6.0	7.1	7.3
D	5.0	5.8	5.6	5.6	5.9	6.3	7.4	7.6	8.0
Oiliness									
A	2.3	2.8	3.1	3.6	4.9	4.2	6.5	6.8	7.5
B	2.5	2.7	3.4	5.3	5.5	5.8	6.4	6.6	7.2
C	3.2	3.6	4.0	5.3	5.8	6.7	7.0	7.6	7.5
D	2.6	3.0	3.5	5.5	6.0	6.2	7.1	7.8	7.3
Consumer willingness to purchase									
A	25.0	25.0	30.0	30.0	40.0	45.0	65.0	65.0	70.0
B	20.0	20.0	25.0	40.0	45.0	55.0	65.0	80.0	85.0
C	25.0	35.0	40.0	40.0	40.0	55.0	75.0	75.0	75.0
D	15.0	25.0	40.0	40.0	55.0	60.0	80.0	85.0	85.0

*A = Cassava mash; B = Cassava flour; C = Cassava flour-Defatted soybean flour (80 : 20); D = Cassava flour-Defatted melon flour (70:30)

Crunchiness increased as frying time and oil temperature increases. However, Akara-akpu supplemented with soybean and melon flours seed were crunchier than other samples. This may be attributed to more oil absorption capacity of the samples that made them become crunchier (Table 3). Also low curnchiness at low. Oil temperature and frying time may be attributed to moisture stabilization in the paste which made the pores very large which did not allow the Akara-akpu samples at that frying conditions to become crunchy.

Akara-akpu fried at lower oil temperature was rated more oily (lower oiliness rating) than samples fried at higher oil temperature. Akara-akpu with shorter frying time was perceived as more oily than that with longer frying time. There was a positive correlation between oiliness and degree of starch gelatinization as the frying time and oil temperature increases. In this study, it was observed that degree of starch gelatinization inhibited the rate of oil penetration in Akara-akpu samples. This was in line with the observations of Fan *et al*. (1997), who reported that starch gelatinization and consequent swelling of the granules.

The crust colour of Akara-akpu samples fried at 180°C for 4 min was generally more acceptable to consumers, then followed by Akara-akpu fried at 160°C for 5 min. Low frying temperature and low frying time had no influence on the crust colour. Flavour and willingness to purchase ratings were affected by low temperature and low frying time. Increased oil temperature and time of frying enhanced the flavour of the samples and consumers willingness to purchase. Based on overall quality and willingness to purchase as selection criteria; high frying temperature (180°C) and frying time (4 min)

Table 4: Total bacterial counts (cfu g^{-1}) of Akara-akpu prepared from cassava paste without or containing defatted soy flour or melon and deep fried

	Frying temperature (°C)								
	140			160			180		
	Duration of frying (min)			Duration of frying (min)			Duration of frying (min)		
Formula cassava paste*	3	4	5	3	4	5	3	4	5
Total bacterial counts cfu g^{-1} of Akara-Akpu									
A	2.40×10^2	1.40×10^2	<30	1.85×10^2	1.15×10^2	<30	1.10×10^2	<30	<30
B	1.60×10^2	1.18×10^2	<30	1.30×10	<30	<30	4.50×10^1	<30	<30
C	1.26×10^2	1.14×10^2	<30	1.10×10^2	<30	<30	3.60×10^1	<30	<30
D	1.60×10^2	9.50×10^1	<30	1.28×10^2	<30	<30		<30	<30

*: A = Cassava mash; B = Cassava flour; C = Cassava flour-Defatted soybean flour (80:20); D = Cassava flour-Defatted melon flour (70:30)

received favorable response with quality rating >7.5 and more than 60% of the consumers who evaluated the products indicated willingness to purchase. According to Heldman and Hartel (1998), although some processes involving elevated temperatures are used to create intentional and positive changes in many foods before consumption, the magnitude of temperature/time relationships normally associated with preservation process usually result in a loss of quality attributes. These reductions in quality occur in all areas, including flavours, crunchiness and colour as well as reductions in heat sensitive nutrients.

The total microbial count ranged from 1.0×10^2 to 2.2×10^2 cfu g^{-1}. Results revealed that Akara-akpu fried above 140°C at 5 min showed no microbial growth (Table 4). This could be attributed to thermal destruction of vegetative cells that are capable of causing growth in the product, the heat serves to kill vegetative organisms and inactive their enzymes. Also, the microbial load of organisms obtained in this study was below the safe level of 2.8×10^2 cfu g^{-1} recommended for Akara-akpu (Chinma *et al*., 2007).

CONCLUSION

The most favorite Akara-akpu from the consumer point of view was that prepared from cassava flour without or containing 20% defatted soy flour and fried at 180°C for 4 min. the total microbial count in 34 out of the 36 studied Akara-akpu was below the safe level of 2.8×10^2 cfu g^{-1}.

ACKNOWLEDGMENTS

The authors are grateful to Professors M.A. Akpapunam and C.C. Ariahu as well as Dr. E.K. Ingbian of Department of Food Science and Technology, Federal University of Agriculture, Makurdi, Nigeria for their immense contribution in this research.

REFERENCES

Blumenthal, M.M. and R.F. Stier, 1991. Optimization on of deep-fat frying operations. Trends in Food Sci. Tech., 2 (6): 144-148.

Chinma, C.E., E.K. Ingbian and M.A. Akpapunam, 2005. Preliminary Studies on the Sensory Properties of Akara-Akpu Prepared from Cassava Mash and Cassava Flour Supplemented with Soyabean and Melon Flours. In: Proceedings of 29th NIFST Conference, Abakaliki, Ebonyi State, Ebuehi, A.T. (Ed.). Nigerian Institute of Food Science and Technology Lagos, Nigeria, pp: 259-261.

Chinma, C.E., E.K. Ingbian and M.A. Akpapunam, 2007. Processing and acceptability of fried cassava balls (Akara-akpu) supplemented with melon and soyabean flour. J. Food Process Preserv., 31 (2): 143-156.

Chinma, C.E., E.K. Ingbian and M.A. Akpapunam, 2008. Storage stability of fried cassava balls (Akara-akpu) stored under ambient condition. J. Food Process Preserv. (In Press).

Fan, J., S.R. Paul and E.J. Pinthus, 1997. Physicochemical changes in starch during deep-fat frying of a model corn starch pathy. J. Food Process Preserv., 21: 443-460.

Fasina, B. and O.O. Ajibola, 1989. Mechanical expression of oil from Conophor nut (*Tetracarpiduim conophorum*). J. Agric. Eng. Res., 44: 275-287.

Heldman, G.I. and M.O. Hartel, 1998. Fundamentals of Heat Processing of Foods. Macmillan Publishing Co. London, pp: 173-182.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated Food Science and Technology for the Tropics. Macmillan Publishers London, pp: 118-189.

Steele, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Edn. McGraw-Hill Book Inc. New York, pp: 185-187.

Tan, P., C. Hung and K.H. Mcwatters, 1995. Akara (Fried cowpea paste) quality as affected by frying/Reheating conditions. J. Food Sci., 60 (6): 1301-1306.

Wootton, M.D.W. and N. Munk, 1971. A rapid method for the estimation of starch gelatinization in processed foods. Food Technol. Aust., 1: 612-615.