Influence of treatments and packaging materials on microbial Quality of Stored Dehydrated Catfish (*Clarias gariepinus*)

By

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Introduction

- Catfish is of good nutritive and economic value and widely sought in many parts of the world including Nigeria because of its palatability (Adeparusi *et al.*, 2010).

- Fish is an extremely perishable food item due to high water content thus, required preservation for future use (Balachandra, 2011).

- The removal of most of the water present in fish muscles by dehydration, extends the shelf-life without the need for refrigeration (Olayemi, 2012).

Introduction (Contd)

- Modern dehydration techniques, have been largely stimulated by the advantages dehydration gives in compactness (Balachandran, 2011), which will in turn aids easy storage and distribution.

- Appropriate dehydration technique with effective packaging as an integral part of preservation processes is expected to maintain the quality of dried catfish, on shelf and during storage (Aworh *et al*., 2002; Oluwamukomi *et al*., 2008).

- The quality of dehydrated catfish can be assessed using a range of physical, physicochemical, biological and organoleptic tests (Adam and Sidahmed, 2012).

Statements of Problem

Limitation of values

- Despite the numerous food and economic values imbedded in catfish (*Clarias gariepinus)*, accessing these values is limited.

• Limited affordable modern dehydration techniques / expensive and sophisticated equipment/operations in some other fish preservation methods like freezing, freeze drying, canning, etc (George, 2010).

•Product instability during storage leading to dried fish losses, majorly due to insufficient drying and inadequate packaging (Aworh *et al*., 2002; Ward, 2003).

•Rejection of exported smoked-dried catfish from Nigeria to UK as a result of inadequate packaging that led to mould growth and insect infestation (Ward, 2003).

A traditional fish smoking kiln

Traditional methods of dehydrated fish storage

An inefficient dried fish packaging

Men and women involved in dried fish business

Justification for the research

Simple dehydration technique with effective process parameters for catfish preservation could serve as an improvement over the traditional and alternative to the sophisticated modern methods.

Adequate packaging could improve the stability and reduce dehydrated catfish losses during storage; and as well aids proper presentation, easy and wider distribution of the product with a positive impact on the economic development of the society.

Objectives

The specific objectives of this research are to:

- establish effective processing parameters (treatments) for dehydration of catfish,
- evaluate storage stability of dehydrated catfish and recommend adequate packaging material for the product, and finally,
- provide information on the microbial safety of stored dehydrated catfish with simple processing and packaging techniques.

Materials and Methods

Materials

- Catfish (*Clarias gariepinus*) was used for the experiment.
- Common salt (Mr Chef brand) was used to make brine solution.
- The convective electric dryer was used for the drying of catfish.
- Packaging materials used for the storage experiment include; high density (HD) and low density (LD) polyethylene, rigid plastic container (PL), paper board carton (CT), and nylon jute bag (BG).
- Chemicals used for the analyses were of analytical grade.

METHODS

Methods

Design

- A three-factor face centered central composite design (CCD) of Response Surface Methodology (RSM) was used.

Independent variables / factors

- Brine concentration (3, 6, 9%) , brining time (30, 60, 90 min) and drying temperature (90, 110, 130^{o}C).

Table 1: Response surface Methodology (RSM) design runs

Run	A: Brine Concentration (%)	B: Brining Time (min)	C: Drying Temperature (oC)
1	6	60	110
2	6	90	110
3	3	60	110
4	3	30	90
5	6	30	110
6	9	90	130
7	9	60	110
8	6	60	110
9	9	90	90
10	6	60	130
11	3	90	130
12	6	60	110
13	6	60	90
14	3	90	90
15	3	30	130
16	9	30	130
17	9	30	90

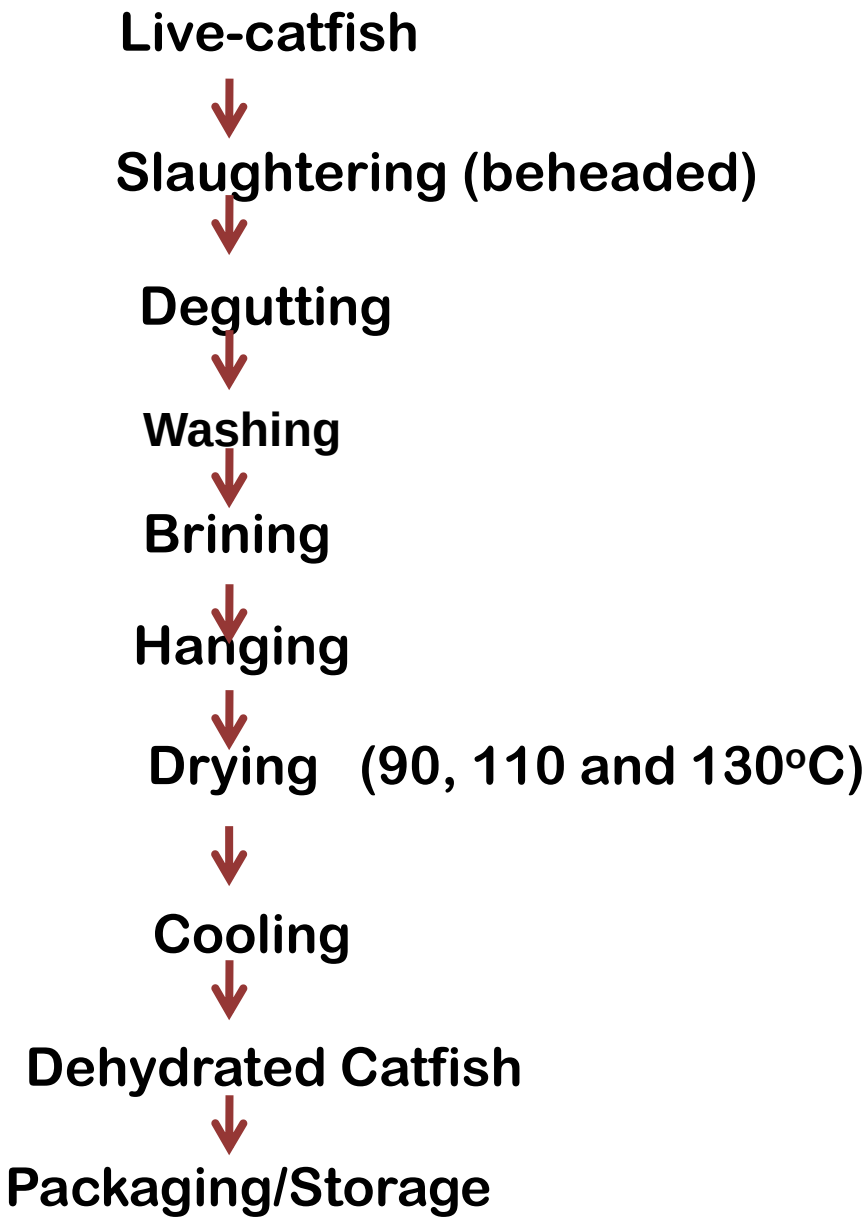

Figure 1: Processing of dehydrated catfish (Eyo, 2001).

Sensory evaluation

General appearance, aroma, texture, taste and overall acceptability of the hydrated, slightly seasoned and simmered samples of dehydrated catfish were evaluated by 18-man sensory panelists using 5-points Hedonic scale, where 5=Like very much; 3=Neither like nor dislike; and 1=Dislike very much as described by Aworh *et al.* (2002).

Packaging and storage

Dehydrated catfish produced with the selected treatments were packaged in moderate sizes of the chosen materials in numbers corresponding to the expected intervals that the analyses were performed.

The nylon jute bag (BG) was used only for the unbrined samples to simulate the packaging of the existing unbrined dehydrated fish as obtained in Nigerian fish markets.

The storage was done under ambient conditions for six months.

I: Rigid plastic (PL) packaging

II: Nylon jute bag (BG) packaging

III: Carton (CT) packaging

Packaged dehydrated catfish

IV: High density polyethylene (HD) packaging

V: Low density polyethylene (LD) packaging

Packaged dehydrated catfish

Microbial analyses

Microbial analysis was done by pour plating technique as described by Harrigan and McCance (1976).

Table 2: The microbial quality parameters of dehydrated catfish determined

MICROBIAL LOAD :	**Unit**
Total viable count	cfu/g
Coliform	cfu/g
Salmonella *E. coli*	cfu/g cfu/g
Fungi (Mould / Yeast)	cfu/g

Software

- Design expert (DX 8.0.3.1) was used for the RSM design of the experimental treatments.

RESULTS

Table 3: Microbial load of the fresh-raw and freshly processed samples of dehydrated catfish (cfu/g)

Code	Process variables			Total viable count (TVC)	*Coliforms*	*Salmonella*	*E. coli*	Fungi (Mould/ Yeast)
	A	B	C					
C5 (Tr1)	6	60	90	ND	ND	ND	ND	ND
C1 (Tr2)	9	90	90	2.0×10^3	ND	ND	ND	ND
U2 (Tr3)	-	-	90	6.0×10^3	ND	ND	ND	ND
B6 (Tr4)	6	90	110	ND	ND	ND	ND	1.0×10^3
U1 (Tr5)	-	-	110	3.0×10^3	ND	ND	ND	2.0×10^3
FRF	No treatment			ND	ND	ND	ND	ND
STD				**5.0×10^5**	**-**	**-**	**-**	**1.0×10^6**

Values are means of duplicate microbial counts.

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (^oC); Tr Treatment; - = No brining; ND = Not detected ; FRF = Fresh raw fish; STD = Standard (ICMSF, 2002).

Table 4: Summary of the sensory evaluation mean scores from ANOVA single factor for the overall acceptability

Run	A	B	C	Average	Variance	Ranking
1	6	60	110	4.025	0.242361	4
2 (B6)	**6**	**90**	**110**	**4.325**	**0.111806**	**1**
3	3	60	110	3.935	0.272806	7
4	3	30	90	3.825	0.292361	10
5	6	30	110	3.925	0.667361	8
6	9	90	130	3.850	0.336111	9
7	9	60	110	4.025	0.145139	4
8	6	60	110	3.775	0.700694	12
9 (C1)	**9**	**90**	**90**	**4.225**	**0.186806**	**2**
10	6	60	130	3.425	0.861806	13
11	3	90	130	4.025	0.422917	4
12	6	60	110	3.400	0.419444	14
13 (C5)	**6**	**60**	**90**	**4.100**	**0.308333**	**3**
14	3	90	90	3.200	0.525000	17
15	3	30	130	3.275	0.867361	16
16	9	30	130	3.825	0.153472	10
17	9	30	90	3.325	0.542361	15
RAW	FRESH		FSH	3.425	0.861806	13

Key: A = Brine Concentration (%); B = Brining Time (min); C = Drying Temperature (^{o}C)

Table 5: Treatments used for the storage study based on the sensory evaluation result

Tr	Code	Brine conc. (%)	Brining time (min)	Drying temp. (^{o} C)
Tr1	C1	9	90	90
Tr2	C5	6	60	90
Tr3	U2	-	-	90
Tr5	B6	6	90	110
Tr6	U1	-	-	110

Tr = Treatment; Conc. = Concentration; Temp. = Temperature; - = No brining.

RESULTS OF PACKING AND STORAGE OF DEHYDRATED CATFISH

Table 6: Microbial load of dehydrated catfish samples at one-month of storage

Treatment A	B	C	Sample code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial coli* (cfu/g)	Fungi (cfu/g)
Body Part									
6	60	90	C5 (Tr1)	PL	$3.0x10^3$	ND	ND	ND	ND
				HD	ND	ND	ND	ND	ND
				LD	ND	ND	ND	ND	$1.0x10^4$
				CT	ND	ND	ND	ND	$1.4x10^4$
9	90	90	**C1 (Tr2)**	PL	ND	ND	ND	ND	ND
				HD	ND	ND	ND	ND	ND
				LD	ND	ND	ND	ND	ND
				CT	ND	ND	ND	ND	$1.0x10^3$
-	-	90	U2 (Tr3)	BG	ND	ND	ND	ND	ND
6	90	110	B6 (Tr4)	PL	ND	ND	ND	ND	$1.0x10^3$
				HD	ND	ND	ND	ND	$2.0x10^3$
				LD	ND	ND	ND	ND	ND
				CT	ND	ND	ND	ND	$6.0x10^3$
-	-	110	U1 (Tr5)	BG	$1.0x10^3$	ND	ND	ND	$6.0x10^3$
Head Part									
6	60	90	C5h	PL	ND	ND	ND	ND	ND
				HD	ND	ND	ND	ND	ND
				LD	ND	ND	ND	ND	ND
				CT	ND	ND	ND	ND	ND
9	90	90	C1h	PL	$1.0x10^3$	ND	ND	ND	ND
				HD	$1.0x10^3$	ND	ND	ND	ND
				LD	ND	ND	ND	ND	ND
				CT	$1.0x10^3$	ND	ND	ND	ND
-	-	90	U2h	BG	ND	ND	ND	ND	ND
6	90	110	B6h	PL	ND	ND	ND	ND	$4.0x10^3$
				HD	ND	ND	ND	ND	ND
				LD	ND	ND	ND	ND	$1.0x10^3$
				CT	ND	ND	ND	ND	$9.0x10^3$
-	-	110	U1h	BG	$1.0x10^3$	ND	ND	ND	$2.0x10^3$

Values are means of duplicate microbial counts.

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); Tr = Treatment; PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; CT = Paper board carton; BG = Nylon jute bag; ND = Not detected.

Table 7: Microbial load of the Dehydrated Catfish Samples at two-month of Storage.

Treatment A	B	C	Sample Code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial coli* (cfu/g)	Fungi (cfu/g)
Body Part				PL	$1.0x10^3$	ND	ND	ND	$1.0x10^3$
6	60	90	C5 (Tr1)	HD	ND	ND	ND	ND	ND
				LD	$1.0x10^3$	ND	ND	ND	ND
				PL	ND	ND	ND	ND	ND
9	90	90	C1 (Tr2)	HD	ND	ND	ND	ND	$2.0x10^3$
				LD	ND	ND	ND	ND	$8.0x10^3$
				PL	ND	ND	ND	ND	ND
6	90	110	B6 (Tr4)	HD	$2.0x10^3$	ND	ND	ND	ND
				LD	ND	ND	ND	ND	ND
Head Part				PL	ND	ND	ND	ND	ND
				HD	$1.0x10^3$	ND	ND	ND	ND
6	60	90	C5h	LD	$3.0x10^3$	ND	ND	ND	ND
				PL	$1.0x10^4$	ND	ND	ND	$1.7x10^4$
9	90	90	C1h	HD	$1.0x10^3$	ND	ND	ND	$8.0x10^3$
				LD	$5.0x10^3$	ND	ND	ND	$6.0x10^3$
				PL	$6.0x10^3$	ND	ND	ND	ND
6	90	110	B6h	HD	ND	ND	ND	ND	ND
				LD	ND	ND	ND	ND	$1.0x10^3$

Values are means of duplicate microbial counts.

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); Tr = Treatment; PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; ND =Not detected.

Table 8: Microbial load of the dehydrated catfish samples at three-month of storage

Treatment A B C	Sample Code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial coli* (cfu/g)	Fungi (cfu/g)
Body Part 6 60 90	C5 (Tr1)	PL	$4.0x10^3$	ND	ND	$1.0x10^3$	$2.0x10^3$
		HD	ND	ND	ND	ND	ND
		LD	$1.0x10^3$	ND	ND	ND	ND
9 90 90	C1 (Tr2)	PL	$1.0x10^3$	ND	ND	ND	$1.0x10^3$
		HD	ND	ND	ND	ND	$6.0x10^3$
		LD	$4.0x10^3$	ND	ND	ND	$6.0x10^3$
6 90 110	B6 (Tr4)	PL	ND	ND	ND	ND	ND
		HD	$1.0x10^3$	ND	ND	ND	ND
		LD	$2.0x10^3$	ND	ND	ND	ND
Head Part 6 60 90	C5h	PL	$1.0x10^3$	ND	$1.0x10^3$	ND	$1.0x10^3$
		HD	$1.0x10^3$	ND	$2.0x10^3$	ND	$1.0x10^3$
		LD	$1.0x10^3$	$1.0x10^3$	$1.0x10^3$	ND	ND
9 90 90	C1h	PL	$9.0x10^3$	ND	ND	ND	$2.0x10^3$
		HD	ND	ND	ND	ND	$1.0x10^3$
		LD	ND	ND	ND	ND	$5.0x10^3$
6 90 110	B6h	PL	$2.0x10^3$	ND	ND	ND	ND
		HD	ND	ND	ND	ND	ND
		LD	$1.0x10^3$	ND	ND	ND	ND

Values are duplicate microbial counts;
Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); Tr = Treatment; PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; ND = Not detected.

Table 9: Microbial load of the dehydrated catfish samples at four-month of storage

Treatment A	B	C	Sample Code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial coli* (cfu/g)	Fungi (cfu/g)
Body Part				PL	ND	ND	ND	ND	ND
6	60	90	C5 (Tr1)	HD	$1.0x10^3$	ND	ND	ND	ND
				LD	$1.0x10^3$	ND	ND	ND	$5.0x10^3$
				PL	$1.0x10^3$	ND	ND	ND	$3.0x10^3$
9	90	90	C1 (Tr2)	HD	$6.0x10^3$	ND	ND	ND	$3.0x10^3$
				LD	$4.0x10^3$	ND	ND	ND	$7.0x10^3$
				PL	$2.0x10^3$	ND	ND	ND	$1.0x10^3$
6	90	110	B6 (Tr4)	HD	$1.0x10^4$	ND	ND	ND	ND
				LD	$1.0x10^3$	ND	ND	ND	ND
Head Part				PL	$1.0x10^3$	ND	$1.0x10^3$	ND	$5.0x10^3$
6	60	90	C5h	HD	ND	ND	$2.0x10^3$	ND	$1.0x10^3$
				LD	$1.6x10^4$	ND	ND	ND	$1.0x10^3$
				PL	$4.0x10^3$	ND	ND	ND	$2.0x10^3$
9	90	90	C1h	HD	$1.1x10^4$	ND	ND	ND	$4.0x10^3$
				LD	$1.5x10^4$	ND	ND	ND	$3.0x10^3$
				PL	$1.0x10^3$	ND	ND	ND	ND
6	90	110	B6h	HD	$7.0x10^3$	ND	ND	ND	ND
				LD	$3.0x10^3$	ND	ND	ND	ND

Values are means of duplicate microbial counts.

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); Tr = Treatment; PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; ND =Not detected.

Table 10: Microbial load of the dehydrated catfish samples at five-month of storage

Treatment A	B	C	Sample Code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial* coli (cfu/g)	Fungi (cfu/g)
Body Part				PL	$5.0x10^4$	ND	ND	ND	$3.3x10^4$
6	60	90	C5 (Tr1)	HD	$5.0x10^3$	ND	ND	ND	$9.0x10^3$
				LD	$3.7x10^4$	ND	ND	ND	$1.4x10^4$
				PL	ND	ND	ND	ND	ND
9	90	90	C1 (Tr2)	HD	ND	ND	ND	ND	ND
				LD	$1.0x10^3$	ND	ND	ND	ND
				PL	$1.3x10^4$	ND	ND	ND	$2.4x10^4$
6	90	110	B6 (Tr4)	HD	$9.0x10^3$	ND	ND	ND	$1.9x10^4$
				LD	$8.0x10^3$	$1.0x10^3$	$5.0x10^3$	ND	$2.0x10^3$
Head Part				PL	$8.3x10^4$	ND	ND	ND	$1.6x10^4$
6	60	90	C5h	HD	$1.1x10^4$	ND	ND	ND	$2.3x10^4$
				LD	$2.4x10^4$	ND	ND	ND	$1.8x10^4$
				PL	$5.0x10^3$	ND	ND	ND	$2.9x10^4$
9	90	90	C1h	HD	$1.2x10^4$	ND	ND	ND	ND
				LD	$6.0x10^3$	ND	ND	ND	ND
				PL	$9.0x10^3$	$1.0x10^3$	ND	ND	$4.0x10^3$
6	90	110	B6h	HD	$6.0x10^3$	ND	ND	ND	$3.2x10^4$
				LD	$1.3x10^4$	ND	ND	$1.0x10^3$	$2.5x10^4$

Values are means of duplicate microbial counts.

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); Tr = Treatment; PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; ND =Not detected.

Table 11: Microbial load of dehydrated catfish samples at six-month of storage

Treatment A	B	C	Sample code	Package	Total viable count (cfu/g)	*Coliform* (cfu/g)	*Salmonella* (cfu/g)	*Escherichial coli* (cfu/g)	Fungi (Mould / Yeast) (cfu/g)
Body Part 6	60	90	C5 (Tr1)	PL	$3.9x10^4$	ND	ND	ND	$1.0x10^3$
				HD	$4.8x10^4$	ND	ND	ND	$2.0x10^3$
				LD	$3.7x10^4$	ND	ND	ND	$6.0x10^4$
9	90	90	**C1 (Tr2)**	PL	$5.0x10^3$	ND	ND	ND	$1.0x10^3$
				HD	$1.0x10^3$	ND	ND	ND	ND
				LD	$9.0x10^3$	ND	ND	ND	ND
6	90	110	B6 (Tr4)	PL	$4.1x10^4$	ND	ND	ND	ND
				HD	$3.2x10^4$	ND	ND	ND	$2.0x10^3$
				LD	$4.2x10^4$	ND	ND	ND	$5.0x10^3$
Head Part 6	60	90	C5h	PL	$1.0x10^3$	ND	ND	$1.0x10^3$	ND
				HD	ND	ND	ND	ND	$1.0x10^3$
				LD	$2.0x10^3$	ND	ND	ND	$1.0x10^3$
9	90	90	C1h	PL	$6.0x10^3$	ND	ND	ND	ND
				HD	ND	ND	ND	ND	ND
				LD	$7.0x10^3$	ND	ND	ND	ND
6	90	110	B6h	PL	$4.3x10^5$	$4.3x10^4$	$5.6x10^5$	$5.0x10^3$	$3.2x10^5$
				HD	$2.0x10^4$	ND	$1.0x10^3$	ND	$5.0x10^3$
				LD	ND	ND	ND	ND	$4.0x10^3$
STD					**$5.0x10^5$**				**$1.0x10^6$**

Values are means of duplicate microbial counts; Tr = Treatment

Key: A = Brine concentration (%); B = Brining time (min); C = Drying temperature (°C); PL = Rigid plastic container; HD = High density polyethylene; LD = Low density polyethylene; ND = Not detected; STD = Standard (ICMSF, 2002)..

Conclusions

❖Effective dehydration conditions (9% brine, 90 min, 90 ^{o}C) and high density polyethylene (HD) packaging material maintained the quality of dehydrated catfish (body part) for storage period of six months (at 30^{o}C; RH≤75%).

❖Head part constitutes the intrinsic spoilage factor occurring in the whole dehydrated catfish.

❖The unbrined dehydrated catfish stored in BG package could not match the expected simulation.

❖Separating the head from the body during processing and storage prevented cross contamination which might result in consequent quality losses in the whole dehydrated catfish, and in this regard the nutritive value of catfish is preserving to aid food security.

Recommendations

- Paper board carton and nylon jute bag should not be used as primary packaging for the storage of dehydrated catfish.

- Head of dehydrated catfish should neither be processed nor packaged together with body part to avoid cross contamination.

- The storage period for the head part of dehydrated catfish should not exceed two months.

- Further study geared towards commercialisation of the product is suggested so as to encourage men and women in profitable entrepreneurship for the economic development of the society.

Contribution to knowledge

This work has been able to:

•establish a simple and effective treatment that could preserved the quality of dehydrated catfish for adequate storage under ambient conditions,

•provide effective packaging material to aid the stability and distribution of dehydrated catfish.

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APPENDICES

Description and dimensions of the packaging materials used

Packaging material	Description	Length (cm)	Width (cm)	Height (cm)	Thickness (mm)	Density (g/dm^3)
High density polyethylene (HD)	Translucent	40.9	12.95	-	0.09	0.9798
Low density polyethylene (LD)	Transparent	41.38	15	-	0.165	0.9492
Paper board carton (CT)	Opaque	38	24.5	10	5	-
Rigid plastic container (PL)	Transparent	28	27.7	6	4.9	-

Recorded prevailing environmental condition during storage of dehydrated catfish

Period of storage	Prevailing conditions	
	Temperature (^{o}C)	Relative humidity (%)
First month	27 - 29	61 – 75
Second month	27 – 30	55 – 75
Third month	27 – 30	Lo – 52 (Hammattan set inn)
Fourth month	24 - 31	Lo – 62 (Hammattan effect)
Fifth month	27 – 32	Lo – 65 (Hammattan effect)
Sixth month	27 - 29	66–75 (With the first rain after the hammattan)

Measured, using an indoor/out door hygro-thermometer (Model; HH 439, China)
Key: Lo = Below 20 %.

Outer and inner view of the electric dryer used

Brining of catfish

Drying operation of catfish in progress

A batch of dehydrated catfish

Mouldy dehydrated catfish in paper board carton package at **two-month** storage

Mouldy body part

Mouldy head part

THANK YOU FOR LISTENING