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Some Hygroscopic Properties of Fish Feed Pellets

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ABSTRACT

The effect of moisture and soaking time on some engineering properties of fish feeds pellets were investigated. The obtained database is essential for the design and development of appropriate machines for post harvest handling, transporting, separation, grading, packaging and storage of agricultural products. Dried locally produced fish feeds pellets were soaked in water at temperature range of 28-32^{0}C for 60 seconds, 120 seconds, 180 seconds, 240 seconds minutes and 300 seconds. The results showed that total surface area (TSA), lateral surface area (LSA), base surface area (BSA) increased non-linearly with soaking time. All physical parameters investigated in this research have non-linear relationship. The obtained results are useful in assessing the storage conditions of feeds especially in high relative humidity areas such as Niger Delta in Nigeria.

Keywords: *Mechanical properties, moisture content, soaking time, axial dimension, surface area*

INTRODUCTION

Kannadhason *et al*. (2008) rated aquaculture as one of the fastest-growing food production industries worldwide. It provides employment opportunities, moderately higher income and healthier nutrition in most of the developing countries of the world. More than 30% to 60% of total operational costs are expended on fish feeds. Concerted efforts have to be developed towards efficient food and feed production due to the population growth. The prominent processing technique used in the fish feed industries is extrusion. Nigeria is one of the major importers of fish feeds. A good understanding of physical properties of fish feeds is necessary in order to design machines of higher efficiency, process and handling operations for optimum efficiency to provide the highest quality end products. Moisture dependent engineering characteristics of some agricultural products have been researched upon by some scientists such as cocoa, bitter kola nuts and shell, fenugreek seeds, tiger nut, peanut, onion and wheat (Davies and Mohammed, 2013, Altuntas *et al*., 2005, Adekanbi *et al*., 2009 and Akcali *et al*., 2006, Bahnasawy *et al*., 2004) and Tabatabaefa, 2003). Some other scientists have also worked on other agricultural products such as soybean, corn extrudates, dried grains, soybean meal, cornmeal, wheat flour, gbafilo fruit and locust bean seed (Davies and El-Okene, 2009, Balasubramanian and Singh, 2007, Davies and Zibokere, 2011, Umar *et al*., 2013 and (Ogunjimi *et al*., 2002).

Other scientists have worked on soybean meal and aqua feeds (Sørensen *et al*., 2011), cocoa bean (Bart-plange and Baryeh, 2002), and pistachio nut and its kernel (Razari *et al*., 2007), peanuts Akcali *et al*. (2006), soybean grains (Tavakoli *et al*., 2009), Simarouba fruit and kernel (Dash *et al*., 2008), Kaleemullah, and Gunasekar (2002) for areca nut and kernels, Thomas and van der Poel (1996) for pelleted animal feed. There is limited information about the effect of moisture on some physical properties of fish feeds pellets. This study aims to investigate the hygroscopic properties of fish feed pellets. Which can be used assessed the storage conditions of feeds, especially in high relative humidity areas such as Niger Delta.

MATERIALS AND METHODS

Calculation Formulas for cylindrical shape materials

Aspect ratio (W) $$W = \frac{h}{2r} \quad (1)$$

The sphericity (φ) $$\Phi = \frac{(1.5W)^{0.67}}{W+0.5} \quad (2)$$

Volume (V) $V = \pi r^2 h = \pi D^2 h / 4$ (3)

Total surface area (TSA)

$TSA = 2\pi r(r + h)$ (4)

Lateral Surface Area (LSA) $LSA = 2\pi rh$ (5)

Base surface Area (BSA), $BSA = \pi r^2$ (6)

Surface area to volume ratio

$SA \div V = 2(r + h) / (r \times h)$ (7)

Base Perimeter (P) $P = 2\pi r$ (8)

Where r represented radius, D is diameter, h is height, W is aspect ratio.

Results and Discussion

The TSA, LSA and BSA, were presented in Fig. 1, 2, 3 and 4. It was observed that the mean TSA, LSA and BSA increased with an increase with soaking time for different sizes of the fish feeds studied. For 3.0 mm pellet size, TSA, LSA and BSA ranged between 0.68 to 1.81 cm^2, 0.52 to 1.26 cm^2 and 0.07 to 0.67 cm^2. While TSA, LSA and BSA ranged between 1.20 to 2.86 cm^2, 0.85 to 1.81 cm^2 and 0.17 to 0.53 cm^2 or 4.0 mm fish feeds pellets size. TSA, LSA and BSA for 6.0 mm and 9.0 mm fish feeds sizes ranged from 1.12±0.15 to 3.46±0.33 cm^2, 1.38±0.33 to 2.11±0.31 cm^2, 0.40±0.01 to 0.67±0.05 cm^2, .2.23±0.26 to 4.38±0.21 cm^2, 1.41±0.27 to 2.78±.0.12 cm^2, 0.41±0.01 to 1.00±0.08 cm^2. It was observed that the three parameters increased with increased in soaking time. This is an indication that feeds absorb water based on the period subjected to water. The variations among the values are significantly different at 5% probability level. The TSA, LSA and BSA, were presented in Fig. 1, 2, 3 and 4. It was observed that the mean TSA, LSA and BSA increased with an increase with soaking time for different sizes of the fish feeds studied. For 3.0 mm pellet size, the TSA, LSA and BSA ranged between 0.68 to 1.81 cm^2, 0.52 to 1.26 cm^2 and 0.07 to 0.67 cm^2.

TSA, LSA and BSA ranged between 1.20 to 2.86 mm^2, 0.85 to 1.81 cm^2 and 0.17 to 0.53 cm^2 or 4.0 cm fish feeds pellets size. The TSA, LSA and BSA for 6.0 mm and 9.0 mm fish feeds sizes ranged from 1.12±0.15 to 3.46±0.33 cm^2, 1.38±0.33 to 2.11±0.31 cm^2, 0.40±0.01 to 0.67±0.05 cm^2, .2.23±0.26 to 4.38±0.21 cm^2, 1.41±0.27 to 2.78±.0.12 cm^2, 0.41±0.01 to 1.00±0.08 cm^2. It was observed that TSA, LSA and BSA increased with increased in soaking time. This is an indication that feeds absorb water based on the period subjected in water. The observed values were significant different ($p<0.05$).

The following equations revealed correlation between TSA, LSA and BSA and soaking time showed for fig. 1:

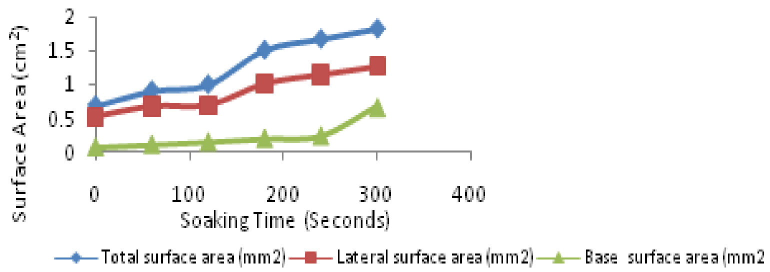

Fig1. *Effect of soaking time on surface area 3.0 mm*

$TSA = 7E\text{-}08T^3 - 3E\text{-}05T^2 + 0.000T + 0.697 \quad R^2 = 0.976$

$LSA = -4E\text{-}08T^3 - 2E\text{-}05T^2 + 0.000T + 0.535 \quad R^2 = 0.972$

$BSA = 8E\text{-}08T^3 - 3E\text{-}05T^2 + 0.0002T + 0.057 \quad R^2 = 0.996$

The following equations revealed correlation between TSA, LSA and BSA and soaking time in Fig. 2:

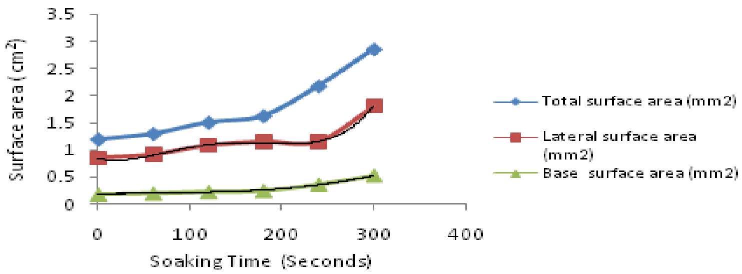

Fig2. *Effect of soaking time on surface area for 4.0 mm feed*

$TSA = 7E\text{-}08T^3 - 1E\text{-}05T^2 + 0.002T + 1.197 \quad R^2 = 0.995$

$LSA = 1E\text{-}07T^3 - 4E\text{-}05T^2 + 0.005T + 0.818 \quad R^2 = 0.944$

$BSA = 2E\text{-}08T^3 - 5E\text{-}06T^2 + 0.000T + 0.169 \quad R^2 = 0.996$

The equations revealed correlation between TSA, LSA and BSA and soaking time in Fig. 3:

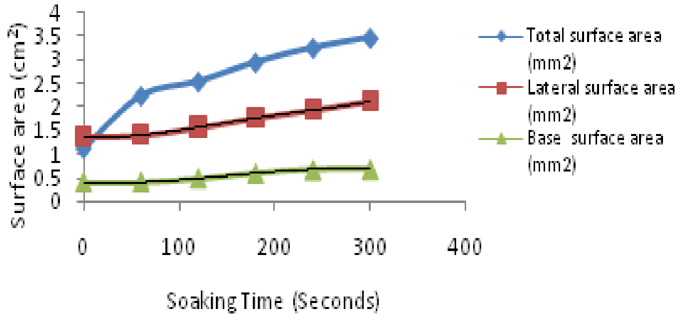

Fig3. *Effect of surface area on soaking time for 6.0 mm feeds*

$TSA = 1E\text{-}07T^3 - 8E\text{-}05T^2 + 0.02T + 1.158 \quad R^2 = 0.989$

$LSA = 9E\text{-}08T^3 - 2E\text{-}05T^2 - 0.000T + 0.375 \quad R^2 = 0.998$

$BSA = 4E\text{-}08T^3 - 2E\text{-}05T^2 + 0.000T + 0.400 \quad R^2 = 0.999$

The equations revealed correlation between TSA, LSA and BSA and soaking time in Fig. 4:

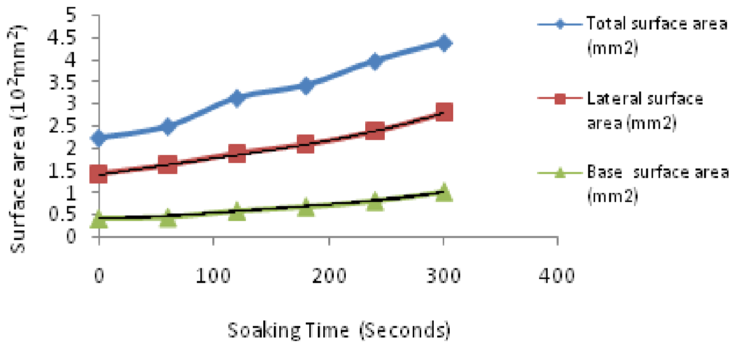

Fig4. *Effect of soaking Time on surface area for 9.0 mm*

$TSA = -3E\text{-}08T^3 + 1E\text{-}05T^2 + 0.005T + 2.208 \quad R^2 = 0.995$

$LSA = 3E\text{-}08T^3 - 8E\text{-}06T^2 + 0.004T + 1.401 \quad R^2 = 0.944$

$BSA = 3E\text{-}09T^3 + 3E\text{-}06T^2 + 0.000T + 0.40 \quad R^2 = 0.996$

The relationship between soaking time, aspect and volume showed in Fig. 5:

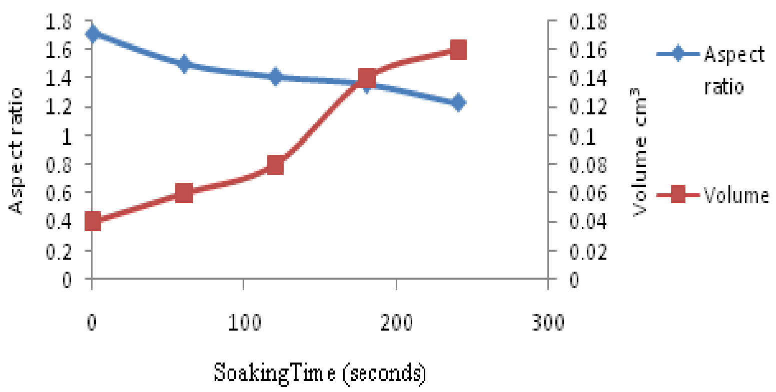

Fig5. *Effect of soaking time on aspect ratio and volume for 3.0 mm feed*

A = -2E-08T³+ 6E-06T² +0.0001T +0.0417 $R^2 = 0.981$

$V = -8E\text{-}08T^3 - 3E\text{-}05T^2 + 0.0052T + 1.7106$ $R^2 = 0.999$

The relationship existing between soaking time, aspect ratio and volume showed in Fig.6:

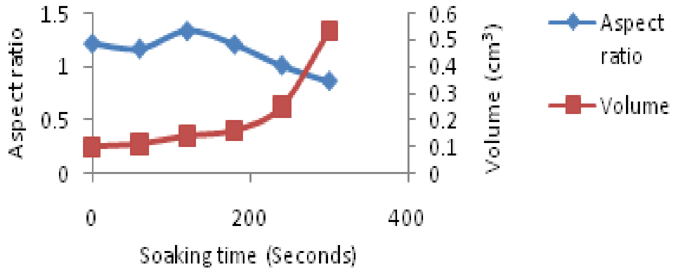

Fig6. *Effect of soaking time on aspect time and volume for 4.0 mm feed*

$A = -2E\text{-}10T^4 - 1E\text{-}05T^3 - 1E\text{-}05T^2 + 0.0003T + 0.0997$ $R^2 = 0.999$

$V = 1E\text{-}09T^4 - 6E\text{-}07T^3 - 0.0001T^2 + 0.0049T + 1.2166$ $R^2 = 0.980$

The relationship between soaking time, aspect ratio and volume is found in Fig. 7:

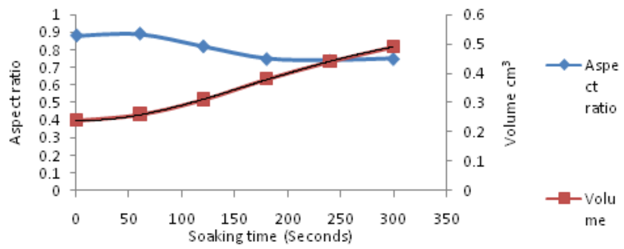

Fig7. *Effect of soaking time on aspect ratio and volume for 6.0 mm feed*

$A = 2E\text{-}10T^4 - 1E\text{-}07T^3 + 3E\text{-}05T^2 + 0.0017T + 0.8797$ $R^2 = 0.999$

$V = 2E\text{-}11T^4 - 2E\text{-}08T^3 - 8E\text{-}.06T^2 + 0.001T + 0.2402$ $R^2 = 0.980$

The relationship between aspect ratio and volume and soaking time is showed Fig. 8:

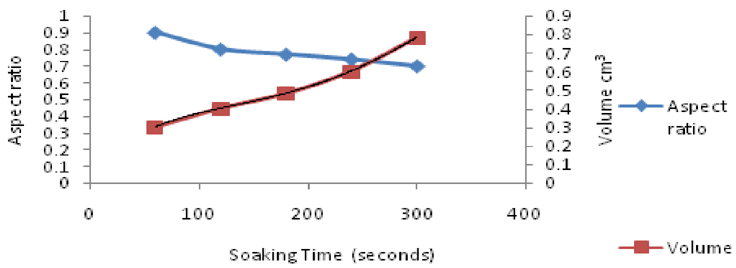

Fig8. *Effect of soaking time aspect ratio and volume for 9.0 mm feed*

$A = 2E\text{-}10T^4 - 2E\text{-}07T^3 + 5E\text{-}05T^2 + 0.0076T + 1.2$ $R^2 = 1.000$

$V = 1E\text{-}10T^4 - 1E\text{-}07T^3 - 4E\text{-}.07T^2 + 0.0054T + 0.08$ $R^2 = 1.000$

The relationship between soaking time and base perimeter is showed Fig. 9:

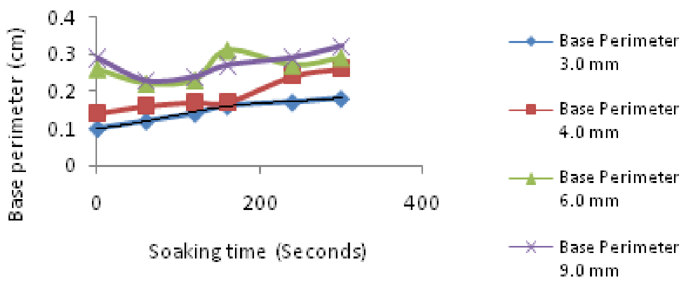

Fig9. *Effect of soaking time on base perimeter*

$B3.0\ mm = 4E\text{-}11T^4 - 2E\text{-}08T^3 - 4E\text{-}06T^2 + 0.0001T + 0.1003 \qquad R^2 = 0.995$

$B\ 4.0\ mm = -2E\text{-}10T^4 + 1E\text{-}07T^3 - 2E\text{-}.05T^2 + 0.0011T + 0.1395 \qquad R^2 = 0.999$

$B\ 6.0\ mm = 1E\text{-}10T^4 - 1E\text{-}07T^3 - 3E\text{-}05T^2 + 0.0023T + 0.2904 \qquad R^2 = 0.991$

$B\ 9.0\ mm = 3E\text{-}10T^4 - 2E\text{-}07T^3 + 4E\text{-}.05T^2 + 0.0028T + 0.2623 \qquad R^2 = 0.728$

The mean height of the four different sizes of fish feeds increased non-linearly from 5.33±0.25 mm to 6.86±0.13 for 3.0 mm size, 5.76±0.25 to 7.04±0.47 for 4.0 mm, 6.17±0.19 to 7.26±0.21 for 6.0 mm and 6.23±0.18 to7.87±0.64 for 9.0 mm with an increase in soaking time from 60-300 seconds (Table 1). The effect of soaking time on the height of fish feeds pellet was statistically significant ($p<0.05$). The expansion observed may be attributed to water absorption, which increases axial dimensions of the feeds. The mean height of feeds was statistically crucial at 5% probability level with soaking time. A similar observation was reported by Davies and El- Okene, (2009) for three varieties of cowpea, Davies and Zibokere, (2011). The effect of soaking time on the Sphericity of fish feeds pellet was not statistically significant ($p<0.05$).

The mean volume of the four different sizes of fish feeds increased non-linearly from 0.04±0.009 to 0.19±0.007 cm^3 for 3.0 mm feed size, 0.10±0.005 to 0.57±0.0029 cm^3 for 4.0 mm feed size, 0.24±0.004 to 0.49±0.008 for 6.0 cm^3 feed size and 0.26±0.009 to 0.53±0.007 cm^3 for 9.0 mm feed size mm^3 with increase in soaking time from 60-300 seconds

Table1. *Some physical properties of fish feeds*

Pellet size (mm)	Soaking Time (sec.)	Height (mm)	Actual diameter (mm)	Ratio of Surface area to volume	Sphericity
3.0	0	5.33±0.25	3.12±0.31	1.66±0.31	0.80±0.02
	60	5.68±0.18	3.78±0.27	1.41±0.23	0.81±0.02
	120	6.12±0.09	4.34±0.12	1.31±0.12	0.82±0.05
	180	6.58±0.10	5.06±0.72	1.08±0.35	0.77±0.05
	240	6.79±0.17	5.52±0.19	1.02±0.17	0.84±0.02
	300	6.86±0.13	5.88±0.56	0.97±0.06	0.77±0.03
4.0	0	5.76±0.21	4.72±0.09	1.14±0.18	0.84±0.01
	60	5.83±0.23	4.98±0.21	1.15±0.20	0.84±0.03
	120	6.51±0.25	5.26±0.11	1.07±0.15	0.84±0.03
	180	6.66±0.57	5.52±0.15	1.02±0.11	0.84±0.03
	240	6.83±0.72	6.79±0.07	0.88±0.03	0.85±0.04
	300	7.04±0.47	8.18±0.06	0.77±0.05	0.86±0.03
6.0	0	6.17±0.19	7.01±0.04	0.89±0.03	0.86±0.03
	60	6.23±0.27	7.22±0.41	0.88±0.06	0.85±0.02
	120	6.38±0.16	7.82±0.53	0.82±0.03	0.86±0.03
	180	6.52±0.02	8.64±0.61	0.77±0.04	0.86±0.04
	240	6.73±0.06	9.15±0.84	0.73±0.03	0.86±0.03
	300	7.26±0.21	9.67±0.46	0.71±0.03	0.86±0.06
9.0	0	6.23±0.18	7.22±0.91	0.88±0.05	0.86±0.03
	60	6.76±0.27	7.52±0.53	0.83±0.03	0.85±0.03
	120	6.89±0.15	8.62±0.67	0.75±0.03	0.68±0.03
	180	7.13±0.43	9.24±0.56	0.71±0.03	0.86±0.06
	240	7.44±0.51	10.08±0.64	0.67±0.03	0.86±0.03
	300	7.87±0.64	11.26±0.87	0.61±0.05	0.86±0.01
	240	6.83±0.25	6.79±0.07	0.88±0.03	0.85±0.06
	300	7.04±0.25	8.18±0.06	0.77±0.03	0.86±0.05

Conclusion

All parameters investigated in this research were moisture dependent physical properties of fish feeds. All the investigated sizes showed significant important at the different soaking time. As soaking time increased, all parameters increased except sphericity. The interaction between the studied parameters and various soaking time revealed non-linear relationship.

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