EFFECTS OF DRYING PARAMETERS ON SOME PHYSICAL PROPERTIES OF A DRIED EXTRUDED FISH FEEDS

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ABSTRACT

Extruded feed is the most typical form of animal feed produced in the world as a result of its numerous advantages over sinking fish feeds. In Nigeria most feeds produced are not floating as a result of poor drying of the feeds. The quality of fish feeds is affected by the physical properties. In this study, the fish feed was formulated and extruded using a single screw extruder, dried in a continuous flow belt dryer for 270 minutes at dryingair temperatures (60, 70, 80, 90 and 100 ^{O}C) drying air velocities (0.7, 0.8, 0.9, 1.0 and 1.2 m/s) and belt speeds (50, 55, 60, 65 and 70 rpm). The density, buoyancy and water stability of the processed feeds were determined. The results show that the minimum value of 545.60 kg/m^3 and 20% were obtained for density and buoyancy of the dried extrudate respectively when the machine was operated at 60 ^{O}C, 0.8 m/s and 70 rpm. The maximum values for density, buoyancy and water stability were55kg/m^3, 99.9% and 65.56% respectively, of the dried extrudate. The effect of the processing conditions on the physical properties (density, buoyancy and water stability) of the feed was observed to be significant ($p < 0.01$).The drying air temperature and air velocity were found to have a major effect on the buoyancy and water stability of the dried extrudate with belt speed having the least effect. Furthermore, the belt speed was found to have a major effect on the density while the drying air temperature and air velocity have minor effects on the dried extrudate density.
Keywords*: Extruded fish feeds, Density, Buoyancy, Water stability.*

1. INTRODUCTION
High-quality nutritionally balanced diets are required by fish to grow and for marketability within a short period. This is possible through the use of fish feeds. Commercially, fish feeds are manufactured either as extruded floating or pelletized sinking feeds. Amalraaj (2010) reported that most fish farmers preferred extruded feeds to sink feeds because they are stable in water, float well, are easy to digest, minimize water pollution, optimize labour usage, minimize wastage of raw materials and save higher energy (Momo *et al*., 2016). The physical properties of feeds are important because they impact the quality of the extrudates. To understand the behaviour of fish feed pellets during processing, transporting, drying, packaging and the ability of the feed to float during fish feeding, mechanical and physical properties of fish feed pellets are required (Khater *et al*., 2014). Rolfe *et al*. (2012), stated that physical properties that affect the floatability of feeds include; density, expansion ratio, sinking velocity, buoyancy or floatability test, water stability and relative absorption ratio. The density of aquatic feeds is important because it affects the sinking and floating properties of the feeds, plant capacity, product appearance and absorption of external coating (Chevanan *et al*., 2007). Extruded products interact with water is characterize by water solubility which indicates index and water absorption of fish feeds which are often important in predicting how extruded feeds convert starch to granule form during processing (Kannadnason and Muthukumarappan, 2010).

It's had been acknowledged that the technical quality of feed pellets such as mechanical strength, uniform moisture in the pellet, drying and structure of the pore are influenced drying of the pellet (Sorensen, 2012; Haubjerg *et al.*, 2014). Reduction in the technical quality of fish feed results in high costs of fish farming that is a reduction in uptake ratios, pollution of both fresh and marine water especially if the fish pellet disintegrates when transported or dispersion offered duringwater immersionand sinks at a velocity outside specifications (Haubjerg *et al.*, 2012). To avoid this, the drying process must be carefully controlled. Excessive energy usage in drying equipment is often reflected in given product quality. Thus, there is the need to study the effect of drying parameters on some physical properties related to the floatability of extruded fish feeds. Although a lot of research work had been done on the effects of drying on extruded floating fish feeds, few works had been reported on the effects of drying on the physical properties of the dried extrudate. Therefore, this research focuses on the effects of drying parameters on some physical properties of dried extruded floating fish feeds.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Sample preparation

The feed materials used were procured from a local market at Akure, Ondo State. The feed was formulated using ingredients used for catfish feed production in Nigeria according to Fagbenro and Adebayo (2005). A single screw extruder which was developed at The Federal University of Technology, Akure, Ondo State was used for the extrusion of the materials. The initial moisture content of the extrudates was determined following AOAC method 44-19 (2000), using a laboratory oven (Thelco Precision, Jovan Inc.,Wincester, VA) at 102°C for 2 h until a constant weight was obtained.

2.1.2. Experimental procedure

The feed materials were finely grinded and weighed to determine their required proportions. About 500 ml of warm water was introduced into 2500 g of the mixed feed materials for proper mixing before it was introduced into the extruder and extruded using a single screw extruder. 2000 g of the wet extruded fish feeds were weighed using a digitized weighing machine. The wet feeds were then dried in a continuous flow belt dryer which was developed at The Federal University of Technology, Akure. The samples were distributed uniformly within the belt dryer as a thin layer. The experiments were performed at air temperatures of 60, 70, 80, 90 and 100 ˚C (Kurt, 2012), air velocities of 0.7, 0.8, 0.9, 1.0 and 1.2 m/ s and drying belt linear speeds of 50, 55, 60, 65 and 70 rpm (Torres and Dincer, 2011) to investigate the effect of these drying parameters on density, buoyancy and water stability of the dried extrudates. Eight successive readings were taken as the drying process continued until there was no change in the weight of the sample. The physical properties of the dried extruded fish feed i.e. density (kg m^{-3}), buoyancy test (%) and water stability were determined.

2.2. Measurement of the Dried Extrudate Physical Properties

2.2.1. Extrudate density

The dried extrudates were cut into 25.4 mm using a razor blade. A kerro electronic balance (Model BL3002) with accurancy of 0.1Mg and sensitivity of 0.01 mg was used to determine the mass while the length of the sectional dried extrudate was determined using a digital calliper (Mitutoyo Inc, Japan) with accurancy of 0.02mm and sensitivity of 0.001″. The density of the dried extrudate was determined as the ratio of the mass of the dried extrudates (8 mm) to the volume by assuming a cylindrical shape for the dried extrudates.

2.2.2 Buoyancy test

This was determined by placing samples of 10 dried extrudates into a 250 ml beaker filled with about 75% distilled water. The degree of floatation was recorded within the time frame of 2 hours by using a stopwatch. The sampling was replicated five times and the mean was obtained. The percentage of floatation at the instantaneous time was calculated as the ratio of the number of dried extrudates afloat to the number of extrudates in the sample (Misra *et al*., 2002).

2.2.3 Water stability

Ten (10) pieces of the dried extrudates were weighed using a kerro electronic balance (Model BLC3002). This was later placed inside a nylon sieve which is tied with a string and inserted into a bowl containing pond water for 30 minutes. After 30 minutes, the feeds were sun-dried for three days and the weight was recorded as M_{30} representing the final weight after 30 minutes immersion. Water stability was determined as the ratio of the weight of extrudates after 30 minutes of immersion to the weight of extrudates (Fagbenro and Jauncy, 1995).

2.3 Data Analysis

Inferential analysis with the aid of SPSS 20 software was used to analyze the data collected and Microsoft Excel (Microsoft Cooperation 2010) was used for graphical descriptions of the data.

3. RESULTS AND DISCUSSION

3.1 Effect of Drying Air Temperature, Velocity and Conveyor Belt Speed on Dried Extrudate Density

Figure 1 shows the dried extrudate density at different machine operational conditions (air temperature, air velocity and conveyor speed). It was observed that the density of the dried feeds decreases as temperature and the air velocity increases under the different machine operating parameters. Also, the maximum fish feed extrudate density of 854.55 kg/m^{3}was recorded when the machine was operated at the lowest air temperature of 60^{O}C, the lowest air velocity of 0.8 m/s and 70 rpm of the conveyor speed while the minimum value of the density of 545.60 kg/m^3 of the dry sample was recorded when the wet sample was dried at the highest temperature of 100 ^{O}C and 1.0 m/s air velocity with the lowest conveyor speed of 50 rpm.

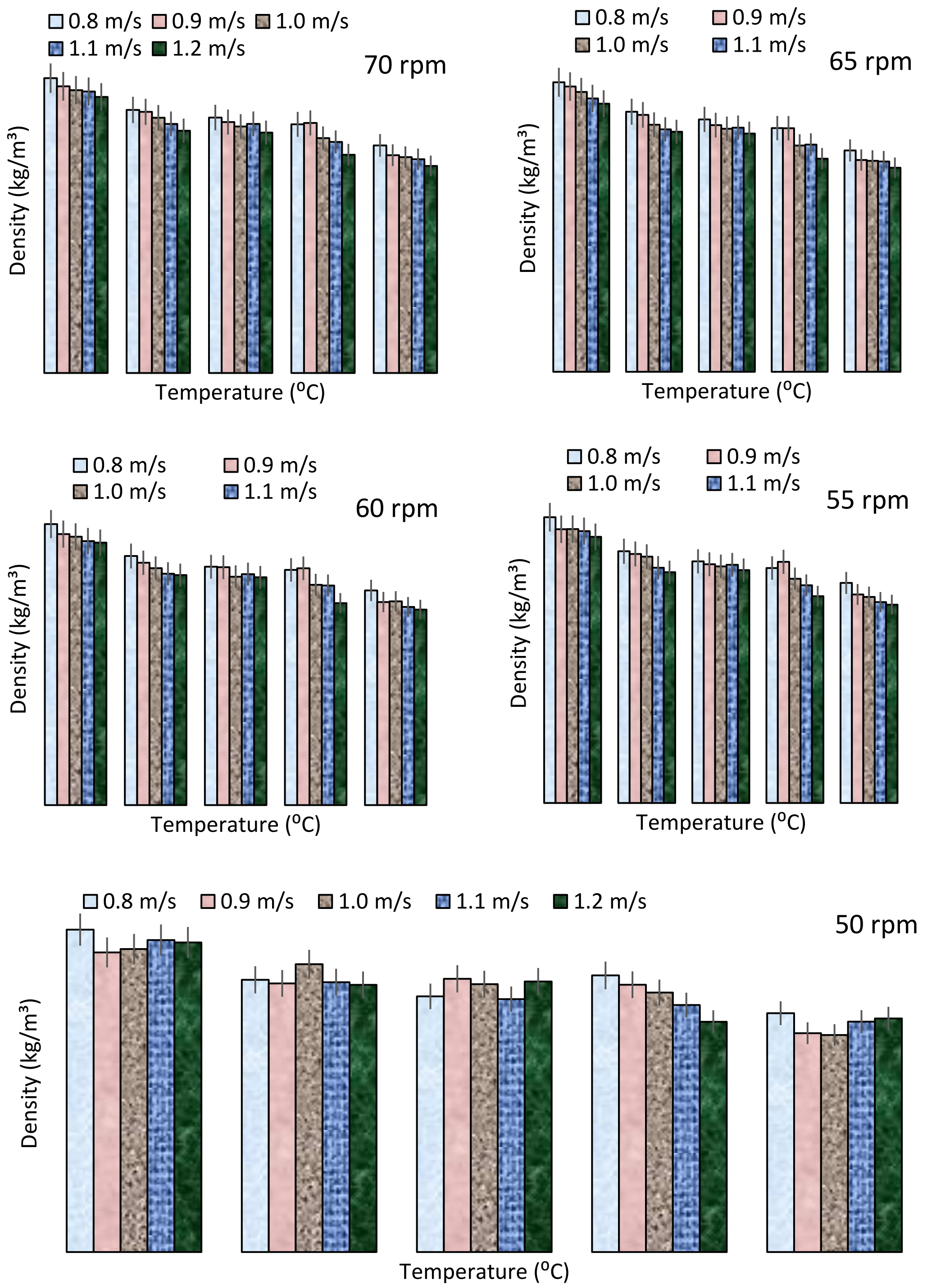

Figure 1: The dried extrudate density at different machine operating parameters.

The result of this study is in a close range with the value of 344 ± 3.11 - 537 ± 1.8 reported by Obirikorang *et al*. (2015) while studying the effects of dietary inclusions of oilseed meals on physical characteristics and feed intake of diets for the Nile Tilapia (*Oreochromisniloticus*). The variation in the density of the extrudate was explained as a function of the operation parameters by developing a multiple linear regression model with an initial consideration of linear relationship with no factor transformation and the resulted model is shown in equation 1. The resulted model shows that the effect of the processing conditions can linearly explain about 89.42% variation in the density of the dried fish feed extrudate at a significant level of P

< 0.01. To validate the accuracy of the model, the experimental data was plotted against the predicted data of the extrudate density as shown in Figure 2.

(1)

Where; ρ is the extrudate density (kg/m^3), T is the air temperature (^{O}C), V is the air velocity (m/s) and Sp is the conveyor speed (rpm).

It was observed that the data (figure 2) was scattered adjacent to a 45° straight line. This implies this model is valid. Also, from equation 1, it can be deduced that the conveyor belt speed has a paramount effect on the variation on the density of the dried extrudates with drying air temperature and drying air velocity having a slight effect on the density variation of the dried extrudates.

3.2 Effect of Drying Air Temperature, Velocity and Conveyor Belt Speed on Dried Extrudate Buoyancy

Figure 3 shows the dried extrudate buoyancy at different operational conditions (air temperature, air velocity and conveyor speed). It was observed that at different machine operating parameters, the buoyancy of the dried feeds increases as temperature and air velocity increase. The result also shows that the maximum value of 99.99% was obtained as the buoyancy of the dried extrudates. This was recorded when the machine was operated at the highest air temperature of 100 ^{O}C, the lowest air velocity of 0.8 m/s and the conveyor speed ranging between 50 and 60 rpm. Also, the minimum value of 20.00% was obtained as the buoyancy of dried extrudates when the drying air temperature was 60 ^{O}C, air velocity of 0.8 m/s and conveyor speed of 70 rpm. A similar result was obtained by De – Cruz *et al*., (2015) who reported that the buoyancy of fish feed ranges between 36.67 to 95 %. Umar *et al.* (2013) stated that buoyancy of fish feeds ranges between 25.00 to 28.00 % and Kamarudin *et al*. (2018) reported a similar range of values of 23.33 -100.00%. The variation in the buoyancy of the extrudate as a function of the operation parameter was analyzed by developing a multiple linear regression model with an initial consideration of linear relationship with no factor transformation and the resulting model is shown in equation 2.

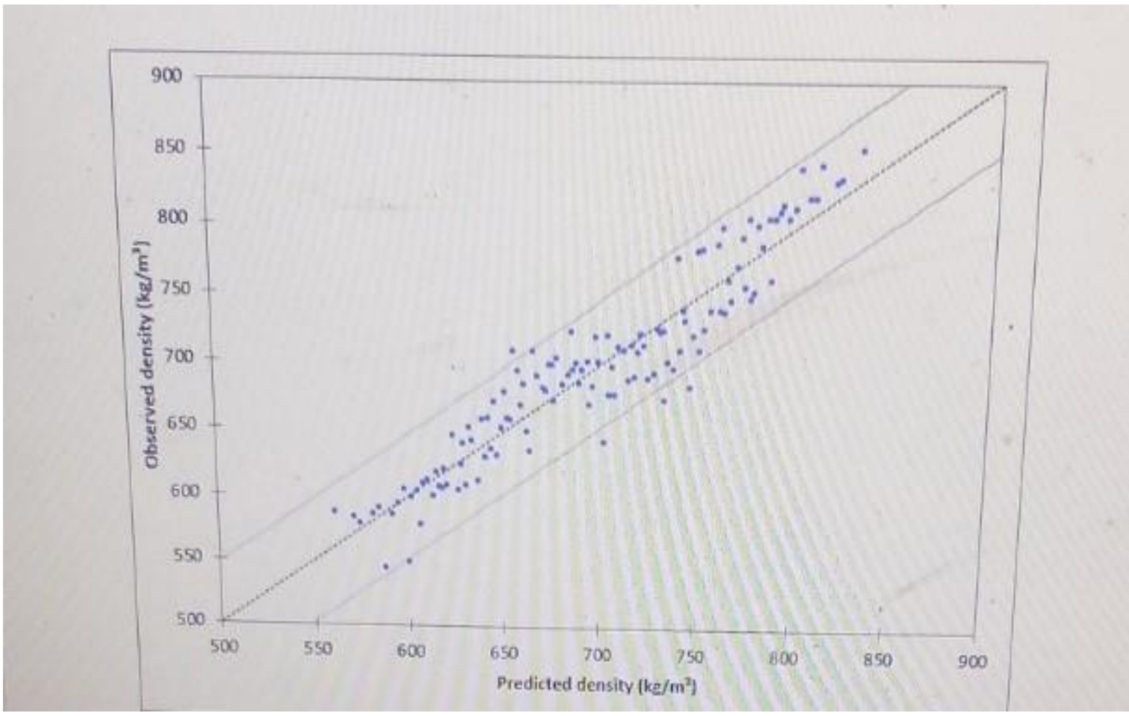

Figure 2: Validation plot for the dried extrudates density model

$$F = -46.59787 - 0.31787S_p + 1.24555T + 30.335334V \qquad (2)$$

Where; F is the buoyancy (%) of the dried extrudate, *T* is the air temperature (^{O}C), *V* is the air velocity (m/s) and *Sp* is the conveyor speed (rpm).

The relationship shows that the operational parameters can linearly explain about 92.94 % variation in the buoyancy of the dried fish feed extrudate at a significant level of $p < 0.01$. Also, from equation 2, it can be inferred that the drying air velocity and drying air temperature have a prime effect on the dried extrudates buoyancy with belt speed having the least effects. Moreover, the accuracy of the model was validated by plotting the experimental data against the predicted data of the extrudate buoyancy as shown in Figure 4. It observed that most of the plotted points fall within the boundary lines between the experimental data and the predicted data. This shows that this model is valid.

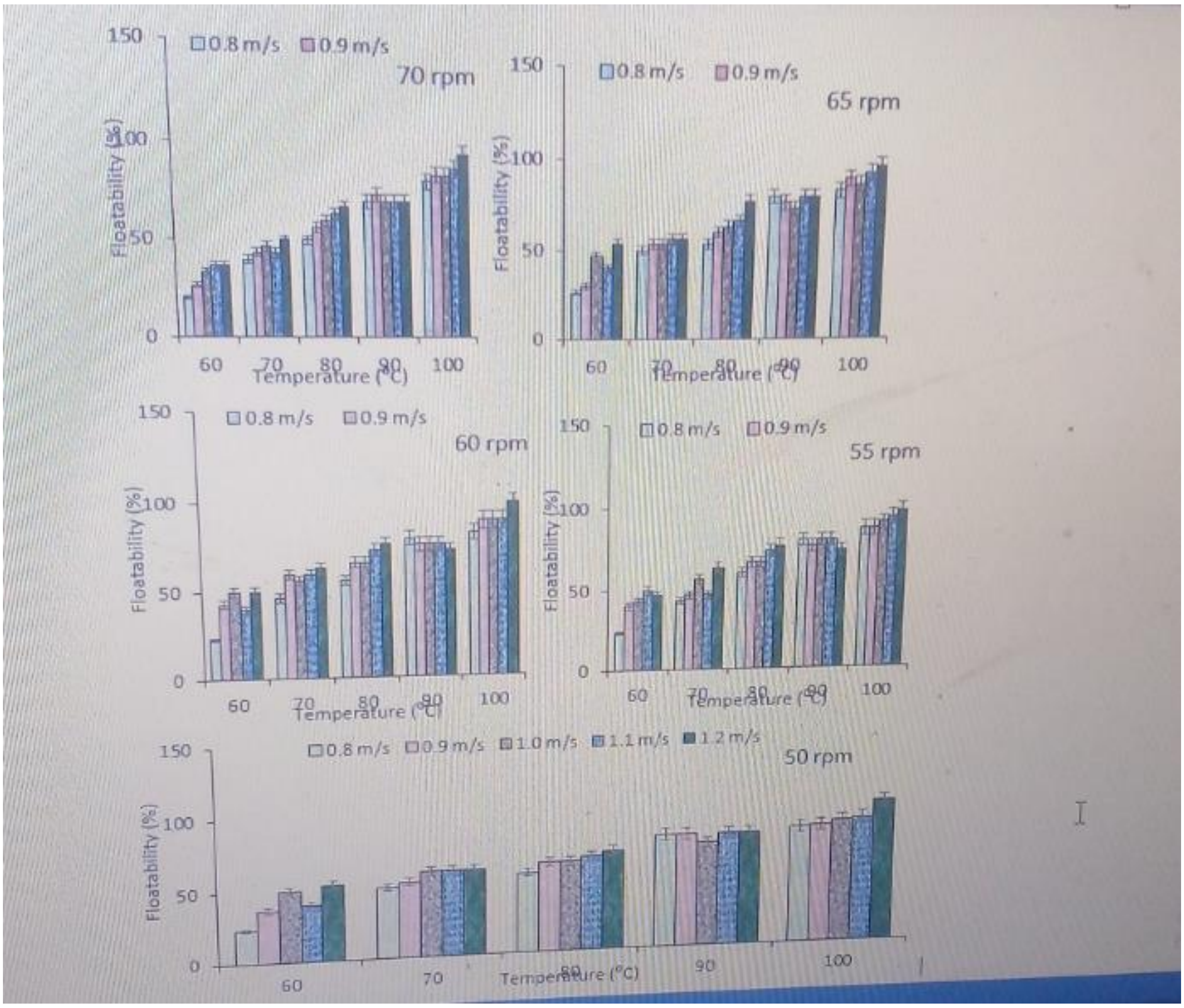

Figure 3: The buoyancy of the dried extrudate under different machine operating parameters

3.3 Effect of Drying Air Temperature, Velocity and Conveyor Belt Speed on Dried Extrudate Water Stability

Figure 5 shows the graphical representation of the extrudate water stability at different operational conditions (air temperature, air velocity and conveyor speed). It was observed that the water stability of the dried fish feeds increases with an increase in the drying air temperature and the drying air velocity and decrease as the conveyor belt speed increases. Furthermore, the water stability of the dried fish feed extrudate under different machine operational parameters shows that the maximum water stability of 65.86% of the fish feed extrudate was recorded when the machine was operated at the highest air temperature of 100 ^{O}C, the highest air velocity of 1.2 m/s and the lowest conveyor speed of 50 rpm 6.45 % was obtained as the minimum value of the dried extrudates and this was recorded when the wet extrudate was dried at the lowest temperature of 60 ^{O}C and lowest air velocity of 0.8 m/s with 60 rpm conveyor speed. However, the result of this study is lower to the range of value (84.50 ±0.19 – 93.96 ± 0.45%) reported for water stability of fish feed by Obirikorang *et al*. (2015), while studying the effects of dietary inclusions of oilseed meals on physical characteristics and feed intake of diets for the Nile

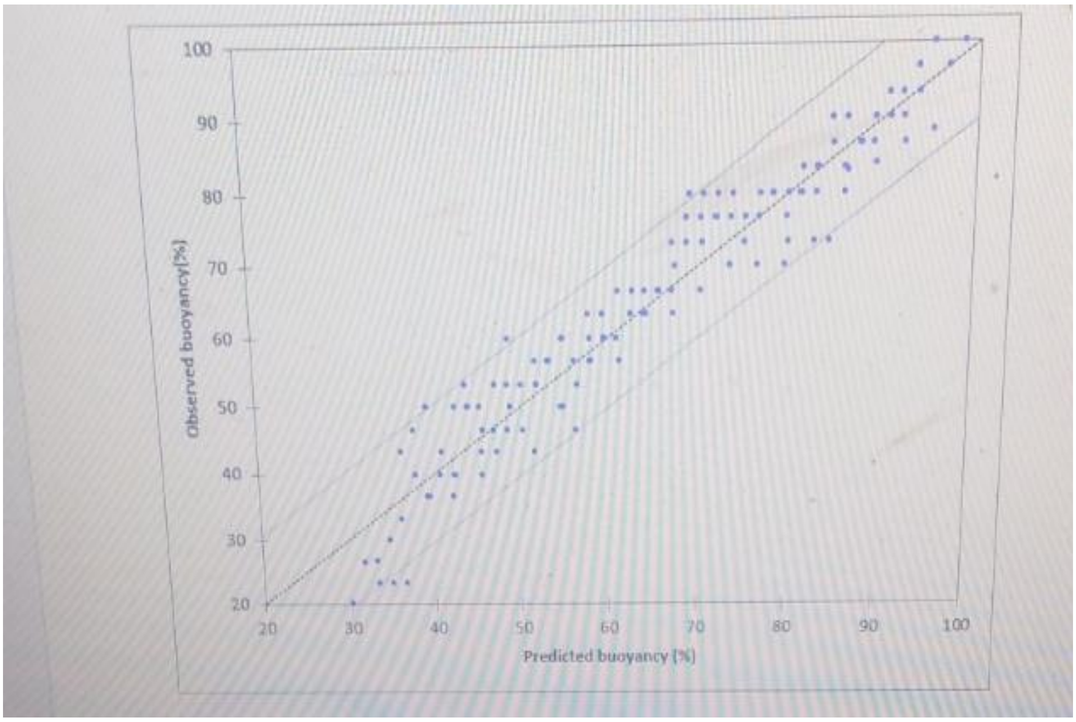

Figure 4: Validation plot for the buoyancy of the dried extrudate model

Tilapia (*Oreochromisniloticus*). De-Cruz *et al*. (2015) reported 11.47 – 17.67% as the range of water stability of fish feed during the study of the influence of processing parameters on the extrusion behaviour and quality properties of the feed pellets and this result fall within the range of value obtained in this study. The variation in the water stability of the extrudate was explained as a function of the operation parameter by developing a multiple linear regression model with an initial consideration of linear relationship with no factor transformation and the resulted model is shown in equation 3. The relationship shows that the operational parameter can linearly explain about 85.78 % variation in the water stability of the dried fish feed extrudate (P <0.01). In addition, the drying air velocity and drying air temperature were found to have an eminent effect on the variation of the water stability of the dried extrudates with the belt speed having minimal effects as extrapolated in equation 3. To validate the accuracy of the model the experimental data was plotted against the predicted data of the extrudate water stability as shown in Figure 6.

$$W_s = -80.6410 - 0.1282S_p + 0.884T + 54.796V \qquad 3$$

Where,

Ws is the water stability (%) of the dried extrudate, T is the air temperature (^{O}C), V is the air velocity (m/s) and Sp is the conveyor speed (rpm).

Furthermore, it was deduced from the developed model that a unit change in the drying air temperature and drying air velocity resulted in a non-significant increment (P<0.05) in the water stability of the dried extrudate by 0.88% and 54.80% respectively. However, an increase in the conveyor speed by 1 unit resulted in a non-significant decrease (P<0.05) in the water stability of the dried extrudate by 0.13%.

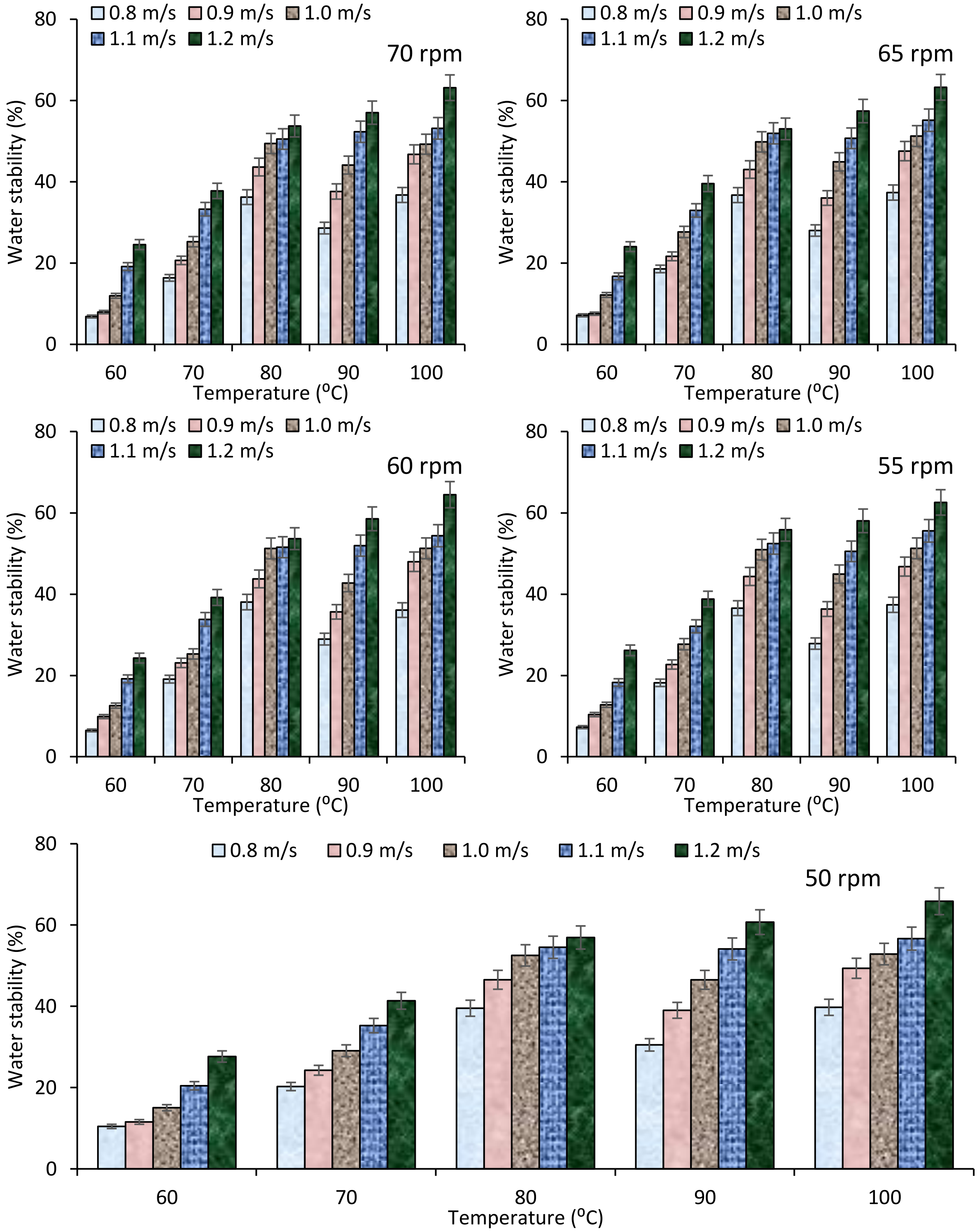

Figure 5: The water stability of the dried extrudate under different machine operating parameters

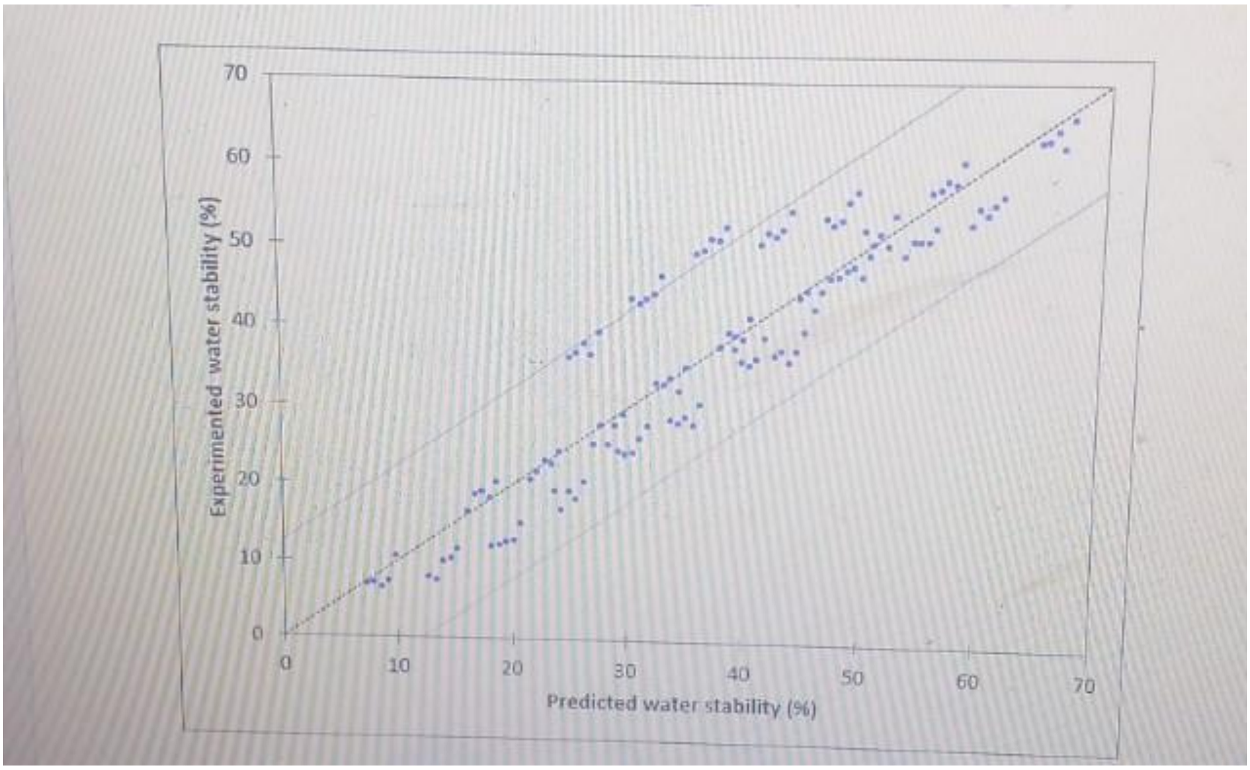

Figure 6: Validation plot for water stability of the dried extrudate model

4. CONCLUSION

The effect of drying parameters on density, buoyancy and water stability related to floatability of dried extruded fish feeds was investigated. The drying air temperature and air velocity has a minor effect on the variation in the density of the extrudate whilst the conveyor speed had the major influence on the variation of the density of the dried extrudate. For variation in the buoyancy of the dried extrudate, the drying air temperature and air velocity have a major effect on the variation whilst the conveyor speed had the least influence on the variation in the buoyancy of the dried extrudate. Variation in the water stability of the dried extrudates shows that the drying air temperature and velocity were found to have a major influence on the water stability of the dried extrudates while conveyor speed has the least effect on the water stability of the dried extrudates.

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