SOME ENGINEERING FACTORS AFFECTING FISH BY- PRODUCTS RECYCLING

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ABSTRACT

*The main objective of the present work is to Study the properties of the fish by-products which result from the fish industry (Fillet tilapia) and the proportion of edible parts to non-edible parts tilapia fish from natural. Some physical properties of tilapia fish and its by-products .The drying behavior of Nile fish by- products was investigated in a mechanical dryer and the mathematical modeling by using thin layer drying model (*Lewis's *models) was used. The impact of the drying air temperature (60, 70 and 80 ^{0}C) ,hot air velocity (1.0 ,1.5 and 2 ms^{-1}) and The thickness layer(5,7 and 9 mm) on the fish moisture losses against drying time has been studied. Drying rate, moisture ratio, cost estimation and Chemical assays of the drying process were also considered. The obtained data showed that, average mass fish, skin, trimming, viscera, Head, backbone and meat 373.815, 12.002, 16.325, 34.631, 67.657, 54.88, 187.136 g respectively. The shortest drying time of the fish was recorded at 150 min with 80 ^{0}C drying air temperature, thickness layer 5mm and 2 ms^{-1} air velocity. While, the longest drying time was recorded at 510 min with 60 ^{0}C, thickness layer 9 mm and 1 ms^{-1} treatments .Moisture content decreased from an initial level of about 106.5% (d.b.) to range between 4.4and 2.2% (d.b.) at the end drying process depending on the drying conditions. Moreover, drying rate was increased with the increase of drying air temperature, air velocity and reducing the thickness of the layer. Between tested model, the modified simple exponential model was found to be the most suitable for describing the drying behavior of the fish by-products. The effects of drying air temperature and velocity on the drying constant and coefficient were also shown. On the other hands, the calculated operation cost of the dryer approaches about 2.92 LE/kg of dried whole fish by-product. The protein content in the final product 45%.*

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INTRODUCTION

Tilapia has been distributed throughout the world and has become the second most important food fishes in the world. Tilapias possess an impressive range of attributes that make them ideal for aquaculture. Fish by-products with high economic value is considered as containing a high proportion of protein. As a result of neglect, lack of recycling is not take advantage of them and cause pollution of the environment with a high degree where it is fast decomposition produces odors and gases are corrupt. In some cases, up fish by-products to 50% of the fish mass . So now the world tended to recycle the by-products and recycled for use in different areas (diet poultry and fish diet). Total Egyptian fish production of about 1.35 G g (GAFRD,2013). Sources of fish By- Products: Fish farm by-products (fishing products) are small fish remaining after fishing and selling to dealers and these small fish represent 5% of the farm produce **(El Said et al, 2011)**,Remnants of fish restaurants that are converting fish to foods, as well as remnants of eating fish from the thorns, head , tail fins and other by-products generated, as it represents the proportion of the intake to the waste generated 50% of the fish weight **(Ali,2000)** and Remnants of fish rings any remaining fish from the sale of any small fish and corrupt by-products in the trading operations, as well as remnants of the Faille.

Fish meal: Fish meal is prepared from the remaining fish by-products hen preparing sliced fish, remnants, canning factories Full rotten fish and fish with low nutritional value. **Ibrahim et la.(2001)** reported that ways of fish meal manufacturing: as first way to cook - pressure - drying- and grind it for fish meal, and are manipulated by adding antioxidants where packaged and stored ,The second method, a method of direct drying where the raw material is dried by hot air directly , The third way solar drying and The fourth way solvent extraction **Rustad (2003)** Found that The major non-edible by-products arising out of fish processing include viscera, skin, scales and bones. In many countries, the fishery sector is unorganized and has problem of disposing fish waste generated as a consequence of processing fish for the consumption. This waste is collected and dumped in waste sites which sometimes are left without any form of control. These fish wastes are an important source of proteins and lipids and therefore special efforts are being made to recover these valuable substances . Chemical treatment is a coagulation process in which added chemicals (coagulants) form flocks to which dispersed pollutants easily attach **(FAO, 2010) . (Sobukola and Olatunde, 2011)** mentioned that Drying of fish is important, because it preserves fish by inactivating enzymes and removing the moisture necessary for bacterial and mould growth. The safe moisture content for fishmeal storage was lower than 12%db. It is important, for digestibility of fish meal, to maintain moisture around the protein. To accomplish this it is essential to keep the maximum product temperature inside the dryers below 100^0C. If protein is overheated the amino acid structure changes. As a result the protein is not easily recognized nor absorbed by the intestines of the animals. From a practical point of view, overheating of the fishmeal makes the fishmeal less digestible. **Zhiqiang Guan et al.(2013)** The hot convective drying of fresh tilapia fillets was evaluated in a heat pump dryer. The influence of the drying temperature (35, 45 and 55^0C), hot air velocity (1.50, 2.50 and 3.50 ms^{-1}) and thickness (3, 5 and 7 mm) of the tilapia fillets on the moisture ratio and drying rate has been studied. It shows that drying process took place in falling rate periods. The experimental drying data of fresh tilapia fillets under different conditions was fitted to nine different commonly used thin-layer drying models Constant drying rate period was not observed, the drying process took place in the falling-rate period. With the increase of the drying temperature, drying velocity and reduction of the thickness, the moisture ratio decreased and the drying rate increased.

The main objectives of this study are:

- Physical properties of tilapia fish by-products.
- Ratio of edible parts to non-edible parts tilapia fishes.
- Thin-layer drying characteristics of fish by-products using the there mal dryer at different air temperature, thickness layer and hot air velocity.
- Estimate drying cost of the dried fish by-products.
- Effect of different process on Chemical Composition.

MATERIALS AND METHODS

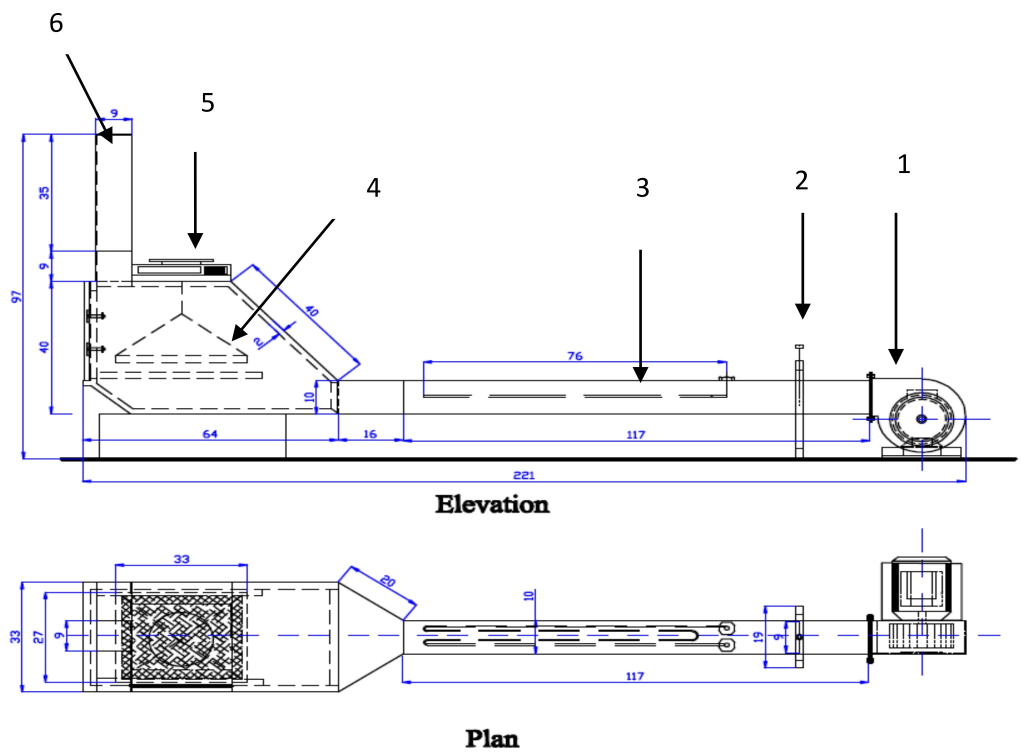
1. **Fresh tilapia and its fish by-products:** Raw material of tilapia fish was used to study its physical properties of parts . Fresh tilapia were obtained from EL- Alabor market Cairo, Egypt. The fish transfer immediately in plastic box containing crushed ice to the house , packed in polyethylene bag and stored at -18^{0}C until the time of the experiment. Before any experimental range, fish taken from the refrigerator and placed in the laboratory to achieve the ambient air temperature.by-products of fresh tilapia (Fillet tilapia) were obtained from EL- Alabor market in the province of Cairo, Egypt. The by-products transfer immediately in plastic boxes containing crushed ice to the house and packed in polyethylene bags and stored at -18^{0}C until the time of the experiment. Before any experimental range, by-products taken from the refrigerator and placed in the laboratory to achieve the ambient air temperature.

2.Unit drying:

The convection dryer was constructed and tested at the work shop of the Faculty Agricultural Engineering , Al-Azhar University, Nasr City, Cairo, in3/2/ 2014 - 3/4/ 2015. The dryer was fitted with a temperature control system. The dryer consists of. (As show in fig(1)).

1. Forced air section: A small air blower of 300 W, 220 V, made in China was used to supply the hot air flow rate. this blower connected to the air heating section.
2. Air control gate :Sections of the sheet thickness of 10 mm moving up and down through the spiral nail to pass the amount of air required
3. Tray drying :Made with a fixed aperture wire mesh of galvanized iron for enter hot air product parts dimensions (330 × 270) mm framed of wood thickness of 30 mm on a rectangular shape.
4. Air heating section: Room with dimensions of 1300 mm length, 100 mm width, 100 mm high made of galvanized iron sheet of 5 mm thickness and insulated from the outside by glass wool with thickness of 30 mm to prevent heat loss. The electrical heater of 3 kW was fixed inside the housing to heat the drying air In the form U.
5. Drying section : The drying chamber was constructed of wooden panels 400 x 330 x300 mm (20 mm thick), The side walls and bottom of drying chamber were insulated by foam layer. Drying air inters the

chamber after leaving Air heating section through an air duct from the bottom to the top of the dryer bin. The dryer door was made of wooden panels with gross dimensions of 330 mm long and 300 mm wide, the door was connecting to drying chamber by two hinges the door was tightly sealed by a rubber gasket during the drying process. unit drying was mounted on a wooden stand 800 mm higher from the ground.



1-Air blower
2-Air control gate
3-Air duct and inlet air heater
4-tray drying
5-Balance
6-Chimney

Fig.(1): Elevation and plan of unit drying.

Measurement instruments:

1.Digital veneer: To measure dimensions (Accuracy with 0.01 mm).

2.Electric oven: with the following specifications (VENTICELL55 type, 230V, 50/60 Hz, 1250 w, 250Max.tempruture) is used to determine the moisture content of by- products samples, at 105^0C for 24 hour drying time.

3.Anemometer: The measured velocity air inside the drying chamber by an anemometer (Chinese industry, Range from 0 to 44 ms-1, accuracy with 0.1 ms-1).

4.Toluene (C7H8): To estimate the real volume, and then estimate the true density.

5. Stop watch: The time spent in the compression process is determined by the stop watch (Casio type).

6. A digital balance was used for measuring the weight of the sample of by-products during drying. Range of the balance is up to 5 kg with a sensitivity of 0.1 g.

7.Temperature control device:

Is connected to the temperature sensor inside the drying chamber for temperature sensor drying air temperature. This sensor is connected to a digital thermostat. Digital thermometers (a type of Dixell, not a model. "XR10CX - 5N0C0)" is the accuracy of 0.1^0C. The sensitivity ranged from 0.1 to 2^0C and work in a temperature range of 0-400^0C.

2.Methods:

1.Initial moisture content of samples:

Initial moisture content of samples was determined by oven at temperature of 105 ^{0}c for 24 hours **(AOAC Standards,2005)**.It can be calculated as follows.

$$\boldsymbol{m_i = \frac{W_m}{W_m + W_d} \times 100} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $\boldsymbol{m_i =}$ Moisture content wet basis,% .

W_m= Mass of moisture in sample (g).

W_d = Mass of bone dry material (g).

$$\boldsymbol{M_i = \frac{W_m}{W_m - W_d} \times 100} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

$\boldsymbol{M_i =}$ Moisture content dry basis,% .

W_m= Mass of moisture in sample (g),

W_d = Mass of bone dry material (g)

2. Moisture content at any time ($\boldsymbol{m_t}$), (wet basis %):

The moisture content, wet basis % is determined every 30 minutes as follows **(Tayel, et al., 2012)**

$$\boldsymbol{m_t = \frac{B - A(1 - m_i)}{B}} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Where:

A = Mass of fresh sample (g).

B = Mass of sample at any time (g) .

m_i = Initial moisture content, w.b. %. .

3. Moisture content (M_t), (dry basis %):

The moisture content, wet basis % is determined every 30 minutes as follows **(Tayel, et al.,2012)**.

$$\boldsymbol{M_t = \frac{B}{A} \times (1 + M_i) - 1} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4)$$

M_i =Initial moisture content, (dry dasis%)

4. Moieture ratio (MR)(d.b %) and drying rate constant, (k): The Drying rate constant (k) is determined as follows. **(Lewis, 1921)**

$$\boldsymbol{MR = \frac{M_t - M_e}{M_i - M_e} = e^{-K\,t}} \quad \dots\dots\dots\dots\dots\dots\dots.\dots.... (5)$$

Where:,

M_i : Initial moisture content, % (d.b).

M_t: Moisture content at any time during drying,% (d.b).

M_e: Equilibrium moisture content, % (d.b) .

k : Drying rate constant (min^{-1}).

t : Drying time , min.

Determination of the drying rate constant, (k):By using equation (5), "k" was expressed in a linear form as follows:

$$\boldsymbol{ln\,MR = -Kt} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

So, plotting ln MR vs." t" results in a slopping down straight line whose slope is k.

5. Cost analysis: The dryer hourly costs were calculated based on the fixed costs and variable costs of convection dryer by using the following formula **(Awady et al., 2003)**

$$\boldsymbol{C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (W.e) + \frac{m}{200}} \quad \dots\dots.\dots\dots\dots (7)$$

Where:**C** = Dryer hourly cost, L.E. /h , ***P*** =Price of dryer, L.E.,=540 L.E , **h** = Yearly working hours, which were is assumed in the present work to be:(300 day/year x 2 period/day x 8 h/period = 4800 h/year) , ***a*** = Life expectancy of machine, about (10 Year). , ***i*** = Interest rate/Year. (The bank interest in Egypt), which was about 11%., ***t*** = Taxes and overheads ratio, which is assumed in the present work to be 20 %. , ***r*** = Repair and maintenance ratio, which is assumed in the present work 10 %., ***W*** = Power of dryer (kW).,***e*** = Hourly cost/kW .h, (0.25 L.E./kW .h)., **m** = The monthly average wage, L.E., (800 L.E), impose that here are 10 dryers becomes (80 L.E./man. dryer, month)., **200** = The monthly average working hours.

$$\boldsymbol{Cost(L.E/Kg_{dried\ product}) = \frac{Dryer\ hourly\ cost(L.E/h)}{Dryer\ productivity(kg_{dried\ product}/h)}} \ldots\ldots(\mathbf{8})$$

RESULTS AND DISCUSSION

1.The mean of fish Tilapia parts :

Prior any experimental run, the fish were taken out of the refrigerator and kept in the laboratory to attain ambient air temperature. On arrival at the laboratory .Ten were dissected fish close in weight to know the average every part of the fish. average mass fish, skin, trimming, viscera ,Head, backbone and meat 373.81 , 12.002 , 16.325 , 34.63 , 67.657 , 54.884 and 187.136 g respectively, and The coefficient of variation were 5.74,0.35,0.36,0.93,1.22,1.4,5.31 respectively . It were aparts proportion in relation the weight of the fish. proportion skin, trimming, viscera , Head, backbone and meat 3.21,4.36,9.26,18.09.14.68 and 50.061% respectively. Part was eaten to by-product represents 50%**.** These ratios approximate percentages mentioned by **(Dumay 2006)** review.

2. Fish by-products specifications :

Average mass, length, width and thickness of a fish by-product were 203.3 g, 22.55 cm, 9.85 cm and 3.304 cm respectively.

3. Apparent density of fish by-products:

Average apparent density of fish by-products (Shops selling fish) 1.107 gcm^{-3} . Knowledge of by-product can determine the density of the vacuum occupied by amount of by-product.

4.Real density of fish by-products:

Average apparent real of fish by-products (Shops selling fish) 1.1305 gcm^{-3}. Use the chemical (toluene) in determining the real density to occupy vacuum between parts by-products .

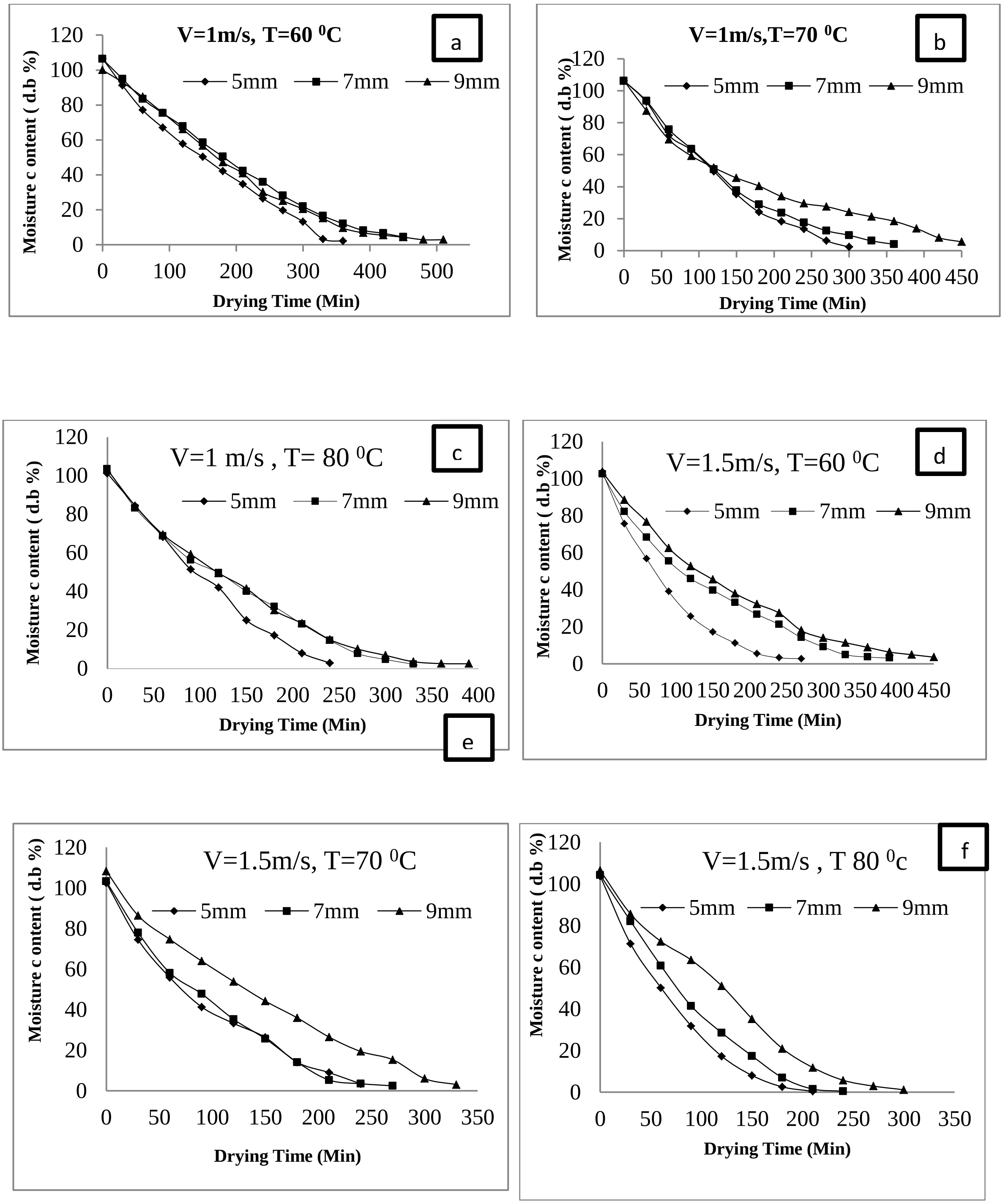
5.Initial moisture content of samples:

Initial moisture content of fish by-product Shops selling fish 68.49 (w.b%). Initial moisture content of fish by-product restaurants fish 66.14 (w.b%).

6.Behavior of the convection drying regimes:

6.1. Evaluation of the effect of convection air temperatures , thickness of the layer, and velocity on the product moisture content and elapsed time:

A single layer of fish by-products was dried in Thermal dryer under controlled condition of temperature, thickness of layer and air velocity. The drying experiments were conducted for temperature range of (60,70 and 80) ^oC, thickness of layer (5,7 and 9) mm and air velocity range of (1, 1.5 and 2) ms^{-1}. General trend was observed where, the initial moisture content decreased with the increasing in drying air temperature, air velocity and drying time. The limited information is available on the kinetics of water removal from fish by-products. The decreased moisture content could be attributed to increased evaporation of water both on the surface and in the by-products due to increasing temperatures and velocities of drying air. Fig.(2) shows that the initial moisture content of 106.5%d b decreased to rang between 2.1 and 2.7%db at the end drying process depending on the drying conditions. For instance, the shortest drying time was recorded at 240min with 80^oC drying air temperature ,thickness 5mm and 2ms^{-1} air velocity. While, the longest drying time was recorded at 510min with 60^oC,thickness 9mm and 1m/s treatments. One drying model (Lewis's) has been used to describe drying curve. The model type, model constant and determination coefficient (R^2) of one different models used for moisture ratio change with drying time are presented in Table 1. Based on these results, the modified simple model was found to be the best fitted model to describe the drying curves in all the treatments tested.



a
V=1m/s, T=60 ^{0}C
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)
b
V=1m/s,T=70 ^{0}C
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)
c
V=1 m/s , T= 80 ^{0}C
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)
d
V=1.5m/s, T=60 ^{0}C
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)
e
V=1.5m/s, T=70 ^{0}C
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)
f
V=1.5m/s , T 80 ^{0}c
5mm
7mm
9mm
Moisture c ontent (d.b %)
Drying Time (Min)

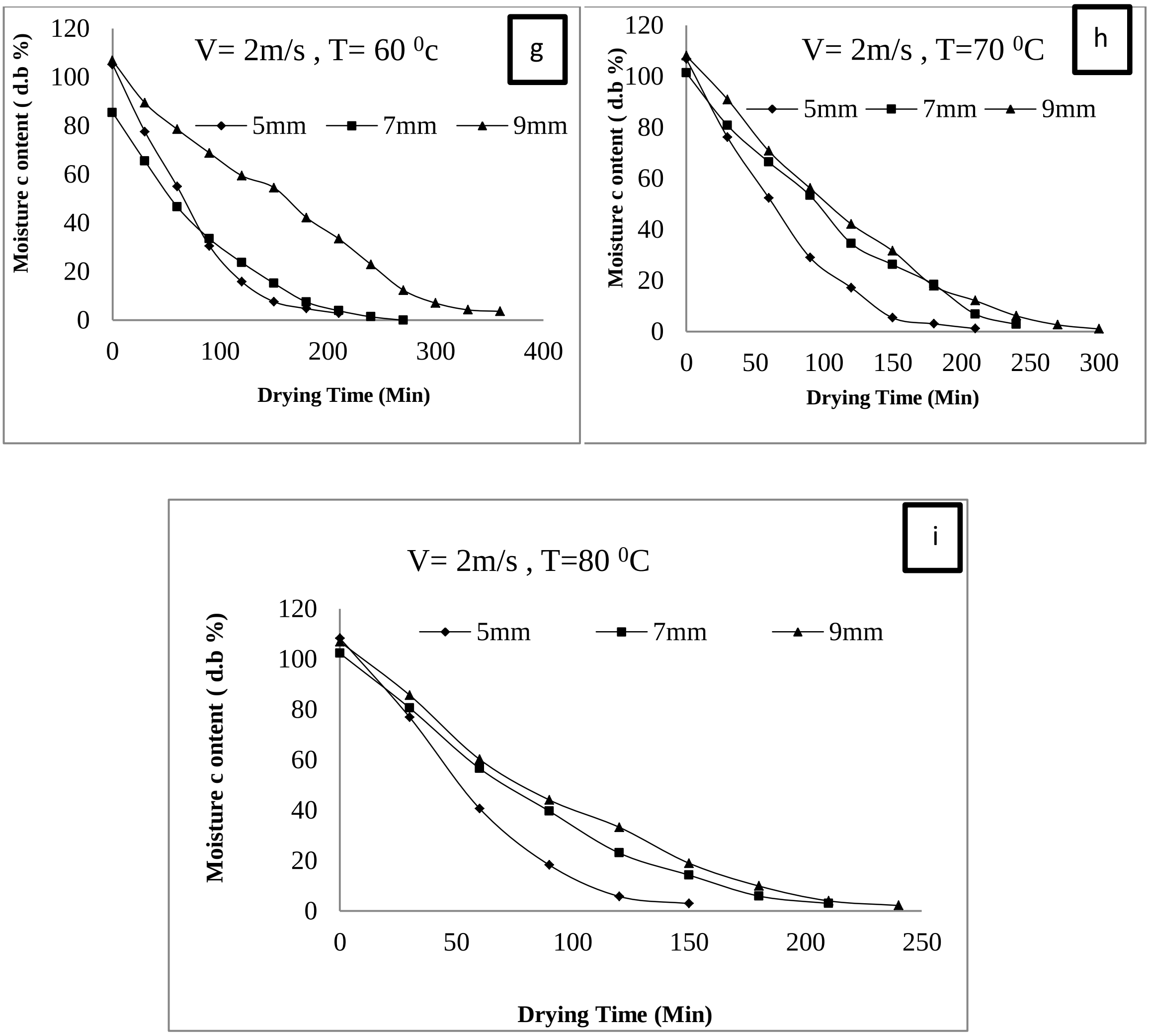


Fig. (2):(a to i) Moisture content(d.b%) as related to drying time(min) at When velocity (m/s) , drying air temperature(^{0}c) and thickness of layer (mm).

6.2. Find drying constant (k) : Table (1) shows the drying constant values (k) obtained at different temperatures , air velocities and thickness of fish by-product . The square root values (R^2) ranging between 0.89 and 0.94 , it is noted that the k values have been steadily increasing with the increase in both temperatures air speeds and inversely with the thickness of the layer. By using SPSS program regression analysis. can optima these relation between K and different variables.

$$K = 0.000133\left(\frac{v^{0.779}.T^{1.284}}{th^{0.805}}\right)$$

$$MR = e^{-0.000133\left(\frac{v^{0.779}.T^{1.284}}{th^{0.805}}\right)t} \quad \ldots\ldots\ldots\ldots\ldots..(10)$$

7.Costs analysis:

The operating cost (L.E./h) for the convection dryer and the costs of kilogram dried product for fish by-product by equation (7) and (8) . The costs for were calculated at the drying conditions that achieved the highest quality of the product and less drying time. The operating cost of convection dryer was 0.6402 L.E./h for . The costs of kilogram dried product were 2.909L.E. /kg dried air temperature 80 °C, thickness layer 5mm and Air velocity 2m/s.

8.Chemical analysis The final product:

Conducted chemical analysis laboratory at the Faculty of Agriculture of the Central University of Al-Azhar. Protein ratio ranged from40to45.88%, fat ratio from 13.4to26.4%, fiber ratio from 25to 6.37, starch ratio from 9.37to23.04%. Table (2) Shows Sample chemical Analysis Under different variables.

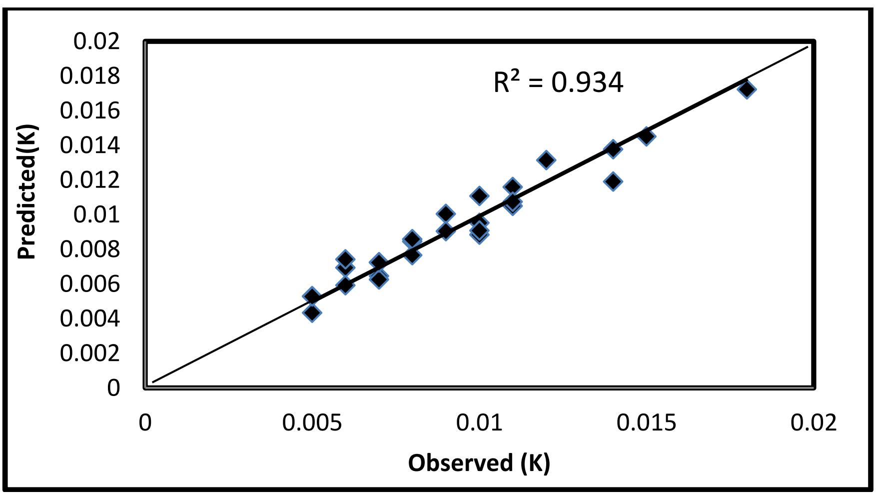


Fig.(3):Predicted and observed (K) for fish by-products slices at different drying condition.

Table (1): Drying rate constants.

Velocity ms^{-1}	Temperature ^0c	mm Thickness	K Min^{-1}	R^2
1	60	5	0.006	96.4
		7	0.005	96.2
		9	0.005	94.8
	70	5	0.008	96.5
		7	0.007	97.9
		9	0.005	98.6
	80	5	0.009	95.6
		7	0.008	96.1
		9	0.007	97.6
1.5	60	5	0.010	98.9
		7	0.007	98.5
		9	0.006	98.4
	70	5	0.011	98.8
		7	0.010	97.8
		9	0.007	97.4
	80	5	0.014	98.6
		7	0.011	97.2
		9	0.008	95.0
2	60	5	0.014	97.2
		7	0.010	98.2
		9	0.006	94.4
	70	5	0.015	97.9
		7	0.010	96.3
		9	0.009	96.7
	80	5	0.018	98.4
		7	0.012	97.0
		9	0.011	97.4

Table (2): Sample chemical Analysis.

Sample	V m/s	T C^0	Th mm	Fat %	Protein%	Fiber%	Starch %
1	1	60	5	26.4	40.41	1.25	17.13
2			7	25.3	43.33	4.13	15.74
3			9	25.5	40.00	5.46	15.62
4		70	5	20.8	41.79	5.87	16.72
5			7	18.2	42.9	4.89	9.37
6			9	16.8	43.58	5.74.	23.04
7		80	5	19.5	42.44	5.65	19.17
8			7	21.0	41.45	3.69	17.12
9			9	18.2	44.04	5.41	16.36
10	1.5	60	5	18.5	41.62	4.65	16.32
11			7	22.0	41.34	5.65	18.44
12			9	18.2	42.9	4.89	9.37
13		70	5	22.3	41.79	4.25	18.17
14			7	15.0	45.88	5.63	15.77
15			9	13.4	45.28	6.50	16.93
16		80	5	17.5	45.51	4.26	20.64
17			7	18.5	45.40	4.79	19.88
18			9	18.8	45.04	6.36	20.94
19	2	60	5	16.8	43.57	5.52	20.91
20			7	19.5	41.78	4.13	19.80
21			9	18.4	43.11	4.82	17.09
22		70	5	17.3	43.95	4.80	18.90
23			7	15.6	42.54	5.41	16.69
24			9	16.0	46.64	5.95	19.83
25		80	5	15.1	45.08	4.87	18.02
26			7	18.4	40.64	4.70	13.91
27			9	14.1	44.45	5.37	13.25

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الملخص العربي

بعض العوامل الهندسية المؤثرة علي تدوير مخلفات الأسماك

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ينتج من صناعة فالية البلطي كميات كبيرة من المخلفات التي ليس لها قيمة اقتصادية وتؤثر على البيئة في أنتاج روائح وغازات كريهة. ويمكن الاستفادة من هذة الكميات الكبيرة من المخلفات كأحد مكونات البروتين الحيواني في علائق الدواجن والاسماك عن طريق اجراء بعض المعاملات عليها من طبخ و عصر وتجفيف وطحن. لذا كان الهدف من البحث دراسة الخواص الطبيعية لمخلفات الاسماك وتحديد نسبة الجزء المأكول الى الجزء الغير مأكول في أسماك البلطي ودراسة تجفيف مخلفات البلطي النيلي في طبقة رقيقة باستخدام مجفف ميكانيكي يعمل بالكهرباء (عند محتوى رطوبي أولى ١٠٦% على أساس جاف) وتحت تأثير ثلاثة مستويات مختلفة من درجة حرارة هواء التجفيف وهى (٦٠-٧٠- ٨٠درجة مئوية) وثلاث مستويات من سرعة هواء التجفيف وهى(١-١.٥-٢ م. ث$^{-1}$) وثلاثة مستويات من سمك طبقة التجفيف (٥-٧-٩ مم)، دراسة فاعلية تلك العوامل على فقد الرطوبة وزمن التجفيف ومعدل التجفيف ونسبة الرطوبة لمخلفات البلطي . وقد تم اختبار نموذج لوصف عملية تجفيف السمك في طبقة رقيقة شملت معادلة (Lewis's) تحت ظروف التشغيل المختلفة. كما تم تقدير تكاليف تشغيل المجفف و التحليل الكميائي لمخلفات السمك المجفف.وكانت النتائج المتحصل عليها أن نسبة الجزء المأكول الى غير المأكول في سمك البلطي ٤٨.٥٢% والكثافة الحقيقية ١.١٠٧جرام . م$^{-3}$. كما أوضحت النتائج أن جميع معاملات التجفيف تزداد في معدل الانخفاض للمحتوى الرطوبي للسمك وكذا زيادة معدل التجفيف للسمك بزيادة كل من درجة حرارة وسرعة هواء التجفيف ، صغر سمك طبقة التجفيف . وبينت النتائج أن اقل فترة لتجفيف السمك هي ١٥٠دقيقة عند ٨٠ درجة مئوية لحرارة هواء التجفيف و٢م/ث لسرعة الهواء وسمك طبقة ٥مم التجفيف بينما أقصى زمن تجفيف هي ٥١٠ دقيقة عند ٦٠درجة مئوية و ١م/ث وسمك طبقة التجفيف ٩ مم. كما بلغت تكلفة تشغيل المجفف ٢.٩٠جنية/ساعة عند ٨٠ درجة مئوية لحرارة هواء التجفيف و٢م/ث لسرعة الهواء وسمك طبقة التجفيف ٥ مم. كما أظهرت النتائج أن نسبة البروتين في المنتج النهائي بلغت ٤٥% .

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