

## **ABSTRACT**

**Abdel-gawad Mohammed Abdel-gawad Saad: Design and Development of Unit for Extracting Wheat Germ Oil. Unpublished Ph.D. Thesis. Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2012.**

An expelling machine for extracting oil from wheat germ was designed and fabricated to be suitable for young investors. The procedures include the design stages, construction and testing. The main machine components are: Hopper (feeding inlet); expellant unit and an electric motor. The power is transmitted by means of a set of pulleys; sprockets; V-belt; chain and speed reducer (gear box). The expelling unit consists of two screw expellant shafts with two expellant barrels.

The expelling machine evaluated at five screw speeds (25, 35, 45, 55, and 65 rpm); four levels of press head clearance (0.5, 1, 1.5, and 2 mm); studying influence of the preheating process (in the range of 60-70°C) by the water at different atmospheric steaming periods (0, 10, 20, and 30 min) to change the initial moisture content of raw material (13.2%) to different levels (15.4, 16.2, and 16.8%). and influence of heating stabilization process (9.5% of moisture content) on expelling machine performance to determine the best Machine capacity (kg/h); Oil recovery (%); Residual oil (%); Oil productivity(L/h); Specific energy consumption (kWh/kg<sub>feed</sub>); and Barrel temperature(°C). also, determine the economic feasibility for developed expelling machine.

Results showed that the expeller could be pressed wheat germ on two stages to give a better performance at as following.

- 1- The maximum machine capacity (42.6 kg/h) was obtained from stabilized wheat germ (9.5% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
- 2- The maximum oil recovery (63%) was obtained from stabilized wheat germ (9.5% moisture content) at 0.5mm outlet clearance and 25 rpm of screw speed.

- 3- The maximum oil productivity (2.36 L/h) was obtained from stabilized wheat germ (9.5% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
- 4- The minimum SEC (0.0304 kWh/kg<sub>feed</sub>) was found from wheat germ (13.2% moisture content) at 2mm outlet clearance and 65 rpm of screw speed.
- 5- The minimum barrel temperature (51.1°C) was found from raw wheat germ (13.2% moisture content) at 2mm outlet clearance and 25 rpm of screw speed.

**Keywords:** Oil Extraction, Expelling machine Design, Wheat Germ Oil, Economic Feasibility.

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**LIST OF SYMBOLS**


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V	The flow rate of fluid, m <sup>3</sup> /sec.
R	Pore radius, m
$\Delta P$	Pressure drop across a pore of length, Pa
L	Pore length, m
$\mu$	Coefficient of viscosity, Pa.sec
$L_p$	Hydraulic conductivity of plasmodesmate, m <sup>3</sup> /sec. Pa
q	The flow rate of fluid
k	The coefficient of permeability
$\rho$	Fluid density
g	Gravitational acceleration
$\frac{\Delta u}{\Delta z}$	Hydraulic gradient in the fluid (pressure difference $\Delta u$ over distance $\Delta Z$ ).
$\sigma_t$	Total applied pressure,
$\sigma_i$	Kernel pressure; the pressure carried by the medium skeleton
U	Inter-kernel fluid pore pressure; the pressure carried by the medium fluid
$Q_T$	Theoretical volumetric flow rate of wheat germ, cm <sup>3</sup> /h.
$\dot{m}$	The maximum required mass flow rate
$\rho_g$	Wheat germ bulk density, g/cm <sup>3</sup>
$\eta_f$	Feeding efficiency
$\eta_v$	Hopper volume efficiency
$t_{int}$	Time interval between filling and re-filling up the hopper
$Q_{act}$	Actual volumetric flow rate of wheat germ, cm <sup>3</sup> /h
$V_H$	The hopper actual volume, cm <sup>3</sup>
$D_h$	Upper hole diameter of the hopper, cm.
$h_h$	Height of hopper, cm.
x	Sidelong length of the hopper, cm
$\theta$	The inclination angle of hopper
$\phi$	The repose angle.
P	Screw pitch
N	Number of turns of screw.

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$L_S$	The axial length of the screw shaft.
$d_S$	Outer diameter of screw shaft.
$l$	Lead of screw.
$\lambda$	Lead angle
$L_t$	The thread length of the screw of one turn.
$L_T$	The total thread length (helix length).
$Z$	Variable distance measured along screw helix
$\alpha$	Taper angle of the screw shaft.
$H_1$	Height of the thread at the starting point of the turns of the screw shaft, mm.
$H_2$	Height of the thread at the end point of the turns of the screw shaft, mm
$T_s$	Torque of the screw shaft, Nm.
$P$	The power requirement for extraction oil process, W
$V_{\text{displacement}}$	Volume displacement per one revaluation, $m^3$
$P_2$	The maximum presser applied on the threads, MPa
$F_a$	The maximum unit force applied on the threads, N
$t$	Thread width, mm
$r$	The radius to the inner diameter of screw shaft, mm ( $d_1/2$ );
$d_1$	Smallest diameter of the screw shaft, mm.
$J$	Polar moment of inertia of circular cross section, $mm^4$
$K_f$	Stress concentration factor
$M_s$	Moment at the most critical cross section arising from the weight of the screw shaft.
$R_s$	Reaction forces acting on the screw shaft at two ends.
$W_s$	Weight of the screw shaft, N.
$\tau_{\text{max}}$	Maximum shear stress, MPa
$\delta_s$	Yield strength
$\rho_t$	The true density of the bulk wheat germ material, $Kg/m^3$ ;
$M$	Weight of the bulk wheat germ sample, Kg
$V_t$	Real volume of the bulk wheat germ sample, $m^3$
BD	Bulk density of wheat germ, $kg/mm^3$

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$W_{\text{Bulk}}$	Weight of bulk wheat germ, kg
$V_{\text{Bulk}}$	Volume of bulk wheat germ, $\text{mm}^3$ .
$W_{\text{T}}$	Weight of sample before drying, g
$W_{\text{D}}$	Wheat of sample after drying, g
$P_{\text{m}}$	Machine capacity, kg/h.
$W$	Machine feeding, kg
$t_0$	Machine operating time, h
$W_{\text{C}}$	Mass of cake, kg.
$O_{\text{C}}$	Oil content of cake, kg
$W_{\text{m}}$	Mass of sample, kg
$O_{\text{m}}$	Initial oil content of sample, kg
$I$	Line current strength, Amperes.
$V_0$	Potential difference, Voltage
$\text{Cos } \theta$	Power factor, equal 0.85
$\text{SEC}_1$	Specific energy consumption of expelling machine
$\text{SEC}_2$	Specific energy consumption needed for steam generation in the steaming unit or for heating in rotary heat stabilization unit
$\text{SEC}$	Total specific energy consumption of wheat germ oil extraction
$C_{\text{gas}}$	Natural gas consumption by $\text{m}^3$
$T_{\text{c}}$	Total hourly cost, EGP/h.
$C$	Initial price of the machine, EGP.
$h$	Working hours per year.
$L_{\text{f}}$	The estimated life-expectancy of machine in years.
$i$	Annual interest rate, (0.1 of initial cost)
$t_{\text{a}}$	Annual taxes and overheads, (0.01 of initial cost).
$r_{\text{a}}$	Annual repairs and maintains rate, (0.1 of initial cost).
$S_1$	Price of electricity, EGP/kWh.
$S_2$	Price of natural gas, EGP/ $\text{m}^3$ .
$P_{\text{m}}$	Machine capacity kg/h.
$m_{\text{s}}$	The operator monthly salary, EGP/month

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