COURSE COMPACT

2016/2017 Academic Session.

COLLEGE: ***College of Science and Engineering***
DEPARTMENT: ***Agricultural and Biosystems Engineering***
PROGRAMME: ***Agricultural and Biosystems Engineering***
COURSE COMPACT for: ***Processing and Storage of Agricultural Products***

COURSE

Course code: ***ABE 512***
Course title: ***Processing and Storage of Agricultural Products***
Credit unit*:* ***3 Credits***
Course status: ***Compulsory***

LECTURER'S DATA

Name of the lecturer: ***Engr. Prof. Zinash Delebo Osunde***
Qualifications obtained: ***MSc. Ph.D***
Department: ***Department of Agricultural and Biosystems Engineering***
College: ***College of Science and Engineering***
E-mail: **osunde.zinash@lmu.edu.ng**
Office Location: ***Office A226 New College Building***

Consultation Hours: ***Monday, Wednesday and Thursday 10 am – 12 noon***

Name of the lecturer: ***Engr. Dr. John O. Ojediran***
Qualifications obtained: ***BSc***., ***MSc. Ph.D, MBA***
Department: ***Department of Agricultural and Biosystems Engineering***
College: ***College of Science and Engineering***
E-mail: **ojediran.john@lmu.edu.ng**
Office Location: ***Office A214 Old College Building***

INTRODUCTION TO THE COURSE

Course Description – *This is one of the core courses in Agricultural and Biosystems Engineering. It deals mainly on postharvest activities of harvest agricultural products. It also involve the study of engineering properties of agricultural materials which is essential in designing of equipments and processes for post harvest operations.*

Course Justification – *Post harvest operations of agricultural products which involve handling, processing and storage is essential in agricultural value chain. An Agricultural Engineer design equipments and processes for all the post harvest operation. Thus it is essential any graduate of Agricultural and Biosystems Engineering have a sound knowledge of the operation the materials used and the process.*

- **Course Objectives-** *At the end of this course, students should be able to*:
  - *(i) Have knowledge of engineering properties of agricultural materials, now how to determine these properties and also use this knowledge in designing machineries and processes.*
  - *(ii) clearly understand the post harvest operations performed on agricultural products*
  - *(iii) understand the basic engineering principles involved in designing processing equipments*
  - *(iv) understand the importance of proper handling of agricultural materials and also identify material handling equipments*
  - *(v) understand the importance of storage of agricultural products and also identify some storage equipments.*

Course Content: *Properties and characteristics of agricultural materials in relation to their Processing and handling methods. Physical, mechanical, rheological, thermal, electrical and chemical properties. Introduction to agricultural product processing, Ambient temperature processing Materials cleaning, sorting and grading techniques. Size reduction and mixing, Processing by application of heat. Handling methods. Storage requirement of agricultural products.*

- **Course Expectations:** *Student taking this course should have passed ABE 413 .*

S/N	GRADING	SCORE (%)
1.	**Continuous Assessments** • C.AI • C.AII (Mid-Semester Test) • C.AIII	 **7%** **15%** **8%**
2.	**Final Examination**	**70%**
3.	**Total**	**100**

Course Delivery Strategies: *Lecture, oral presentation, group and individual work, field work/excursion, laboratory work*

Course Duration *Three hours per week for 15 weeks (45hours)*

LECTURE CONTENT

Week 1: Registration

Week 2: Course outline presentation, General Introduction

Objective: This helps students to have a general overview of the course, methods of delivery, time frame and other relevant information about the course.

Description this session generally will be an interactive session, the lecturer and students will now each other. There will be a general introduction of students and the lecturer. There will be a discussion on the students SIWES experience and relate it to the course content.

Week 3: Engineering properties and characteristics of Agricultural materials

Objective: to understand the different engineering properties of agricultural products, understand its variation and importance in processing operations and design of machines.

Description physical, mechanical, rheological properties methods of determination, its importance and also application of this information in designing of processing equipments will be handled

Week 4: Engineering properties and characteristics of Agricultural materials

Objective: to understand the different engineering properties (aerodynamics and hydrodynamics) of agricultural products, understand its variation and importance in processing operations.

Description: aerodynamics, hydrodynamics properties methods of determination, its importance and also application of this information in designing of processing equipments will be handled.

Week 5: Engineering properties and characteristics of Agricultural materials

Objective: to understand the different engineering properties (thermal, electrical and chemical) of agricultural products, understand its variation and importance in processing operations.

Description: Thermal, Electrical and chemical properties methods of determination and its importance will be handled.

Week 6: Introduction to agricultural product processing CA1

Objective: to understand the definition and classification of agricultural product processing

Description: define agricultural product processing, identify various unit operations in agricultural product processing. Discuss the various classification of agricultural product processing.

Week 7: ambient temperature processing of agricultural materials / CA1

Objective: to understand the primary processing methods of agricultural products such

as cleaning, sorting, grading,
Description: the engineering method of ambient temperature processing will be address and the important engineering properties for this operation will be related to the process.

Week 8: ambient temperature processing of agricultural materials
Objective: to understand ambient temperature processing methods of agricultural products such as size reduction and mixing operations.
Description: the engineering method of ambient temperature processing will address and the important engineering properties for this operation will be related to the process.

Week 9: Processing by application of heat**.**
Objective: to understand heat processing, its impact on the food, heat processing such as blanching, pasturing, sterilization and drying will be handled
Description: the engineering method of processing by application of heat, heat and mass transfer processes. Relevant engineering properties of food will be related to the process.

Week 10: CA II
Objective: this is the midterm test
Description: this is the mid term test

Week 11: Handling methods.

Objective: to understand the different methods of handling of agricultural product during processing, storage and transportation.
Description: The engineering implication of handling of agricultural products during processing, transportation and storage, handling equipments and methods will be handled.

Week 12: Storage requirement of agricultural products.
Objective: to understand storage requirement and various storage structures used for agricultural products.
Description: understand importance of storage, types of storage structures, methods of design and development of storage structures will be handeled
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Week 13: Storage requirement of agricultural products.
Objective: to understand the storage requirement of perishable crops and identify its importance in shelf life extension of this products
Description: some agricultural crops are highly perishable, its shelf life is some days or wees. However with appropriate technology this can be extended. This appropriate technologies will be address

Week 14: CA III
Objective: this is the third and final test
Description: this is the third and final test

Week 15: Revision
Objective: to revise the entire semesters lecture, relate it to application in practical terms, discuss case study. Answer questions from students if any.
Description: This session will be interactive where the lecturer and students discuss

the entire lecture and its applicability in the food processing. Any areas the students are having challenge will also be addressed.

Relevant Literature

1) Elements of Crop Storage by Musa Maama and Onwualu A. P.
2) Fandamentals of Engineering for Agriculture A. P. Onwualu, C. O. Aubo, I. E. Ahaneku.
3) Agricultural Processing and Storage Engineering by J. C. Igbea
4) CIGR hand book of Agricultural Engineering Hand Book by Osamu Kitani.
5) Physical properties of Agricultural materials Moshenin N. N.

HOD's Observations and further Comments ---------- Course compared adequate ----------

Name: Dr Okwuosa Signature: Date: 5/9/16

LANDMARK UNIVERSITY, OMU-ARAN
DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING
Course title: Processing and Storage of Agricultural Products Code: AGE 512

Course Content: *Properties and characteristics of agricultural materials in relation to their Processing and handling methods. Physical, mechanical, rheological, thermal, electrical and chemical properties. Introduction to agricultural product processing, Ambient temperature processing Materials cleaning, sorting and grading techniques. Size reduction and mixing, Processing by application of heat. Handling methods. Storage requirement of agricultural products.*

LANDMARK UNIVERSITY, OMU-ARAN
DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING

ALFA SEMESTER 2016/17 SESSION FINAL EXAMINATION

Course title: Processing and Storage of Agricultural Products Code: AGE 512
Answer any five questions units 3 Time allowed: 3 hours

1) a, What do you understand by the term agricultural product processing? (2 marks)

b. The average values for major, minor and intermediate diameter for 50 samples of castor seed and its weight is given below.

Major diameter = 17,2mm;
intermediate diameter =13.1mm;
minor diameter = 7.9mm,
Weight = 0.97g.

Calculate the (i) arithmetic mean diameter, (ii) geometric mean diameter, (iii) volume, (iii) sphericity, (iv) density, (v) frontal area, (vi) aspect ratio and (vii) surface area of the seed. (8 marks)

c. If the above given seed is to be conveyed using a pneumatic conveyor through a 20 cm diameter pipe at a flow rate of 0.2 m^3/s. Compute the drag coefficient and the terminal velocity. Density and viscosity of air is assumed to be 1.29 kg/m^3 and 1.91 x 10^{-5} Ns/m^{-2} (4 marks)

2) a. Peeling is a necessary operation in the processing of fruits and vegetables. List and discuss the different mechanical peeling methods used in processing of fruits and vegetables. (8 marks)

b. List and discuss indicating their similarities and differences) the different processing methods using steam and water. (6 mks)

3) a. 100 kg of yam chips containing 80 % water is to be dried at 90 ^oC down to a moisture content of 8 %. If the initial temperature of the yam chips is 25 ^oC, calculate the quantity of heat required for drying under atmospheric pressure. The latent heat of vaporization of water at 90 ^oC and at standard atmospheric pressure is 2257 kJ/kg. The specific heat capacity of the food is 3.8 kJ/kg^oC. (6 marks)

b. Based on heat requirement, agricultural product processing methods is divided in to different unit operation, discuss and give at least four examples for each. (8 marks)

4) a. Why is storage of agricultural products a basic requirement in running a farm enterprise? (4 marks)

b. What are the basic requirement in i) grain and pulses storage
ii) tuber and root storage (6 marks)

c. Highlight the importance of efficient material handling in agricultural products processing industry (4 marks)

5) a. If air at 40 ^{o}C and 20 % RH is blown through a continuous dryer from which it emerges at a temperature of 25 ^{o}C. Estimate the quantity of water removed per kg of air passing and the volume of drying air required to remove 10 kg of water per hour. (6 marks)

b. Using a chart discuss the rheological properties of agricultural materials. Why is the study of rheology important in processing of agricultural materials? (6 marks)

6) a. Granulated sugar with average size of 500 µm, is milled to powder sugar of 26 µm using 12 hp motor. Compute the size reduction ratio and estimate the power required to reduce the sugar to 18 µm. 1hp = 745.7 W. (6 marks)

b. Define the following thermal properties and give the units of measurements

(i) Latent heat
(ii) Thermal conductivity
(iii) Enthalpy
(iv) Surface heat transfer coefficient. (8 marks)

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ALFA SEMESTER 2016/17 SESSION FINAL EXAMINATION

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Marking scheme

Q1. a. **Agricultural processing** is any activity that maintains, raises the quality or changes the form or characteristics of an agricultural product. Processing activities are undertaken to provide a greater yield from a raw farm product by either increasing the amount of the finished product, the number of finished products or both and to improve the net economical value of a product.

b. Arithmetic mean diameter = (a+b+c)/3 = (17.2+13.1+7.9)/3 = (38.2)/3 = 12.73 mm

Geometric mean diameter = $(axbxc)/^{1/3}$ = $(17.2x13.1x7.9)/^{1/3}$ = $(1780.028)^{1/3}$ = 12.119 mm
Volume $4/3(\pi ab^2) = 4/3(\pi 17.2x(13.1)^2)$ = 12364.02 mm^3 = 0.01236
Sphericity $((axbxc)/^{1/3})/a$ = 12.119/17.2 = 0.704
Density = weight/volume = 0.97/12364.02 =
Frontal area = $\pi/4\ (D_g)^2 = \pi/4$ x $(12.119)^2$ =
Aspect ratio= (intermediate dia)/ (major dia)
Surface area = $2\pi b^2 + 2\pi(ab/e)\sin^{-1}e = 2\pi(13.1)^2 + 2\pi(ab/0.647)\sin^{-1} 0.647$

c. Reynolds number = $(Vd\rho_f)/\eta$ =

$A = \pi/4(d^2) = \pi/4(0.2^2)$ =
V= Q/A = (0.2/60)/A =

$$\mathrm{Re} = \frac{Vd\rho_f}{\eta}$$

For laminar flow the drag coefficient can be estimated as: $C = \frac{1.328}{(\mathrm{Re})^{0.5}}$ while for turbulent flow it can be estimated as: $C = \frac{0.455}{(\log \mathrm{Re})^{2.58}}$

Terminal velocity can be estimated as: $V_t = \left[\frac{2mg(\rho_p - \rho_f)}{\rho_p \rho_f A_p C}\right]^{\frac{1}{2}}$

Q2. a. The different mechanical peeling methods in frout and vegetable processing are:

- ***Flash steam peeling*:** Foods (eg root crops) are fed into a pressure vessel which is rotated at 4-6rev/min. High pressure steam (1500kpa) is introduced and all food surfaces are exposed to the steam by rotation of the vessel for predetermined time, which differs according to the type of food. The high temperature causes the rapid heating of the surface layer within 10-15 s. The low thermal conductivity of the food prevents further heat penetration and cooking of the product. Texture and colour of the product is preserved. The pressure is then instantly released and the surface of the food is flashes off and discharged with the steam. Water sprays are used to remove the remaining traces.
- ***Knife peeling:*** stationary blades are pressed against the surface of a rotating fruits or vegetable to remove the skin. Alternatively the blade may be rotating against stationary foods. This method is particularly suitable for citrus fruits where the skin is easily removed and there is little damage or loss of fruit.
- ***Abrasion peeling***: Food is fed into carborundum rollers or placed into a rotating bowl which is lined with carborundum. The abrasive surface removes the skin and it is washed away by water. The method has a low energy costs and good surface appearance of the food. However irregular surfaces may cause problem of peeling more so the method has high product loss, produces large volume of diluted waste and relatively low through put.
- ***Caustic peeling***: A chemical solution (sodium hydroxide) is heated to 100 – 120^{o}C and food is passed through it. The solution softens the skin of the product which is removed by high pressure of water spray. This method is used for root crops. It is causes change in the colour of the product and incurs high cost.
- ***Flame peeling***: Mostly used for onions, the peeler consists of a conveyor belt which carries and rotates the food through a furnace heated to higher than 1000^{o}C. The outer paper shell and hairs are burned off and the charred skin is removed by high pressure of water sprays.

b. The processing methods using steam and water are blanching, pastorization and sterilization
Blanching: It is used to destroy enzyme activities in vegetable and some fruits, prior to further processing. Blanching reduces the numbers of contaminating micro organisms on the surface of foods and hence assists in subsequent preservation operations. It also softens vegetable tissues to facilitate filling into containers.

Pasteurisation: It is a relatively mild heat treatment, usually performed below 100^{o}C which is used to extend the shelf life of foods for several days (milk) or several months (bottled fruit). Pasteurization can be of packaged foods or unpackaged liquids. Some liquid foods (beers, fruit juice) are pasteurised after filing in to containers. Hot water is normally used if the food is packaged in glass to reduce the risk of thermal shock to the container. Metal or plastic containers are processed using steam air mixture or hot water. After pasteurisation the food is cooled to about 40^{o}C. Unpackaged liquids are pasteurised using heat exchangers, such as plate heat exchanger.

Heat Sterilization: is the unit operation in which foods are heated at a sufficiently high temperature and held for a sufficiently long time to destroy microbial and enzyme activity. As a result, sterilized foods have a shelf life in excess of six months. The severe heat treatment during sterilization produces substantial changes in nutritional and sensory qualities of foods. Damage to nutrient and sensory components is reduced either by reducing the time of processing in containers or processing foods before packaging

Q3. a. $M_w = \frac{(m_i - m_f)M_i}{(100 - m_f)}$ $M_w = \frac{(80-8)100}{(100-8)} = 78.26kg$

Heat required = 100 (90 – 25) 3.8 kj/kg^oC + 78.26 x 2257j/kg

= 100 x75 x 3.8 + 176632.82

= 28500 + 176632.82

= 205132.82 kJ

b. Based on heat requirement it can be:

◊ Ambient temperature processing this include: raw material preparation (cleaning, grading, sorting, peeling), size reduction (cutting, milling, grinding), mixing and forming, mechanical separation (centrifugation, filtration, and expression), membrane concentration, irradiation

◊ Processing by application of heat this is divided in to:

- heat processing using steam or water which include: Blanching, pasteurization, sterilization, Evaporation, extrusion,
- heat processing using hot air which include: dehydration, drying, baking and roasting, heat processing using hot oil which include: fraying and
- heat processing by irradiated energy microwave and infrared energy

◊ Processing by removal of heat chilling and freezing, freeze drying, freeze concentration

Q4. a. Storage is an important aspect of running a farm for a number of reasons as given below:

- To ensure steady supply of food throughout the year, since food harvest is seasonal
- To guarantee the availability of raw materials to feed the agro allied industries
- To keep planting material from generation to the other without loss of viability
- To stabilize food prices by stock pilling when food prices are low and releasing into the market when prices go up.
- To encourage farmers to produce more food since the excess of what they produce will not be lost

b. i. Storage requirement for grain and pulses:

- the moisture content and temperature of the grain must be low, moisture content must be reduced to safe level,
- damaged grain should not be stored, the grain must be cleaned devoid of foreign matter
- the foreign-material content of the grain,
- the type and hybrid of the grain, and
- the interstitial atmosphere around the grain (temperature and relative humidity). The effect of relative humidity and temperature of the storage environment can be controlled by regular monitoring and ventilation of the store.

ii. In root and tuber storage only sound tubers without any damage should be stored,
damaged tubers should be cured before storage.
The store should be clean and should not have access to rodents,
there should be sufficient ventilation and

should be constructed under a shed to reduce the effect of high temperature.
Regular inspection of stored tubers is important to remove sprouts and rotted tubers, and to monitor the presence of rodents and other pests.

c. Efficient material handling in processing industry is important because it enables:

- Savings of storage and operating space
- Better stock control
- Improved working conditions
- Improved product quality
- Lower risk of accidents
- Reduced processing time
- Lower cost of production
- Less wastage of materials and operating time

Q5. a. temperature= $40^{o}C$; RH = 20% Absolut humidity = 0.012

Outlet temperature = $25^{o}C$ outlet absolute humidity = 0.0162

Air required to remove 1 g of water = 0.0162 – 0.012 = 0.0042 g/kg each kg of air removes 0.0042 g of water

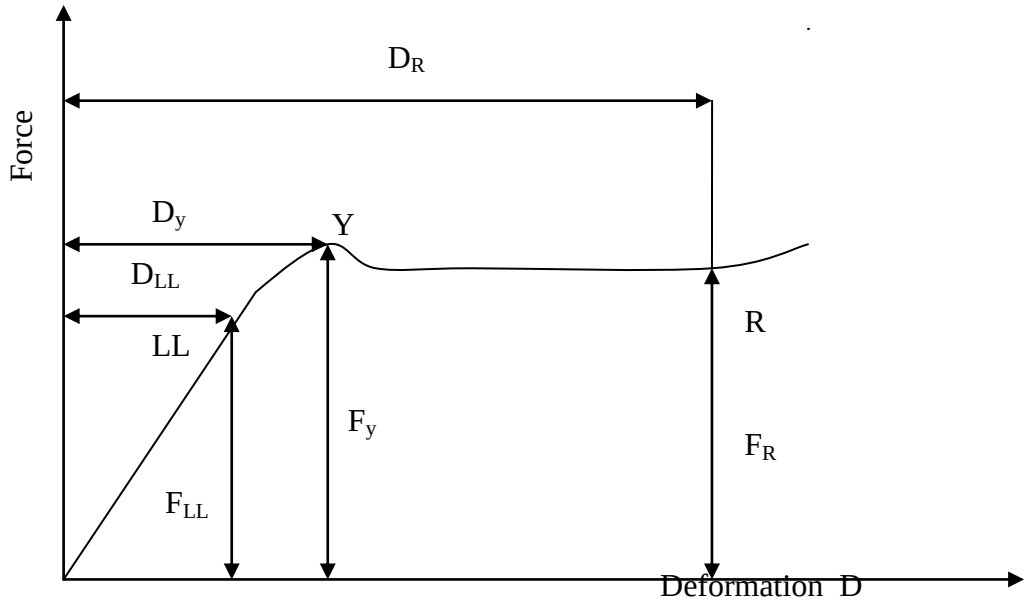
For 10 Kg of water 10/0.0042 = 2380.95 kg of air

Specific volume of air at inlet temperature and humidity = 0.98 m^3/kg

Air required in volume = 0.98 m^3/kg * 2380.95 kg = 2333.33 m^3 of air

b. When force is applied on a material and its action result in *deformation* and/or *flow* in the material this mechanical property is referred to as **rheological property**. Rheologically, mechanical behaviour of a material is expressed in terms of the three parameters *force, deformation/flow* and *time*.

C. figure below show the force deformation characteristics of agricultural material. When force is applied to an agricultural material there will be a deformation or flow. Until the linear limit the force applied is proportional to the deformation. However after the yield point there is deformation when little or no force is applied.



Force – Deformation curve for an agricultural product LL- Linear Limit; y - Bioyield point; R – rapture point

Q 6. a. size reduction ratio = 500/26 = 19.23

Power required = 12 745.7 = 8948.4 w

Using Rittingers law $E = k_1\left[\frac{1}{x_2} - \frac{1}{x_1}\right]$ = substituting $8948.4w = k_1\left[\frac{1}{26} - \frac{1}{500_1}\right]$

K1 = 245409

Then energy required to reduce to 12 µm = $E = k_1\left[\frac{1}{x_2} - \frac{1}{x_1}\right]$ = $E = 245409\left[\frac{1}{18} - \frac{1}{500}\right]$

= 12652 w = 12652/745.7 = 16.96 ⟶ 17 hP

b. Latent heat (kJ/kg): This is the amount of heat energy that is absorbed or emitted when a substance undergoes a physical phase change. It could be latent heat of vaporization if heat is used to vaporize liquid and latent heat of sublimation if it is vaporized from solid.

Thermal Conductivity ($Jm^{-1}s^{-1o}C^{-1}$*):* This is the measure of materials ability to conduct heat. In foods the thermal conductivity depends mostly on composition, but also on any factor that affects the heat flow paths through the material, such as percentage void space (porosity) moisture content, shape, size, arrangement of void spaces, homogeneity, orientation of fibers and chemical composition. The amount of heat Q that flows through a slab of material of thickness *x* having a

thermal conductivity k is calculated as $Q = \frac{kA(T_2 - T_1)}{x}$ where A is the surface area of the material normal to direction of heat flow and T_1 and T_2 are the surface temperature of the material. Thermal conductivity of agricultural materials is measured using the thermal conductivity probe. Line heat source probes are used frequently for agricultural materials.

Enthalpy (kJ/kg): Enthalpy is the heat content or energy level of a material. The amount of heat energy required to heat a material from temperature T_1 to temperature T_2 is simply M x ($h_2 - h_1$). Where M is the mass of the material and h_2 and h_1 are the enthalpy at temperature T_2 and T_1 respectively. Enthalpy has been used more for quantifying energy in steam than in foods. However it is convenient for frozen foods which often contain unfrozen water.

Surface heat transfer coefficient ($W/m^{2o}C$): The surface heat transfer coefficient is used to quantify the rate of heat convection to or away from the surface of an object. It is used to quantify heat transfer in food heating or cooling application. The surface heat transfer coefficient is equal to the heat flux through a surface divided by the difference between the surface temperature and the convicting medium temperature or the amount of hat transferred per meter square of the surface is given as: $Q = h_s A(T_2 - T_1)$ Where h_s is the surface heat transfer coefficient. The surface heat transfer coefficient can be regarded as the conductance of a hypothetical surface film of the cooling medium of thickness x_f then $h_s = {}^{k_f}\!/_{x_f}$ where k_f is the thermal conductivity of the cooling medium.