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Application of Neuro-Fuzzy to palm oil production process.

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Abstract

Palm oil is an important nutritional food requirement and in order to facilitate the production of palm oil for consumption, the production process of palm oil has been investigated. The basic operations involved in the production of edible palm oil include; purchase, transportation and reception of oil palm bunches; bunch threshing and fruit fermentation; sorting and weighing of oil palm fruits; boiling, digestion and pressing of palm oil fruits; clarification and drying of palm oil and palm oil storage. A Neuro–Fuzzy model was used to analyze the performance of palm oil production process as it affects the basic operations involved in the production of edible palm oil. The research work can be applied to any other small or medium scale production firm for better efficiency.

Keywords
Edible Palm Oil, Production Process, Bunch Reception, Fruits Digestion, Production Stages, Neuro–Fuzzy.

1.0 Introduction

Palm oil is a fatty edible vegetable oil, derived from the flesh and the kernel of the fruit of the oil palm tree. The oil palm tree is a tropical, single stemmed tree having feather like leaves that gains a height of around 20 meters. The palm bunches move through a series of processing stages to obtain the edible palm oil. These stages include: purchase of oil palm bunches, transportation of oil palm bunches, reception of oil palm bunches, bunch threshing, fruit fermentation, oil palm fruits sorting, weighing of oil palm fruits, boiling of oil palm fruits, fruits digestion, fruits mashing or pressing, oil clarification, oil drying and palm oil storage.

The oil palm (Elaeis guinensis), is a tropical plant crop and a native of West Africa. Its processing has been an age long industry. It is either processed manually or mechanically. There are about 2.1 million hectares of wild oil palm plantations, 105,000 hectares of small holder plantations and 82,209 hectares of estate plantations in the country. With these and the projected expansion of about 205,000 hectares, the oil palm will remain the major source of edible oil in Nigeria, and over 80% of palm oil and palm kernel in the country are produced by small scale processors whose capacities vary from a few hundred kilogrammes to about 8 tonnes per day [8].

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The oil palm exists in a wild, semi-wild and cultivated state in the three land area of the equatorial tropics: Africa, South-East Asia and America [6].

Oil palm is the highest yielding of all the oil bearing plants and the spread of the oil by seed may be through the agency of gravity and water, of animals or of man and the movement by gravity and water is of limited occurrence especially as the fruit does not float [16]. Oil palm has been classified into three major categories, the dura-shell, which consists of medium messocarp content, the tenera which possesses thick mesocarp and the pisifera, which consists of small pealike kernel in fertile fruits [18].

The use of any piece of land for planting oil palm is determined by the quality of the soil and the topography, and the land should be level or slightly undulating, well drained, fertile and deep, and virgin forest soils are preferable to soils that have been cropped. Normally, oil palm seeds are de-pulped by subjecting the fruits to heat followed by de-pulping. Seeds for planting should not be subjected to high temperature for de-pulping purposes. When the mature bunches are harvested, the seeds are extracted from the bunch, stored in a cool place till the mesocarp softens on its own [7].

A popular method for nursery the oil palm seedlings is the single stage polybag nursery which involves the use of black polythene bags filled with topsoil for planting the oil palm seeds. These polythene bags are perforated at the bottom to allow excess water to drain out during the nursery process [4].

The establishment of oil palm bunch processing plant is related to the demand for the product. Analysis of demand is a necessary step in translating marketing objectives into marketing programme and is a continuing activity to determine where and to what extent the market for the company products and services exist and how they can best be served [14]. He stated that the market demand for oil palm products, especially palm kernel oil is very high both in our local and in international markets and the production of palm kernel oil in Nigeria is still much below the market demand. Berger [1], stated that the non-cholesterol quality and digestibility of palm oil make it a popular source of energy, and that palm oil is used for the manufacture of solid fat products, native soaps, waxes for candles, pomade and fuel for orthodox lamps.

Neuro fuzzy, which is a combination of neuro network and fuzzy logic, was used in our analysis. To enable a system to deal with cognitive uncertainties in a manner more like humans, we incorporate the concept of fuzzy logic into neural networks to evaluate the performance characteristics of the production process and the resulting hybrid system is called fuzzy neural, neural fuzzy, neuro-fuzzy or fuzzy-neuro network. Neural network and Fuzzy logic are also used for systems modeling and simplifications [12],[13] and [17]. The use of soft computing techniques, such as data mining, fuzzy logic, artificial neural networks, genetic algorithms, and neurofuzzy techniques have been recognized as improved tools for solving problems in the servicing industry, [15, 19].

Fuzzy logic has been widely used for tracking uncertainty, while its integration with artificial neural networks is a recent development in capturing the individual weaknesses in fuzzy logic and artificial neural networking [5, 9]. The offspring of this marriage, neurofuzzy, has been applied for numerous tasks: in the reinforcement learning of traffic signal control [2], for identification of autonomous underwater vehicles [3, 10], in real time modeling and control [5], for robust parameter estimation [9], and in vibration monitoring [11]. Therefore, there is a need to use and develop a practical approach such as the neurofuzzy approach which can deal with uncertainty or vagueness in system parameters.

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2.0 Operational activities in oil palm production

The operation of the basic activities of the oil palm processing company involves the production manager who interacts with the marketing department which in turn interacts with the finance department. The finance department interacts with the purchasing department and then with the production manager as shown in Figure 2.1.

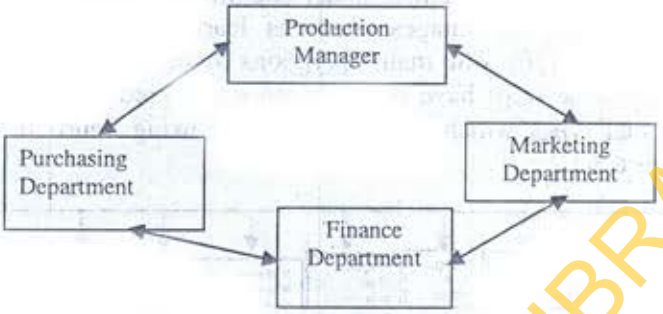

Figure 2.1: The system concept for the manager.

The basic activities and stages involved in the process of producing edible oil palm are shown in Figure 2.2 and these steps have been carefully analyzed and modified to six basic operations and operational types which are now analyzed using neuro fuzzy networks and models as shown in Figure 3.1.

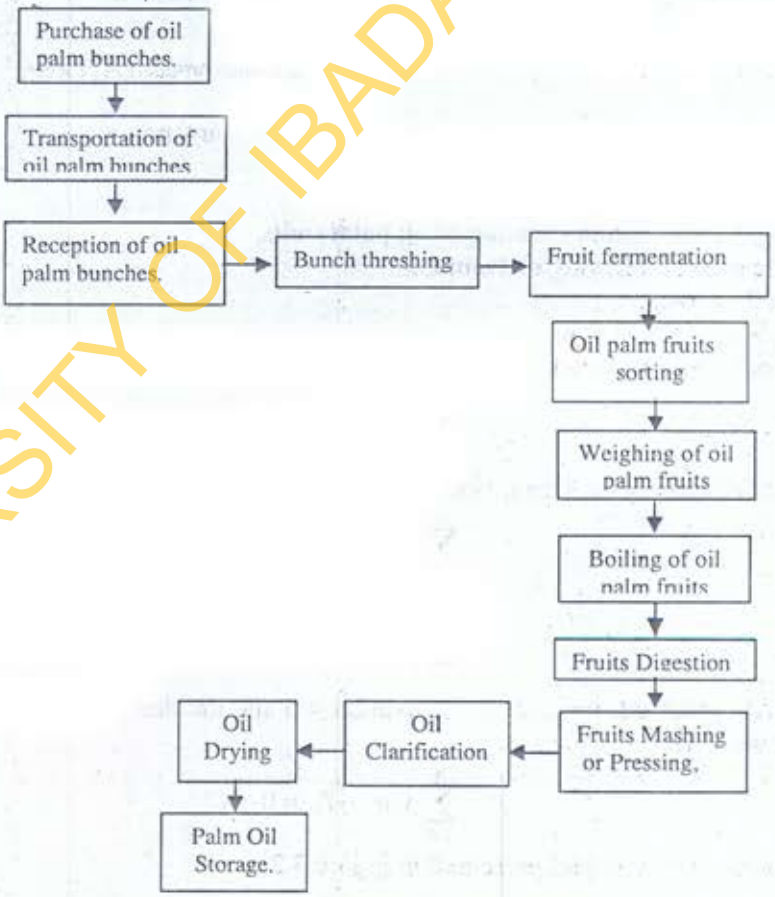

Figure 2.2: Basic activities in palm oil production

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3.0 Neuro Fuzzy logic model

The structure of the neurofuzzy model shows the interrelationship among input, layers and output elements. A neuro – fuzzy model was used to analyse the operation of the basic activities of the oil palm processing firm. It combines the fuzzy – logic and neural network principles to generate model that will result in the evaluation of specified desired output. While fuzzy logic performs an inference mechanism under cognitive uncertainty [22], computational neural networks offer exciting advantages, such as learning, adaptation, fault-tolerance, parallelism and generalization [20]. The main operations involved in palm oil production are shown in Figure 2.2 and these steps have been carefully analyzed and modified to six basic operations and operational types which are now analyzed using neuro fuzzy networks and models as shown in Figure 3.1

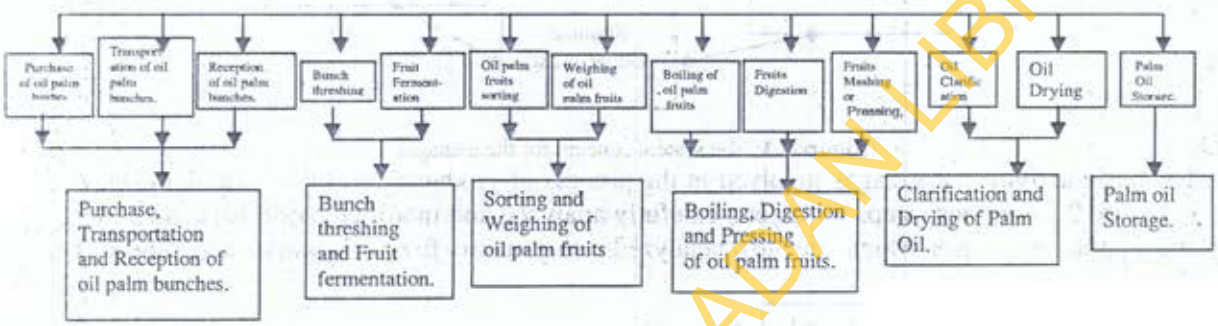

Figure 3.1: Fuzzy logic control of pounded yam flour production process.

Let y_1 = Purchase, Transportation and Reception of oil palm bunches.
y_2 = Bunch threshing and Fruit fermentation.
y_3 = Sorting and Weighing of oil palm fruits.
y_4 = Boiling, Digestion and Pressing of oil palm fruits.
y_5 = Clarification and Drying of Palm Oil.
y_6 = Palm oil Storage.
$Y = y_1 + y_2 + y_3 + y_4 + y_5 + y_6$
where Y is the palm oil produced.

$$\sum_{i=1}^{n} y_i = Y \tag{3.1}$$

for $i = 1, 2, 3, \ldots, n$, and $n = 6$. This gives the following weighted equation:

$$\sum_{i=1}^{n} y_i w_i = Y_d \tag{3.2}$$

$$\sum_{i=1}^{n} y_i w_i - Y_d = 0 \tag{3.3}$$

where w_i = weight attached, $i = 1, 2, 3, \ldots, n$ and $n = 6$ and the desired product, $Y_d = Y$. From equation (3.1), we have:

$$\sum_{i=1}^{n} y_i w_i - Y_d = 0 \quad \text{s(3.4)}$$

This gives the neuro fuzzy model presented in Figure 3.2.

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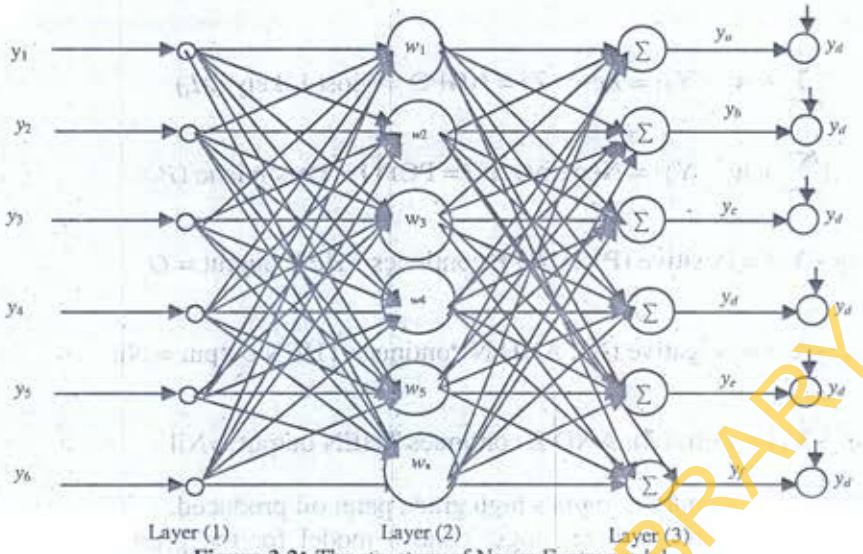

Figure 3.2: The structure of Neuro Fuzzy model.

The above structure is now modified to get the simplified structure of the neuro fuzzy model as presented in Figure 3.3.

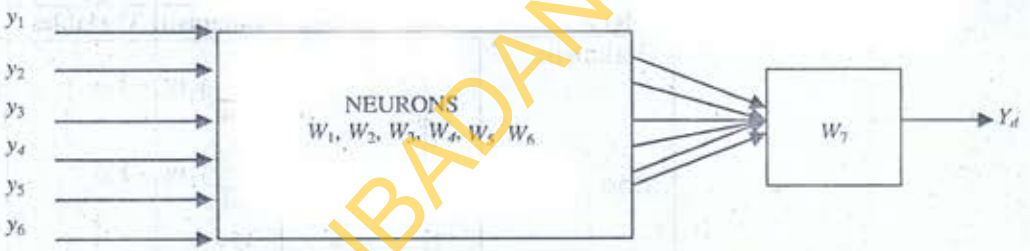

Figure 3.3: Simplified structure of the Neuro Fuzzy model .

3.1 Neuro Fuzzy input and output parameters

Applying the neuro-fuzzy model to optimize the production process of the palm oil, we have the following neuro-fuzzy model components:

3.1.1 Input Parameters

(i) bunch reception (y_{br}),
(ii) bunch sterilization (y_{bs}),
(iii) bunch threshing (y_{bt}),
(iv) fruits digestion (y_{fd}),
(v) pulp pressing (y_{pp}),
(vi) oil clarification and drying of oil and (y_{cd}), and
(vii) palm oil storage (y_{ps}).

These neuro-fuzzy components are combined with the use of neuro-fuzzy commands "IF", "AND" "Continues" and "THEN" to develop a rule-structure followed in the use of the model as in Figure 3.3.

3.1.2 Output parameters

(1) High grade palm oil (Optimistic, O_p),
(2) Normal grade palm oil (Most Likely, M_l),
(3) Poor grade palm oil (Pessimistic, P_e).

The Linguistic Variables;

(1) $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Positive (P) = HGPO = Optimistic (O_p)

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(2) $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Zero (Z) = NGPO = Most Likely (M_l)

(3) $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Negative (N) = PGPO = Pessimistic (P_e).

IF $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Positive (P), AND P continues THEN output = O_p

IF $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Negative (N), AND N continues THEN output = Nil

IF $(\sum_{i=1}^{n} y_i w_i - Y_d)$ = Zero (Z), AND Z continues THEN output = Nil

Note: The positive (P) output implies high grade palm oil produced.

The components of fuzzy logic control model for the production of palm oil with membership functions are presented in Table 3.1.

Table 3.1: Relationship between Fuzzy output and membership function.

Level	Interpretation	Fuzzy Output	Linguistic Variables.
1	Optimistic	Positive	$(\sum_{i=1}^{n} y_i w_i - Y_d)$
2	Most Likely	Zero	$(\sum_{i=1}^{n} y_i w_i - Y_d)$
3	Pessimistic	Negative	$(\sum_{i=1}^{n} y_i w_i - Y_d)$

3.2 The system operating rules.

INPUT No 1: {"Input", Positive (O_p), Negative (P_e), Zero (N)}.

INPUT No. 2 {GP– Getting Positive (O_p), GN- Getting Positive (P_e), GZ- Getting Zero (N)}.

The system response with its output becomes:

Output O_p = Optimistic, P_e = Nil, and N = Nil.

The graphical illustration of Table 3.1 is presented in Figure 3.4 and the degree of relationship between fuzzy output and membership function ranges from 0 to 1.0 [21].

The interpretation of the graph shows that:

(i) When the real output is higher than the desired output the model prompts positive (optimistic output).

(ii) When the real output is lower than the desired output the model prompts negative (pessimistic output); and

(iii) When the real output and the desired output are equal the model prompts zero (Most Likely output).

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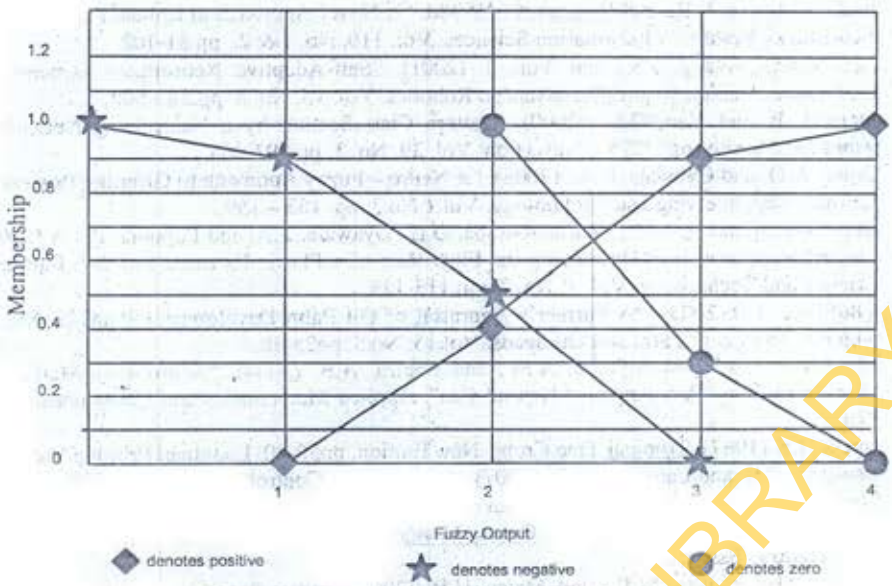

Figure 3.4: Graph of Fuzzy logic Control model

4.0 Conclusion

Palm oil which is very essential to mankind is consumed in many nations all over the world. The production of edible palm oil by a company located in Edo State of Nigeria has been thoroughly examined.

The neuro-fuzzy model is designed to control a functioning system to attain a specified desired output. In this case the specified desired output attained with the aid of neuro-fuzzy model is the condition of producing high grade palm oil at minimum cost of production. It was therefore more convenient to use neuro fuzzy models and networks to control the production process of the palm oil as the production stages were drastically reduced from initial thirteen steps to six basic processes. This also reduced the overall production cost of palm oil production for both domestic and commercial consumers.

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