International Journal of Engineering Research Updates

Journal homepage: https://orionjournals.com/ijeru/

ISSN: 2783-0187 (Online)

ORION SCHOLAR JOURNALS

(RESEARCH ARTICLE)

Check for updates

Optimization of wheat flour production processes in a flour mill industry using linear programming

Tamunoiduabia Ibisiki *, Okwu Elemchukwu Isaac and Barinyima Nkoi

Department of Mechanical Engineering, Rivers State University, Nkpolu-Orowurokwo, Port Harcourt.

International Journal of Engineering Research Updates, 2022, 03(01), 001–010

Publication history: Received on 09 April 2022; revised on 29 June 2022; accepted on 01 Jully 2022

Article DOI: https://doi.org/10.53430/ijeru.2022.3.1.0025

Abstract

This study applied linear programming method as an optimization package to analyze the operational processes of wheat flour mill industry, with functional models developed using defined variables constraints of wheat flour x_1, baking flour x_2 and semolina x_3 for objective functions. Furthermore, a proficient operational process of wheat flour mill industry based on raw materials requirements and production cost using linear programming method with MATLAB application to optimize the operational process of wheat flour production plant by maximizing raw material resources and minimizing production cost using a modified milling process flow chart for enhanced products yield from the milling of the whole wheat grains, and a monthly analysis of the available wheat resource for production and machine hours operated during each month. The results after computing the average supply of wheat and available machine hours as variables and modelled into linear programming equations for optimization showed increase in semolina production, reduction in wheat flour production and reduction in production cost of baking flour respectively. In addition, the profit generated showed a significant increase in the months of December at ₦164,850.00 (highest) when the machine hours and wheat available were at its peak. Thus, baking flour was found to be the least profitable among the three products monthly and recommendations suggested a reduction in its production cost to enable profitability in its production.

Keywords: Wheat Flour; Baking Flour; Smolina; Process Optimization; Linear Programming

1 Introduction

Wheat flour industry is growing rapidly as a result of the food consumption involving foods made with wheat flour. The flour mill industry accounts for wheat flour production and consumption in Nigeria. The domination of wheat in economy is observed to be increasing in revenues and also increasing production cost, however, the profits are not increasing as expected. This has led to several evaluations by wheat flour production companies in terms of efficiency in production cost and raw material usage. Wheat flour production cost consist of direct cost, indirect cost, and overhead cost. Currently, wheat flour Companies plan their production based on sales demand forecast from marketing survey. This planning is mostly efficient from sales perspective, while planning for production processes is not optimally developed yet. In production industries, optimization is a major production factor in obtaining maximum production, however most industries do not have an optimized production system [1].

Linear programming (LP) was developed for solving complex production planning problems and is a branch of operations research, which deals with the problem of optimization (maximizing or minimizing) of a linear function (in production terms it can be profit or cost) which is subject to some linear constraints (raw materials and manpower). The linear function to be maximized can be profit or to be minimized can be cost of production, while the constraints in this case study is related to the available raw materials for production of each product [1, 2]. In addition, linear

* Corresponding author: Tamunoiduabia Ibisiki
Department of Mechanical Engineering, Rivers State University, Nkpolu-Orowurokwo, Port Harcourt.

programming includes the optimization of a linear objective function that has a series of limitations in form of linear equality and inequalities. The aim of linear programming is to use a mathematical model to obtain the best output (maximum profit, minimum cost). Linear programming is mainly used in commercial and economic situation; however, it can be used for some engineering problems. Some of the industries that used linear programming are transportation, energy, telecommunications and factories. Also, it is useful in modeling issues of planning, routing, scheduling, allocation and design. An evaluation of 500 largest companies in the world showed that 85% of them have used linear programming [3].

Wheat flour has commonly been used for creating pastry products however, in recent times, more research has been done to modify its properties [4] The author tried combining potato flour with wheat flour to create a better flour. The author found out that it was sweeter but wheat flour was potentially more nutritious. Zhang (2020) asserted that all kinds of flour products which are made of wheat flour have already become the staple food on people's dining table. He posited that the improvement of living standard and the quality requirements for the flour products have gradually improved [5]. Farooq *et al.,* (2013) applied response surface methodology (RSM) for suitable optimization of supplement and emulsifier for improving wheat flour protein without adversely affecting naan texture during storage. They observed that RSM analyzed the number of levels of gram flour and GMS (glycerol monostearate) by log-linear response functions giving 13.06% gram flour and 0.32% GMS as the suitable combination for acceptable texture of naans, which was verified by sensory evaluation [6] In addition, Okpala & Okoli (2013) used response surface methodology as the optimization technique for biscuits produced from blends of pigeon pea, sorghum and cocoyam flours. They applied sensory attributes such as appearance, taste, texture, crispness and general acceptability, while the protein quality indices were biological value and net protein utilization. The results showed that, while the addition of pigeon pea improved the protein quality, its addition resulted in reduced sensory ratings for all the sensory attributes with the exception of appearance. It was asserted that the results from this optimization recommended that biscuits should contain 75.30% sorghum, 0% pigeon pea and 24.70% cocoyam flours as the best proportion of these components [7].

Also, Bressiani *et al.,* (2017) carried out a study to evaluate the effect of particle size distribution on composition, properties rheological, pasting, microstructural and baking properties of whole grain wheat flour (WGWF) of three different particles sizes (194.9 μm, 609.4 μm and 830.0 μm). They concluded that in the sample of finer particles, more pronounced adverse effects in quality (dough rheology, bread volume and texture) compared to the medium particle sizes sample suggests that the larger contact surface and the increased release of reactive compounds due to cell rupture interact with the gluten-forming proteins changing their functionality [8]. Furthermore, Sang *et al.,* (2020) researched on the milling yield quality on physicochemical properties of wheat flour in general, and observed the significant differences in proximate analysis, color, solvent retention capacity, pasting property, and antioxidant activity as the yield increased to maximize the production of wheat flour from wheat kernels. The authors further asserted that adding clear flour and shorts did not significantly affect the quality of the wheat flour in comparison with straight flour samples [9].

Gomez *et al*., (2020) analysed the consumption of whole grains, including bread made with whole-wheat flour, and reported that it is promoted for health benefits and reduced risk for disease and mortality, consumer acceptance, and consumption of some whole-wheat products is low compared to that of white breads. The author did a review which focused on the understanding of whole-wheat flours, both their positive and negative aspects, and how to improve those flours for the production of whole-wheat breads. Thus, this study addressed genetic aspects, various milling systems, and pretreatment of bran and germ, and concluded that the baking process and use of additives and enzymes may also improve product quality to help consumers meet dietary recommendations for daily whole-wheat consumption [10] Besides, Bressiani *et al.,* (2019) showed that particle size influences the functionality of the gluten network. The SRC (solvent retention capacity) test revealed that the water absorption increased from 77.43% to 85.76%, with decrease in particle size, thereby concluding that the equipment allowed a better understanding of the functionality of whole grain with regards to the behavior of protein properties. Whole grain with coarse particles demonstrated a greater impact on the gluten network, indicating a negative effect on the baking quality [11].

More also, a research was carried out to address milling and shelf-life issues that are unique to whole wheat flour. It was observed that no standard methods are available for whole wheat flour milling, resulting in very different bran particle sizes It was suggested that moderate bran particle size is the best for bread production, while small particle size is better for non-gluten applications [12] The influence of different milling processes on the physicochemical properties and steamed bread quality of whole wheat flour. The authors used medium hard red wheat, soft white wheat and Canada hard wheat as raw materials. Results from Liu *et al.,* (2015) showed that whole wheat flour made from entire grain grinding processes had higher viscosity values but lower particle size than bran recombining processes [13] El-Porai *et al.,* (2013) also studied the effects of normal and hard milling and different conditioning times on flour properties of

Egyptian wheat Sakha 94 and Gemmeiza 11. Thus, the study concluded that pan bread produced from Gemmeiza 11 flour was found to have acceptable quality grade for all sensory characteristics than bread produced from Sakha 94 flour [14].

Furthermore, the effect of lip extraction on protein salvation, pasting, and dough rheological behavior of flours. Dough from hard wheat (HW), semi-hard wheat (SHW) and soft wheat flours were analyzed. The selected varieties reported a grain hardness index of 17 to 95 variation. The result of the analysis showed that soft wheat has lower tryptophan fluorescent emission and water absorption (WA) than semi-hard (SH) and Hard (HW) varieties change in pasting parameters on defatting was the highest for soft wheat (SW). Native Flour (NF) of hard wheat has high protein content, pasting and dough strength and fluorescence intensity relative to the soft wheat (SW). Whereas, on defatting, the reverse is the case. More so, the protein pattern of native flour and defatting flour has no significant difference. Defatting significantly heightened all rheological and mixographic features except peak time. It was discovered in the overall that the defatting of flour improved paste and dough strength [15] The quality and protein composition, intrinsic lipid content, damaged starch content and grain hardness index also affect the theological behavior [16] Hexane is a non-polar solvent used widely for the extraction of most of nonpolar lipids from wheat flour whereas, a small fraction of lipids is also co-purified during extraction

Pareyt *et al.,* (2011*)* polar solvents like butanol are widely used for the extraction of flour bound. Lipids. These findings hence revealed that different lipid solvents primarily target free lipids. Wheat flour was treated with hexane alone or mixture of hexane: Isopropanol (1:1) yielded total extractable lipids of 59.9% and 72.0% respectively [17] The protein content (PC) of both NF and DF was using AOAC method: The three replications were subjected to quality analysis [18]. To compare PC of NF and DF flour, data of PC for NF of different varieties of wheat were adopted [19] Many characteristics of flours (NF & DF) of different varieties of wheat were measured using a mixograph [20] Therefore, the removal of lipids from flours with hexane resulted in a decrease in the levels of phytic acid content of 25%, 17% and 30% respectively, for wheat, barely, and corn flours but had very lies or no effect on the levels of other constituents [21].

Therefore, the expansion of the wheat flour industry has been increasing as people across all divides are changing their consumption habits from consuming rice based food to flour based food. Various factors affect the stability of wheat flour quality but competitive price and product availability in market are the commonest challenges that wheat flour industry faced. Crown flour Mill Limited (Olam Grains) is one of the major companies that produce wheat flour having a high demand in the market share of its products in Nigeria. The increase of market share also raised company's revenues and increased the company's production cost which has forced the company to apply methods of optimization of resources continuously to be able to produce at lowest cost while still maintaining its quality. Thus, the aim of this study is to optimize wheat flour production process in a flour mill industry using linear programming to investigate the best operational processes of wheat flour mill industry, analysis of wheat flour production process based on required raw materials and production cost, and optimization of operational process of wheat flour production plant by maximizing raw material resources and minimizing production cost.

2 Process Description

The flowchart showing wheat flour production process is shown in Figure 1.The production processes involved intake and cleaning stage (first and second round of cleaning), tempering stage, milling stage and packaging.

2.1 Intake and Cleaning Section

At this stage, the wheat is being loaded into a storage tank from a truck and then gets prepared for the cleaning stage. Wheat is received and weighed using weighing machine capable of weighing loaded trucks. The weight is obtained by subtracting the weight of the truck when emptied from the weight when it was loaded. It is then transferred to the storage facility where it is stored using elevators and conveyors. The wheat is tested for protein and other characteristics and graded into various categories. In addition, this process is followed by cleaning which is done by first passing the wheat over series of coarse fine sleeves that remove unwanted materials such as chaffs and straws. Stones may be removed by passing wheat over short openings that allows stones to fall out of mass and be trapped. The wheat is then passed over a magnetic separator to remove any metallic particle present.

2.2 Tempering

The wheat is tempered or conditioned for milling by adding a little quantity of water (usually between 4 - 6%) depending on the initial moisture content of the wheat being milled in order to soften the outer layer of the wheat grain to ease milling. The wheat is then allowed to lie in the conditioning bins for between 10 and 24 hours.

2.3 Milling Process

Milling is the process by which the endosperm is extracted from the grain by passing it through series of rollers rotating at different speeds. The break system primarily comprised of roller mills that run in opposite directions at different speeds. Its purpose is to separate the endosperm from the rest of the kernel. To achieve this, the wheat is allowed to run through the roller mills up to five times, after this, sifters are also used to separate the endosperm from the bran and germ which is typically a co-product known as wheat feed. The purification system consists of purifiers that is used to sort particles based on size, air resistance and specific gravity. The roller mills further reduce the size of the particles, and this reduction system consists of roller mills and sifters in sequence. The roller mills in this sequence are smooth, resulting in a finer grind, and this phase reduces the endosperm to flour. This process is repeated up to 11 times to obtain the finesse required for the flour. The mill products are flour (75%), semolina (3%) and bran (22%).

2.4 Packaging

The finished product (flour) is then bagged in 50Kg bags. The bagging process include operations such as loading, weighing and sewing.

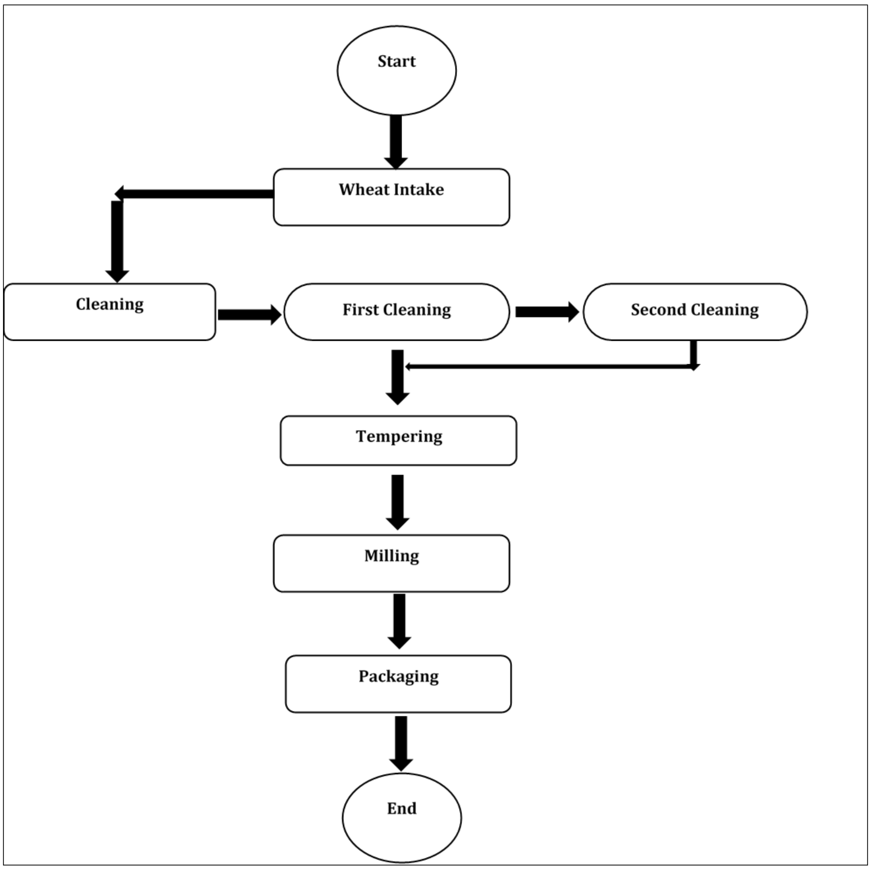

Figure 1 Process Flow Diagram for Wheat Flour Milling

3 Methods

The methods applied in carrying out this research study are discussed thus.

3.1 Linear Programming Model

Linear programming optimization technique is widely applied by managers to make the best use of available resources. This is applicable under conditions such as limited available resource, allocation of available resources to other competing activities and existence of linear relationship between the variables in the problem. Thus, these conditions are satisfied in this study, thereby enabling the application of linear programming mode.

The objective function is defined as,

$$\text{Optimize (Max or Min) } Z = \sum_{j=1}^{n} C_j x_j + \sum_{i=1}^{m} (0 s_i) \quad \text{...(1)}$$

$$\text{Subject to; } \sum_{j=1}^{n} a_{ij} x_j + s_i = b_i \quad \text{... (2)}$$

Which can be expressed in matrix form as

$$\text{Optimize (Max or min) } Z = CX^T \quad \text{... (3)}$$

$$\text{Subject to; } Ax + s = b, \text{ where x and s} \geq 0. \quad \text{... (4)}$$

Where Z is overall production profit to be optimized, X is the amount of products to be optimized, b is constraints of production, A is the materials required for production, and s is slack variable;

The objective function and constraint equations for production optimization as established by Lilly (2015) was used to model the monthly production rate and variables as follows [22]

$$\text{Max } Z = C_1X_1 + C_2X_2 + C_3X_3 \quad \text{... (5)}$$

Subject to the constraints:

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 \leq b_1 \quad \text{... (6)}$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 \leq b_2 \quad \text{... (7)}$$

$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 \leq b_3 \quad \text{... (8)}$$

$$a_{41}x_1 + a_{42}x_2 + a_{43}x_3 \leq b_4 \quad \text{... (9)}$$

where Z is maximum profit, c_1 is unit profit from wheat flour production, c_2 is unit profit from baking flour production, c_3 is unit profit from semolina production, x_1 is quantity of wheat flour to be produced, x_2 is quantity of baking flour to be produced, x_3 is quantity of semolina to be produced, b_1 is available wheat for production, b_2 is available time for cleaning, b_3 is available time for milling and b_4 is available time for packaging.

Hence, the standard time for processes in wheat flour, baking flour and semolina production is expressed in standard linear programming form as,

$$1/20x_1 + 1/20x_2 + 1/100x_3 \leq b_1 \quad \text{... (10)}$$

$$60x_1 + 60x_2 + 60x_3 \leq b_2 \quad \text{... (11)}$$

$$20x_1 + 15x_2 + 25x_3 \leq b_3 \quad \text{... (12)}$$

$$5x_1 + 3x_2 + 5x_3 \leq b_4 \quad \text{... (13)}$$

b_1, b_2, b_3 and b_4 are constraints values which are different for each month depending on the availability of the wheat and machine available time for that month. Hence, the maximization problem would be solved monthly.

3.2 MatLab Software

The steps involved in MatLab technique of solving linear programming equations include an overall idea of the problem, goal identification (maximizing or minimizing), variables and constraints identification, model quantities into mathematical notation and checking model for completeness and correctness. The function applied in this study is

$$\text{Max, f (x), such that} \quad A.x \leq b, \quad \text{... (14)}$$

$$Aeq.x = beq, \quad \text{... (15)}$$

$$lb \leq x \leq ub \quad \text{... (16)}$$

In MATLAB C++ programming the equation is solved using the following function,

[x, Z] = linprog (f, A, b, Aeq, beq, lb, ub) ………………………………………. (17)

where x is quantity of item x_1, x_2, …x_n to be produced, Z is maximum profit when optimized, f is objective function, A = k by n matrix where k is number of inequalities and n is number of variables, b is vector of length k, Aeq is k by n matrix where k is number of equalities and n is number of variables, beq is vector of length k for equalities, lb is lower boundary for limit for which x can exist and ub is upper boundary for limit for which x can exist

3.3 Collection of Data

The wheat flour production plant data applied in this study was taken from Crown flour Mills Limited (Olam Grains) that specializes in the production of wheat flour, pasta product and semolina, and the wheat flour production processes will be the focused production line for optimization. Thus, the analysis of wheat production demand yielded 1/20ton of wheat to produce 50kg of wheat flour and baking flour, while 1/100ton of wheat to produce 10kg of semolina. Also the cleaning period of 60 minutes for each operational stage (wheat flour, baking flour and semolina), milling time of 20 minutes for wheat flour, 15 minutes for baking flour and 25 minutes for semolina respectively. In addition, a packaging time of 5 minutes for wheat flour, 3 minutes for baking flour and 5 minutes for semolina respectively. Hence, production process analysis between January 2020 and December 2020 are evaluated.

4 Results

4.1 First Quarter Analysis

The result of the LP solutions for the different products produced relative to that of the company data for first quarter is shown in Table 1.

Table 1 Linear Programing Solution for First Quarter

Product(X)				Profit (C)
	Wheat flours(x_1)	**Baking flours(x_2)**	**Semolina (x_3)**	
January	-	-	480.58	N132.160
February	433.12	-	-	N142,930
March	450	-	-	N144,070

For the first quarter, it can be seen from the LP solution that baking flour was not produced, Semolina was produced only in the month of January while Wheat flour was produced in the months of February and March, with more profit made in March.

4.2 Second Quarter Analysis

Table 2 Linear Programing Solution for Second Quarter

Product(X)				Profit (C)
	Wheat flours(x_1)	**Baking flours(x_2)**	**Semolina (x_3)**	
April	-	-	463.33	₦157,530
May	-	-	452	₦128,820
June	-	-	475	₦152,030

The result of the LP solutions for the different products produced relative to that of the company data for second quarter is shown in Table 2.

The LP solution for the second quarter shows no significant production of both wheat flour and baking flour in the months of April, May and June, only Semolina was produced, with more profit in April.

4.3 Third Quarter Analysis

The result of the LP solutions for the different products produced relative to that of the company data for third quarter is shown in Table 3.

Table 3 Linear Programing Solution for Third Quarter

Product(X)				**Profit (C)**
	Wheat flours(x_1)	**Baking flours(x_2)**	**Semolina (x_3)**	
July	-	-	459.17	N128,570
August	-	-	484	N160,450
September	-	-	451	N137,820

In the third quarter, the LP solution also shows no significant production of wheat flour and baking flour, as only semolina was produced with more profit made in the month of August.

4.4 Fourth Quarter Analysis

The result of the LP solutions for the different products produced relative to that of the company data for fourth quarter is shown in Table 4.

Table 4 Linear Programing Solution for Fourth Quarter

Product(X)				**Profit (C)**
	Wheat flours(x_1)	**Baking flours(x_2)**	**Semolina (x_3)**	
October	-	-	488.35	₦124,530
November	-	-	500.17	₦145,050
December	-	-	515.17	₦164,850

Furthermore, both wheat flour and baking flour were not produced from the LP solution as only semolina was produced with maximum profit in the month of December.

5 Discussion

The results from linear programming method of optimization for each month with variable machine hours available and wheat available is shown in Figure 2. The optimized results showed that for maximum productivity, only one of the three products should be manufactured monthly. On an average, the range of semolina to be produced was between 451 tons in September and a maximum of 515 tons in December. Thus, in months like February and March, optimized model results showed that wheat flour was more profitable with 433 tons produced in February and 450 tons produced in March. Also, the results for baking flour showed that its production was not included in the optimization for any month due to its lowest profitability when compared with wheat flour and semolina. Besides, comparing the linear programming results and the company's (Crown flour Mill) production data shown in Figure 3, it was observed that all three products (wheat flour, baking flour and semolina) were profitable to the company. However, the optimized model shows that only products with the higher profit after cost price is determined as more profitable product, thus, the optimization affirms that more resources should be put into the production of semolina as it generates more profit than the other products.

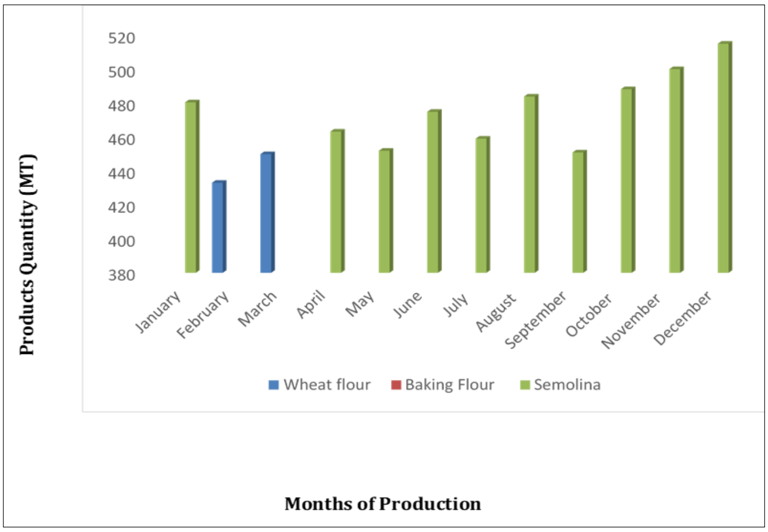

Figure 2 Linear Programming Solution for Wheat Flour, Baking Flour and Semolina

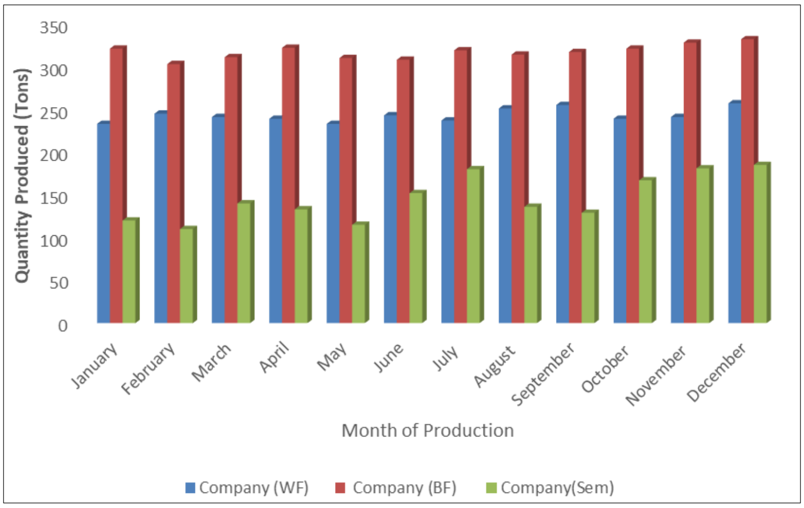

Figure 3 Company production Data for 2020

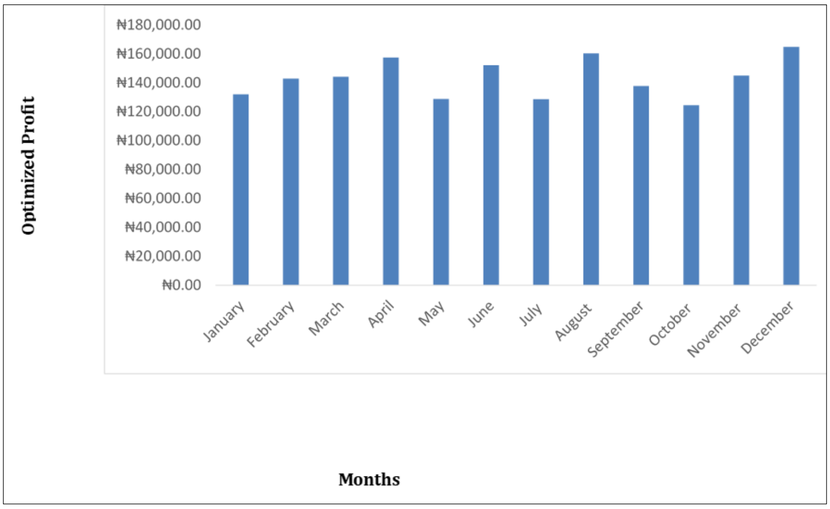

Figure 4 Production Month

In addition, the maximum profit for the year 2020 was obtained during the month of December while the lowest profit was recorded at October through the linear optimization of production as depicted in Figure 4. This indicates that much of the production was done during the month of December as it possessed the highest amount of available wheat (31500 tons) and machine hours (30910 hours). Unfortunately, the profit data from the company for the period of research (January to December 2020) was not provided for this study due to company's policy on confidentiality of privileged information.

6 Conclusion

This research analyzed the operational process of a wheat flour company using the various stages involved in production of flour from milling, tempering, cleaning and packaging. These production processes are used in making wheat flour, baking flour and semolina from wheat material monthly. The average supply of wheat and available machine hours on a monthly basis was also applied for the year 2020 and these variables were computed and modeled into linear programming equations for optimization. The production data from January to December 2020 was evaluated from data provided by the company before optimization and compared with the results from the optimized model. It was observed that for February and March, wheat flour production was more favorable with an optimized production rate of 433 and 450 tons, baking flour production was not recommended by the model while semolina production for the rest of the year was optimized and the model showed an average of 476 tons monthly. Therefore, the maximum profit obtained from the optimized results showed that December was the highest grossing month of about N 168, 000 increase in profit and the lowest grossing month was October with about N 124,000 decrease in profit.

Compliance with ethical standards

Acknowledgments

I hereby acknowledge the support of all academic and non-academic staffs of the Faculty of Engineering, Department of Mechanical Engineering, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt for the success of this research study.

Disclosure of conflict of interest

We the authors disclosed that there is no conflict of interest in carrying out this research study

References

[1] Pruckler M, Siebenhandl-Ehn S, Apprich S, Holtinger S, Haas C, Schmid E. Wheat Bran Based Biorefinery 1: Composition of Wheat Bran and Strategies of Functionalization. *LWT Food Science and Technology.* 2014; *56*(2): 211-221.

[2] Sharma, J. K. (2013). Operations Research: Theory and Applications. New Delhi: Macmillan Publishers

[3] Kourosh R, Farhang KN, Reza H, Hamid RS, Ebrahim A. Solving Linear Programming Problems. *Singaporean Journal of Business Economics and Management Studies.* 2013; *1(*10): 2-5.

[4] Machine AP, Massingue AA, Ngome MT, Balane SG, Munguambe AA, Armando EJ, Asaam S. Physicochemical and Sensory Properties of Bread with Sweet Potato Flour (Ipomea Batatas L.) as Partial Replacer of Wheat Flour Supplemented with Okra Hydrocolloids. *African Journal of Food Science.* 2020; *14(*11): 385-394.

[5] Zhang K. Effect of Wheat Flour with Different Quality in the Process of Making Flour Products. *International. Journal of Metrology Quality. Engineering.* 2020; *1*(1): 6-17.

[6] Farooq Z, Rehman SU, Abid M. Application of Response Surface Methodology to Optimize Composite Flour for the Production and Enhanced Storability of Leavened Flat Bread (NAAN). *Journal of Food Processing and Preservation.* 2013; *37:* 939-945.

[7] Okpala LC, Okoli EC. Optimization of Composite Flour Biscuits by Mixture Response Surface Methodology. *Food Science and Technology International.* 2013; *19*(4): 343-350.

[8] Bressiani J, Oro T, Santetti G, De Almeida J, Bertolin T, Gómez M, Gutkoski L. Properties of Whole Grain Wheat Flour and Performance in Bakery Products as a Function of Particle Size. *Journal of Cereal Science.* 2017; *7*(5): 45-52.

[9] Sang SK, Yang SB, Mi JK, Dabeen L, Kwak HS. Influence of Wheat Flour Milling Yield on Physicochemical, Microbial, and Antioxidant Properties of Korea Wheat (Triticum Aestivum L. var. Jokyoung). *Journal of Food Quality.* 2020; *9*(20): 112-120.

[10] Gómez M, Gutkoski LC, Bravo-Núñez A. Understanding Whole-Wheat Flour and its Effect in Breads. A Review. *Comprehensive Review in Food Science & Food Safety.* 2020; *19:* 3241– 3265.

[11] Bressiani J, Oro T, Da Silva P, Montenegro F, Bertolin T, Gutkoski L, Gularte M. Influence of Milling Whole Wheat Grains and Particle Size on Thermo-Mechanical Properties of Flour Using Mixolab. *Czech Journal of Food Science.* 2019; *37:* 276-284.

[12] Doblado-Maldonado AF, Pike OA, Sweley JC, Devin JR. Key Issues and Challenges in Whole Wheat Flour Milling and Storage. *Journal of Cereal Science.* 2012; *56:* 119-126.

[13] Liu C, Liu L, Li L, Hao C, Zheng X, Bian KE, Zhang J, Wang X. Effects of Different Milling Processes on Whole Wheat Flour Quality and Performance in Steamed Bread Making. *LWT Food Science and Technology.* 2015; *6*(2): 310-318

[14] El-Porai ES, Salama AE, Sharaf AM, Hegazy AI, Gadallah MGE. Effect of Different Milling Processes on Egyptian Wheat Flour Properties and Pan Bread Quality, *Annals of Agricultural Sciences.* 2013; *58*(1): 51-59.

[15] Singh N, Kaur A, Katyal M, Singh AM, Ahlawat AK, Bhinder S. Defatting Effect on Functionality of Wheat. *Food Chemistry.* 2016; *197*: 316-324.

[16] Heliciane C, Carole P, Hubert C, Maren BD, Guy DV, Philippe C, Bernard O. The Effects of Organic Wheat Flour By-Products on Sour Dough Performances Assessed by a Multi- Criteria Approach. *Food Research International.* 2018*; 106:* 974-981.

[17] Pareyt B, Finnie SM, Putseys JA, Delcour JA. Lipids in Bread Making: Sources, Interactions and Impact on Bread Quality. Journal of Cereal Science. 2011; 54: 266-279.

[18] Pycarelle SC, Winnen KLJ, Bosmans GM, Haesendonck IV, Pareyt B, Brijs K, Delcour JA. Wheat (Triticum Aestivum L.) Flour Free Lipid Fractions Negatively Impact the Quality of Sponge Cake. *Food Chemistry.* 2019; *271*: 401– 409.

[19] Katyal M, Singh N, Virdi AS, Kaur A, Chopra N, Ahlawat AK, Singh AM. Extraordinarily Soft, Medium Hard and Hard Indian Wheat Varieties: Composition, Protein Profile, Dough and Baking Properties. *Food Research International.* 2017; *100:* 306– 317.

[20] Kaur A, Singh N, Kaur S, Katyal M, Virdi AS, Kaur D, Singh AM. Relationship of Various Flour Properties with Noodle Making Characteristics amongst Durum Wheat Varieties. *Food Chemistry.* 2015; *188*: 517-526.

[21] Kandil A, Li J, Vasanthan T, Bressler DC, Tyler RT. Compositional Changes in Whole Grain Flours as a Result of Solvent Washing and their Effect on Starch Amylolysis. *Food Research International.* 2011; 44*:* 167– 173.

[22] Lilly, M. T., Ogaji, S. & Probert, S. D. (2015). Manufacturing Engineering, Management and Marketing. Beijing: Partridge Publisher