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Viability of Millet as Adjunct to Malted Barley in Brewing Process

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Abstract: This study presents the discussion and result of the assessment of locally available millet as an adjunct to malted barley in wort production for brewery operation. The investigation carried out included formulating models using linear programming to actually optimize productivity in the brewing industries. The use of mainly imported raw material in the brewery industry has both economical and technological merit and will lead to high cost of production and poor utilization of locally available resources which cannot help the Nigeria industry as a developing nation. It was therefore, concluded from the work that millet could be used as adjunct to malted barley for wort production leading to a cost reduction of #26.42K.

Key words: Wort production, brewery, malted barley, optimize, linear programming

INTRODUCTION

The increase in demand for beer production at a reduced cost of production as forced many countries to make judicious and more effective use of locally available raw materials or to replace them with new brewing materials and one of such possibilities is the conversion of unmalted raw materials with microbial enzymes.

Barley is undoubtedly employed in the preparation of fermented liquors long time ago especially in places where it is used as food. The barley is especially used in Europe so as to produce the necessary enzymes and to modify the major substrate-starch and protein (Okosun, 1999).

Unmalted cereal such as millet, a major and cheap source of starch and protein in Nigeria, especially in the food processing and poultry sector could be used as necessary adjunct since they are cheaper source of starch and of fermentable sugar while still retaining the good and normal quality of beer (Ogbeide, 2007). The cost of malted barley is roughly double that of millet. Sorghum are used in many parts of Tanzania as food and for brewing alcoholic beverages, these grains are used as a source of starch and of fermentable sugar which may be malted or unmalted.

In a developing country like Nigeria where the consumption of beer has grown astronomically over the past decades and this is very glaring looking at the growth and increases in the number of breweries in recent years, notwithstanding, Nigeria still stand tall among the lowest alcohol consuming countries of the world, this is as a result of the fact that beer are brewed at high cost since there is shortages of the malted barley and coupled with the high cost of its importation, inflation rates, cash flow problem, hence the use of millet offers great advantages in brewing industries (Middleman, 1986).

Objectives of the study: The objectives of this study are to:

- Formulate a brewing model using linear programming.
- Examine the quantities of millet to be used as adjuncts taking into considerations brewing restrictions.
- Optimize the cost of beer production in brewing industries
- Assist interested brewing industries in policy making in their choice of raw material.

Millet as a necessary adjunct: Millet, as one of the strongest and cheaper sources of starch in a developing country like Nigeria cannot be over emphasized. It is mainly used as an adjunct because they provide extract at a lower cost than is available from malted barley and because they are readily available. The millet is dried and milled so as to remove the germ and husk which contains fatty oil up to about 7.2% (Middleman, 1986). Millet have traditionally been the adjunct of choice among brewers because corn is consistent in term of composition, availability and produces a spectrum of fermentable sugar and dextrin similar to that produced by malted barley after it has undergo enzymatic conversion. It has a sweet and fine flavor which is compatible with many styles of beer, it is also used as adjuncts because it lowers the polyphenol content of beer, thereby enhancing superior chill-proof qualities and reducing haze potential (Peterson, 1996) a millet taste may be apparent making it more generally suited for the sweet dark beer, some brew expert claim that the use of millet to about 8-15% will help stabilize the flavor of beer (Bobos, 2000).

MATERIALS AND METHODS

Major raw materials: The major raw materials used by the brewer in the brewing industries are:

- Malted barley
- Adjunct
- Hops
- Brewer yeast
- Water

Malted barley: This is the major raw material which may be in 2 or 6 rows of kernels, although there are other types, while the 2 row barley are richer in extract, the 6 row barley are richer in enzymes, hence this study will be based on the 6 row barley so that the adjuncts used can compensate for the enzymes which help in breaking down the starch and protein to a lesser compounds which are soluble in water and when dissolved in water the resulting liquid is known as wort.

Adjuncts: This could be any cereal rich in starch with very low protein content so that the enzymes from the 6-row barley can split the starch which will help to produce beer at a lower cost. Adjuncts (millet) are a source of additional alcohol and also contribute to the aroma, colour of the beer. Table 1 shows the grain and grit percentage composition of millet.

Gelatinization temperature is necessary both in the malting and mashing processes so as to achieve the required wort for beer production (Table 2).

Hops: These contain bitter substances like humulone which help to increase and improve the biological stability, head and body of the beer.

Brewer yeast: These belong to the family of saccharomyces cerevisiae. They are of two types.

The top yeast which form spores and ferment vigorously at elevated temperature and tends to float on top of the beer and the bottom yeast. It is adapted to low temperature and it settles at the bottom of the brew after fermentation.

Table 1: Grain and grit percentage composition of millet

	Maize	
	Grain (%)	Grit (%)
Extract	70.4	85
Protein	11.4	10
Fat and oil	0.9	0.5
Ash	2.9	1.1

Source: (Peterson, 1996)

Table 2: Gelatinization temperature for millet

Size (Um)	10-25
Gelatinization temperature(°C)	60-73

Source: (Okosun, 1999)

Water: This is another major raw material of the brewer that can only be used in its pure state so as to attain the quality of the beer needed and different pH levels are required for the preparation of different brands of bear.

Model formulation: A model was developed using linear programming to optimize, in this case to minimize the cost of production taking account of the necessary constraints (limited resources) associated in the form of

$$\sum_{j=1}^{n} aij\ xj \overset{\leq}{=} bi \quad \text{where } i = 1, 2....n$$

Having the objective function (the total cost reduction) in the form of

$$Z = \sum_{j=1}^{m} Cj\ Xj = bi \quad \text{where } i = 1, 2...m$$

Where Cj are constant values and Xj represent the level of activity or the system variable and the objective function is to be minimized or maximized (Milner, 1988).

An optimization technique enables the determination of the best ratio of malted barley to the adjunct used (millet) in producing the needed wort of high standard.

In this study, 2 main sources of starch was considered in producing the wort required, they are malted barley and millet.

The model simplify to

Minimize

$$Z = \sum_{j=1}^{m} Cj\ Xj$$

Subject to

$$\sum_{j=i}^{6} aij\ Xj \geq bi \text{ where } i = 1, 2,.....n$$

Denoting the mash component used in the wort production by Xj

Where j =1, 2, ….n

Cj = Cost of 1kg of input j (₦/gravity)

Aij = The amount of component type i in kg of input type j

Where i = 1 simple sugar

I = 2 ash content

I = 3 protein content

I = 4 fat and oil content

Table 3: Minimum industry specification of each component

Component	Value specification
Carbohydrate	706.8
Protein	12
Fat and oil	17.5
Ash	30
Adjunct	350

Source: (Nigerian breweries Plc)

I = 5 ash material balance
I = 6 adjunct

bi = Minimum industry specification for component I (g hL^{-1}) as shown in Table 3. Where i = 1, 2 ….n.

It is pertinent to note that the developed model has taken care of the contribution from the component to the wort gravity of the mixing, an amount equal to the product of its gravity of the mixing by considering percentage composition of grain (Frederick and James, 1983).

The model using malted barley and millet

Minimize $Z = 100x_1 + 25x_2$
Subject to:
Carbonhydrate: $0.76x_1 + 0.705x_2 \geq 706.8$
Protein: $0.11x_1 + 0.114x_2 \geq 12$
Fat and oil: $0.017x_1 + 0.009x_2 \leq 17.5$
Ash: $0.025x_1 + 0.029x_2 \leq 30$
Material balance: $x_1 + x_2 = 1000$. Where, x_1 = malted barley and x_2 = millet
Adjunct: $x_2 \leq 350$

Acquisition and analysis of data: All primary data especially on composition and constituent of the malted barley for beer production were sourced mainly from the Nigerian breweries Plc, Lagos State and Bendel breweries in Edo State and this data were compared with one another for consistency, before the final data was determined. Data on price and composition of the millet as adjuncts were collected from the Agronomy Department of International Institute of Tropical Agriculture, (AIITA), Ibadan.

RESULTS AND DISCUSSION

The results of the formulated model which indicates that millet can be used as adjuncts to malted barley and this indicates that proper combination of 65% of malted barley and 35% of millet will results into a cost reduction of #26.25K,(this is better compared to when rice or maize was used as adjunct) but it must be noted that the right hand side of the equation was multiplied by 1000 for feasibility of the model and the final result was then divided by 1000 because of the conversion from kg to g and vice-versa.

The optimum solution from the model is as shown

- Sixty five percent of malted barley should be used
- Thirty five percent of millet should be used in mash formation
- These cereal combination results to maximum cost of #73.75
- The combination gives a cost reduction of #26.25

The maximum change in resource availability for malt and millet model is:

- Increasing the availability of carbohydrate over 0.759 kg hL^{-1} and decreasing it to a very low value of negative infinity if possible will lead to infeasibility of the model.
- Increasing the protein content of the wort over 0.11 kg hL^{-1} and decreasing it to a very low value of negative infinity if possible will lead to infeasibility of the model.
- Increasing the availability of fat and oil to a value as high as infinity and decreasing it to a value less than 0.014 kg hL^{-1} will lead to infeasibility of the model.
- Increasing the availability of ash over a very high value if possible and decreasing it below 0.0254 kg hL^{-1} will lead to infeasibility of the model.
- Increasing the adjuncts used to a value higher than 100% and decreasing it to a value below 0% will lead to infeasibility of the model.

The marginal change in marginal cost

- The contribution coefficient of malt can vary from a value of 25 to a very high value as high as positive infinity.
- The contribution coefficient of millet for wort production can vary from a value as small as negative infinity if possible to a value of 100.

CONCLUSION

The investigation carried out to access the viability of millet as adjunct to malted barley revealed that it results into increased brewing capacity, reduced labor cost, shorter brewing cycle and minimize cost of beer production taking into cognizance the quantities of maize to be used as discussed in this study, also the study have properly examined and established the formulation of brewing model from the locally available millet in relation to the malted barley used, hence interested brewing industry should take advantage of this rare opportunity of choice of raw material for beer production in order to create room for optimization in the industry.

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