Potential African Substitutes for Hops in Tropical Beer Brewing

*Ajebesone P. E.[1] and Aina J.O.[2]

[1] Department of Food Science and Nutrition, E.N.S.A.I.
P. O. Box. 455, University of Ngaoundere, Cameroon.
[2] Department of Food Technology, Faculty of Technology, University of Ibadan, Nigeria.
*Corresponding author.

Abstract

The potential of four selected tropical vegetables, *Grongonema latifolium* (Utazi), *Vernonia amigdalina* (Bitter leaf), *Azadirachta indica* (Neem) and *Garcinia cola* (Bitter Kola) as substitutes for hops in tropical beer brewing were evaluated.
The vegetables were processed into powder by drying at 50°C for 24 hours (such that they maintained their original colour) and then cooled in dessicator before milling in a hammer mill. Proximate analysis showed that these vegetables had protein and crude fibre values comparable to those of commercial hops. Fat content values were however much higher than those for hops with *Grongonema latifolium* having the highest values of 19.10%. *Garcinia cola* with a total resin value of 8.24% and an essential oils value of (1.16ml/100g) had values which were significantly different from those of hops. The other three had values comparable to those for hops. Bitterness levels were high when the vegetables were extracted with organic solvents, than with distilled water. These values however decreased, the longer the storage period. Losses in bitterness were more when the vegetables were stored at ambient temperature than when they were stored at refrigeration or freezing temperatures. Losses in bitterness were more for water extracts than for organic solvent extracts.

Key words: Hops, Resins, Essential Oils, Bitterness level.

Introduction

Hops the female flowers of the hop plant (*Humulus lupulus*) are grown in the temperate regions of the word, solely to meet the demands of the brewing Industry (Hough *et al.*, 1982, Grant, 1977). Hops contribute to foam stability and also provide hop flavour, hop character and preservative properties to the beer (Laws, 1983). In most tropical countries, the hops are imported. With the expansion of the brewing industry in Africa, huge amounts of money are therefore being spend by developing countries for the importation of hops.

A lot of effort has been made in the brewing industry for the substitution of barley with some local cereals. The substitution of hops with local raw materials has not however received the same attention. Some pioneer work by Okafor and Anichie (1983), showed that leaves of the tropical vegetable, *Grongonema latifolium* (utazi), show great potential as substitute for hops.

They found out that this plant possessed some antiseptic properties against beer spoilage micro-organisms. The chemical properties of beer brewed using this plant did not differ much from that brewed with hops though their organoleptic differences were pronounced (Okafor and Anichie, 1983). Okafor and Anichie (1983) however did not characterise the vegetable as they only used it for brewing and sensory analysis.

This piece of work intends to characterise in addition to *Grongonema latifolium*, three other bitter vegetables used for food in the tropics. These are *Vernoniq amygdalina* (Bitter leaf), *Azadirachta indica* (Neem) and *Garcinia cola* (Bitter kola). *Azadirachta indica* is used in some parts of Africa for the treatment for malaria, while *Garcinia cola* is used in some areas for the treatment of stomach ache and gastritis. All four vegetables have one thing in common. They are bitter vegetables.

The principal objective of this study is therefore to compare these vegetables to commercial hops by:

- Carrying out proximate analysis for both the vegetables and hops
- Extracting the resinous components and essentials oils
- Investigating the effect of the type of solvent used for extraction, the temperature and duration of storage on the bitterness levels of these vegetables.

Materials and Methods

Procurement of raw Materials

Freshly picked Neem and Bitter leaf were collected from the Forestry Research Institute, Ibadan (F.R.I.I.), while Utazi and Bitter Kola were purchased from a local market in Ibadan. Hop pellets were supplied by Africana Breweries Ltd. Ibadan. Chemicals used in routine analysis adopted were as detailed by;

(a) The Association of Official Analytical Chemists (A.O.A.C.)
(b) American Society of Brewing Chemists (A.S.B.C.)
(c) Institute of Brewing (I.O.B.)

Processing of vegetables to powders

Fresh vegetables were destalked, sorted and then washed in tap water. They were then air-dried for about 10 mins, after which they were transferred into an air drought oven, at a temperature of 50°C for 24 hours. The vegetables were then allowed to cool to room temperature in a dessicator and then subsequently milled to powder using a laboratory hammer mill (Gibbons, Model 8).

The resulting powders were then put into high density polythene bags of thickness

0.06 mm, heat sealed and then stored in air tight metal containers. The flow chart below represents the process.

Proximate Analysis

The moisture content, protein content, fat content, ash content, crude fibre content and the amount of total resins and essential oils were determined as described by the Association of Official Analytical Chemists and the Institute of Brewing.

Preparation of Vegetable Extracts

A 0.15% (w/v) solution of vegetable sample and solvent was boiled for 90 minutes, after which it was allowed to cool, and then transferred into an air tight transparent glass bottle and then subsequently stored at three different temperatures.

- Ambient temperature (27 ± 1)°C
- Refrigeration temperature (7 ± 1)°C
- Freezing temperature (0 ± 1)°C

Bitterness level determination

Bitterness level values for the extracts were determined by the method described by Hough *et al.* (1982).

Determination of the storage stability of vegetables and hops extracts

Bitterness level values for extracts stored at three different temperatures and for different lengths of time were then measured.

Results and Discussion

Table 1 compares the proximate analysis values of the vegetables to those of commercial hops. *Grongonema latifolium* had the highest fat content, wish was about six times the value for commercial hops. This partially explains why beer brewed with *Grongonema latifolium* as reported by Okafor and Anichie (1983), had a poor foam head. Protein values for the vegetables were comparable to those of commercial hops. Total resin values for *Grongonema latifolium*, *Vernonia amygdalina* and *Azidirachta indica* compare well with those for hops.

However **Table 2** shows all the vegetables having values for hard resins greater than that for hops. The hard

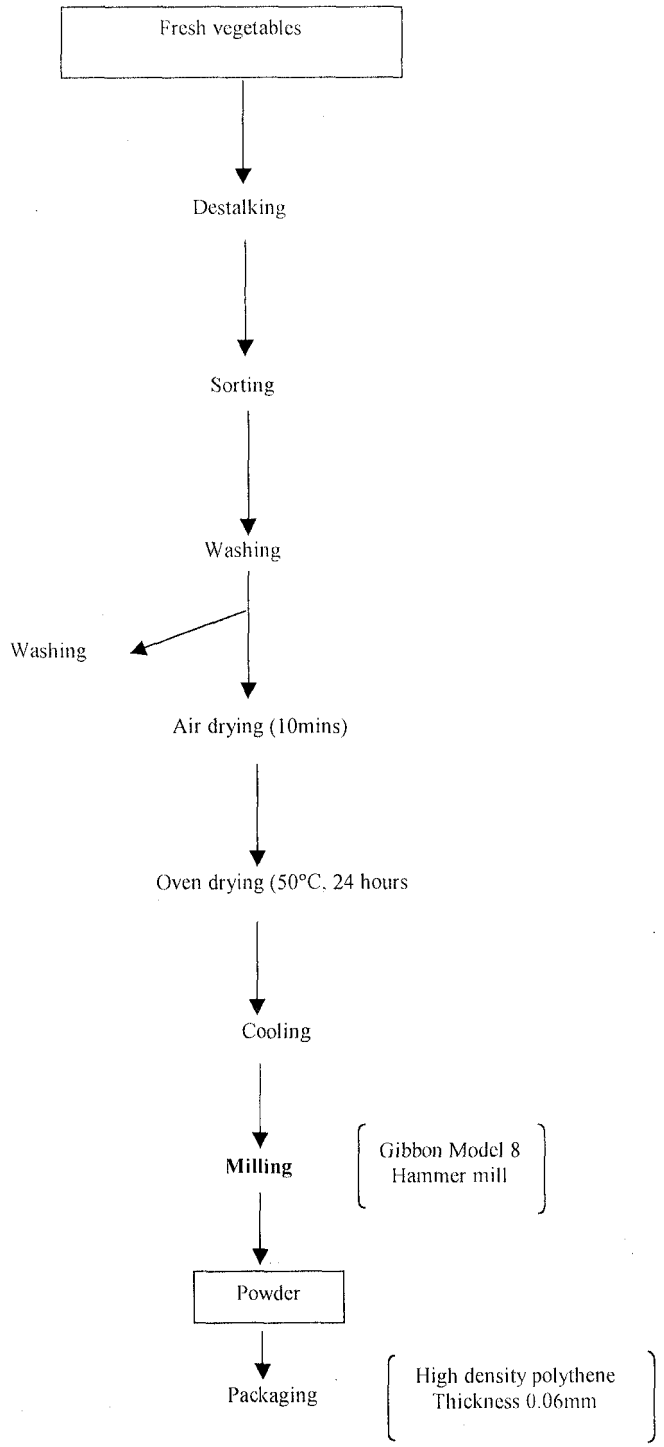

Fig 1. Vegetable processing into powder.

Table 1. Proximate analysis of vegetable samples compared with that of hops

*	% Composition (dry weight basis)				
	Grongonema latifolium	*Vernonia amygdalina*	*Garcinia cola*	*Azadirachta indica*	*Hops
Moisture	12.84	13.12	12.24	11.64	10.00
Fat	19.10	12.27	9.92	8.56	3.00
Protein (Nx6.25)	15.30	16.34	13.08	10.06	15.00
Crude fibre	2.13	3.40	2.17	2.66	3.86
Ash	14.60	8.91	13.62	9.94	8.00
Essential oils	0.61	0.63	1.16	0.77	0.5
Total resins	22.95	18.75	8.24	15.07	15.30

* Source: Hough, Briggs and Stevens (1982); IOB (1977).

Table 2. Resin components of fresh (24hrs) vegetables and hops

Constituents	% Composition (dry weight basis)				
	Grongonema latifolium	*Vernonia amygdalina*	*Garcinia cola*	*Azadirachta indica*	Hops
Total Resins	22.95	18.60	8.24	15.07	18.16
Soft Resins	18.60	13.32	6.07	10.28	16.13
Hard Resins	4.35	5.43	2.17	4.79	2.03

Table 3. *Bittering potentials of water and organic solvent extracts of the vegetables and hops.

Solvents	Bitterness levels in ABU**				
	Grongonema latifolium	*Vernonia amygdalina*	*Garcinia cola*	*Azadirachta indica*	Hops
Water	18.40	14.34	12.10	14.12	38.96
Ethanol	42.00	38.61	28.24	32.84	46.58
Acetone	47.43	45.85	29.40	33.61	48.46
Toluene	48.64	46.96	30.66	35.12	49.96

* Results are presented as means of triplicate experiments.
** Analytical Bitterness Units.

Table 4. Effect of temperature and duration of storage on the biterness levels of water extracts

Vegetable	Percentage reduction in bitterness levels								
	4 Weeks			8 Weeks			12 Weeks		
	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C
Grongonema latifolium	49.51	10.02	8.45	50.10	10.48	9.04	50.23	11.66	9.48
Vernonia amygdalina	32.04	6.99	5.07	34.02	7.31	5.93	35.77	7.65	7.44
Garcinia cola	20.06	4.89	3.31	21.48	5.86	4.42	22.64	6.03	4.95
Azadirachta indica	23.06	6.22	3.56	25.24	7.81	4.63	26.61	7.21	5.12
Hops	5.12	2.31	1.84	8.05	3.94	2.11	9.23	4.14	2.54

Table 5. Effect of temperature and duration of storage on the bitterness levels of Ethanol extracts

Vegetable	Percentage reduction in bitterness levels								
	4 Weeks			8 Weeks			12 Weeks		
	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C
Grongonema latifolia	27.76	4.33	3.18	28.47	4.98	3.47	28.66	5.14	3.84
Vernonia amigdalina	23.87	4.15	2.97	26.31	4.72	3.26	28.19	4.99	3.62
Garcini cola	12.72	3.68	2.48	14.46	4.01	2.96	16.04	4.26	3.16
Azadirachta indica	17.21	4.06	2.73	19.23	4.48	3.11	20.69	4.68	3.49
Hops	3.14	1.62	1.14	4.35	1.67	1.67	5.35	2.04	1.98

Table 6. Effect of temperature and duration of storage on the bitterness levels of Acetone extracts

Vegetable	Percentage reduction in bitterness levels								
	4 Weeks			8 Weeks			12 Weeks		
	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C
Grongonema latifolium	25.29	4.88	3.11	27.13	4.97	3.17	27.32	5.11	4.38
Vernonia amygdalina	21.41	4.02	3.03	25.22	4.28	3.06	26.07	4.72	3.34
Garcinia cola	12.61	3.10	2.06	19.15	3.54	2.61	21.07	3.96	2.93
Azadiracht a indica	16.85	4.02	2.79	2.68	3.86	2.94	22.41	4.15	3.17
Hops	3.07	1.44	1.03	4.12	1.15	1.27	4.63	1.68	1.94

resins are generally accepted as the oxidation products of the soft resins (Grant, 1977). These values suggest that the vegetables will oxidise or deteriorate faster than commercial hops.

The bittering levels of the vegetable extracts are presented in **Table 3.** The values clearly show that the vegetables differ in their degree or level of bitterness. Water extracts gave low bittering values, whilst organic fat solvent extracts gave much higher values. These values were comparable to those of hops. The enhanced bittering yields by organic extracts implies the removal of interfering fat and other lipid materials from the vegetable tissues. These results are consistent with the report of Ashurt (1971) that non-polar fat solvents are suitable extracts for the bittering constituents of hops.

Tables 4, 5, 6, and **7** illustrate the effect of storage temperature and the duration of storage on the bitterness levels of the vegetables.

The results clearly show that hops has a better storage stability than the vegetable extracts. Bittering stability varied with the vegetable, extractant, storage temperature and duration of storage. *Grongonema latifolium* showed the highest losses in bittering potential among the vegetables. Generally however, losses in bitterness were more for water extracts than for organic solvent extracts stored for the same length of time and at the same temperature. After twelve weeks of storage at ambient temperature, most organic solvent extracts still maintained over 70% of their original bitterness, while some water solvent extracts had lost as much as 50% of their bitterness.

Results also show that freezing and chilling storage led to lower losses in bittering potential than storage at ambient conditions. This is in agreement with the reports of Grant (1977) and Hough *et al.* (1982) which say that cold storage provided greater stability for hop bitterness than storage at elevated temperatures. Generally, bitterness levels decreased with the duration of storage.

Table 7. Effect of temperature and duration of storage on the bitterness levels of Toluene extracts

Vegetable	*Percentage reduction in bitterness levels								
	4 Weeks			8 Weeks			12 Weeks		
	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C	27±1°C	7±1°C	0±1°C
Grongonema latifolium	16.51	3.41	2.92	20.36	3.94	3.14	21.64	4.04	3.38
Vernonia amygdalina	15.76	4.23	2.84	17.44	4.46	3.08	19.21	4.63	3.21
Garcinia cola	9.32	2.98	1.66	10.66	3.28	2.15	11.41	3.66	2.47
Azadirachta indica	12.16	3.25	2.36	13.49	3.80	3.75	15.78	3.91	3.01
Hops	2.21	1.06	0.88	3.88	1.64	1.26	3.92	1.89	1.47

⇔ Results of tables 4, 5, 6 and 7 are represented as means of triplicate experiments.

Conclusion

Grongonema latifolium, *Vernonia amygdalina*, *Garcinia cola* and *Azadirachta Indica* all have great potential as substitutes for hops. *Grongonema latifolium*, *Vernonia amygdalina* and *Azadirachta Indica* because of their high bitterness levels, will impart considerable bitterness to beer while *Garcinia cola* with its high value in essential oils will impart flavour and aroma to beer.

The vegetables will maintain their bitterness for longer periods if they are stored at cold temperatures. Stability may also be increased further by pelletizing the powders of the vegetables and then vacuum packing. This will reduce their contact with oxygen and also the rate of oxidation.

References

A.O.A.C. (1975). Association of Official Analytical Chemists. Official Methods of Food Analysis, 19th Edition. Washington D.C.

Ashurt, P.R. (1971). Hops and their uses in brewing. Modern brewing technology Mac Millan Press. London.

Eijinathen, C.L.M. (1969). Kola, its botany and cultivation. Communication N° 59. Department of Agricultural Resources. Royal Tropical Institute, Amsterdam.

Fayemi, A.A. (1982). The processing and preservation of bitter leaf (*Vernonia amygdalina*). MSc. thesis in the Department of food Technology. University of Ibadan. Nigeria.

Grants, H.L. (1977). The practical brewer. Master brewers' association of the Americas. Impressions Inc. Madison, Wisconsin. 128-146.

Hough, J.S., Briggs, D.E., Stevens, R. and Young T.W., (1982). Hopped wort and beer. Malting and brewing science vol. 2. Chapman and Hall. London.

Laws, D.R.J. (1981). Hop processing. Journal of the Institute of Brewing. 87, 296.

Laws, D.R.J. (1983). Hops. Brewers guardian 110 (5) 71-74.

Manary, R.C., William, E.A. and Doe, P.E. (1983). Enzymatic degradation of a-Acids in hops. Journal of the Institute of Brewing, 89,200-204.

Okafor, N., and Anichie, G. (1983). West African hop substitute for sorghum lager. Brewing and Distillation International, 13, 20-21.

Princewill F.I. (1975). Bitter leaf. Proceedings of the First National Seminar on Fruits and Vegetables, Ibadan, 12-14.

Sharpe F.R., Laws, D.R.J. (1981). The essential oils of hops. Journal of the Institute of Brewing 87,96-108.

Uko, E.E. (1988). Preliminary studies on tropical hop substitutes. MSc. thesis. Department of Food Technology. Faculty of Technology. University of Ibadan.

Usher, G. (1974). A dictionary of plants used by man. Constable and Co. Ltd. London 598 pages.