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Pilot Scale Brewing Trials Using Formulated Blends of Selected Local Vegetables as Hop Substitute

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Suitability of two blends of Utazi (*Gongronema latifolium*), Bitter leaf (*Vernonia amygdalina*) and Bitter cola (*Garcinia kola*) in ratios 1:6:2.3 (THS 1) and 0:1:2 (THS 2) as replacements for commercial hops in sorghum lager brewing was investigated. Proportions of vegetables in both blends were obtained through linear programming. Both blends were analysed for fat, tannin, essential oil, total resin and alpha acid contents and then tested on pilot scale brewing trials alongside commercial hops that served as control. Beer samples produced were analysed for their chemical composition, colour, clarity, head foam (formation and retention), bitterness and flavour. The blends of vegetables tested had similar chemical composition and organoleptic properties as those of commercial hops, and offer replacement potentials for the latter in sorghum-based lager beer brewing. However, the use of the vegetable blends will require an efficient filtration system for production of beer of acceptable clarity.

Keywords : Beer brewing, Hop, Utazi, Bitter leaf, Bitter cola, Sorghum.

Hop, a brewing raw material, imparts desirable flavour, aroma, colour, bitterness and foam stability to beer in addition to conferring antiseptic properties to the product (Hough 1980). Unfortunately, commercial hops are produced from the flowers of the hop plant (*Humulus lupulus*), a temperate crop that cannot be successfully grown in tropical countries like Nigeria. Therefore, its import into Nigeria for beer brewing is imperative. The large sum of money spent on the import of hops by over thirty-three indigenous brewing industries in Nigeria (Federal Office of Statistics 1986; FAO Yearbook 1987; Corporate Directory 1990) and the attendant drain on foreign exchange, necessitate the search for cheaper and locally available alternative sources. Bittering and anti-microbial properties of neem (*Azagdiratha indica*), kola nut (*Kola nitida*), utazi (*Gongronema latifolium*), bitter cola (*Garcinia kola*) and bitter leaf (*Vernonia amygdalina*) were evaluated (Okafor and Anichie 1983; Eka 1984; Aina and Uko 1990; Okoro 1993). Although the authors suggested potential uses of these vegetables as hop substitutes in beer brewing, they concluded, however, that no single vegetable satisfactorily replaced commercial hop. There is a need, therefore, to examine possibility of replacement of commercial hop with a combination of vegetables. Indeed, hops of commerce are a blend of different varieties of hops (Hough 1980).

The prospects of replacing commercial hops with pelletised blends of utazi, bitter leaf and bitter cola in ratios established through linear programming are discussed in this communication.

Preparation of blends of hop substitutes : Freshly harvested matured and healthy utazi (*Gongronema latifolium*), bitter leaf (*Vernonia amygdalina*) and bitter cola (*Garcinia kola*) were washed with distilled water, drained and oven-dried at 80°C for 24 h in a draught air oven, until they were sufficiently crispy. The dried vegetables were milled using a Hammer mill (8,000 rpm; Chrystylab mill, model 8) with sieve size of 1.25 mm and then kept in airtight containers, until required for preparation of blends tested as hop substitutes. The milled samples of dried utazi, bitter leaf and bitter cola were mixed in the ratios of 1:6:2.3 and 0:1:2 to make two blends of vegetables THS 1 and THS 2, respectively. The blending ratios were obtained through linear programming as described by Okoro (1993). The resulting blends were pelleted by applying 2 metric tonnes pressure on 1g sample for 1 min using a Carver laboratory press (Model C, Ser. No. 3400-298; W 142 V9050 Fountain BLVD). The pellets produced were of 1.2 cm width and 0.6 cm thickness. The pellets were vacuum-packed in 0.15 mm thick polythene sachet using a domestic vacuum packaging unit (PIFCO) and stored in a cool dry place.

Brewing trials : Brewing trials were conducted at the Sona Breweries Plc, Sango Ota, Ogun State. Sorghum malt was prepared as described by Okon and Uwaifo (1985). Malting lasted a maximum of 5 days and the green malts were oven-dried at 50°C for 48 h to reduce moisture level from 45 % to about 8 %. Wort produced from malted sorghum was used in the conventional brewing procedure (Hough et al. 1982) employed in production of beer. In the control brewing trial (trial 1), commercial hop was used during the boiling operation, while THS 1 and THS 2 replaced commercial hop as substitutes in trials 2 and 3, respectively.

Analytical procedures and organoleptic evaluation : The alpha acid, essential oil, resin and tannin contents of the blends were determined using the Institute of Brewing (1985) method. The analytical bitterness, colour, haze, attenuation (real and apparent), real extract, alcohol and carbon dioxide contents of the beer produced from the three brewing trials were also determined as described by Institute of Brewing (1977). Foam head retention was determined using the method of Hough et al (1982).

A panel of five trained judges evaluated beer samples in terms of foam (formation and retention), colour, bitterness and flavour in a sensory evaluation using a 9-point Hedonic scale (Larmond 1977).

Statistical analysis of results : Results obtained in the study were subjected to statistical analysis as per the procedures of Steel and Torrie (1980).

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TABLE 1. COMPONENTS OF BREWING IN THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS

	Blend		
Constituents, %	THS 1	THS 2	Commercial hops+
Alpha acid	8.27	7.93	11.00
Essential oil	1.46	1.25	0.50
Total resins	14.86	15.11	15.30
Fat	6.20	4.39	3.00
Tannin	3.42	3.58	4.00

Each value is mean of three replicates
+Source: Sona Breweries Plc, Sango-Ota, Ogun State (1999)

Alpha acid, essential oil, total resin, fats and tannin present in hops are responsible for the desirable physical quality attributes of beer (Okafor and Anichie 1983; Eka 1984; Aina and Uko 1990; Okoro 1993). Hence, they constituted the input variables in the linear programming employed for obtaining the proportions of each of the test vegetables in the two blends (THS 1 and THS 2) tested as hop substitutes in the brewing trials 1 and 2. Consequently, the resulting blends were analysed for the components and the results are shown in Table 1. Both blends showed similar composition excepting in case of fat, which was significantly higher in THS 1. Furthermore both blends compared with commercial hops (Sona Breweries Plc) in terms of their contents of total resins and tannins. On the other hand, because they were superior in their contents of essential oil, they had remarkably less amounts of alpha acid. However, they were found similar to Wye-Challenger, a brand of hop, in their alpha acid contents (Marr 1985).

In order to ascertain suitability of the two blends of the test vegetables as replacements for commercial hop used in the brewing industry, ingredient formulation for brewing of the brand of beer being produced by Sona Breweries Plc i.e. Gold larger beer was adopted. In addition, this consideration will lend the results to practical application. The commercial hop and the two blends of vegetables tested in the present study were used at the same rate (4.0 $g1^{-1}$). Results in Table 2 show that colour, haze formation, head foam retention, apparent and real degrees of attenuation and bitterness of the beer produced in the present study were markedly affected by the hop materials used. With the exception of apparent and real degrees of attenuation, significant effect of the hop material on the other quality attributes is in agreement with earlier reports (Hough et al. 1982).

Comparison of the affected quality parameters among the beer produced with the blends and the commercial hops indicated that replacement of commercial hop with THS 1 did not affect colour and foam head retention of the product. On the other hand, with THS 2 as replacement, intensity of colouration was reduced, whereas head foam retention increased significantly. The use of both blends resulted in significantly higher haze formation and degrees of attenuation (apparent and real), while bitterness was significantly reduced (Table 2).

Results of organoleptic assessments of beer brewed with the experimental hop substitutes and the commercial

TABLE 2. QUALITY ATTRIBUTES OF BEER BREWED WITH THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS*

Parameters	Blend brewed with			
	THS 1	THS 2	Commercial hops	±SEM
Colour, EBC	15.00^a	7.50^b	16.00^a	2.682
Haze formazin, EBC	1.10^a	0.85^b	0.65^c	0.130
Foam head retention, sec	134.00^b	140.00^a	128.00^b	3.464
pH	4.08	3.88	4.05	0.062
CO_2,g/l	4.80	5.10	5.70	0.265
Alcoholic content, w/w; %	4.76	3.50	3.83	0.377
Specific gravity (at 20°C)	1.00371	1.00659	1.00761	1.168E-3
Real extract, %	3.10	3.00	3.70	0.219
Refractive Index	35.00	31.30	35.80	1.386
Apparent degree of attenuation, %	92.28^a	91.56^a	82.51^b	3.144
Real degree of attenuation %	74.80^a	78.44^a	66.82^b	3.432
Apparent density ρ	1.95	1.95	1.95	0.333
Bitterness, EBU	23.00^b	21.00^b	27.00^a	2.728

Each value is mean of three replicates
*Values in a row denoted by different superscripts are significantly different (p>0.05)

TABLE 3. MEAN SCORES OF ORGANOLEPTIC ASSESSMENTS OF BEER BREWED WITH THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS

	Blend		
Parameters assessed	THS 1	THS 2	Commercial hops
Foam formation	8.4	8.5	8.5
Foam retention	7.8	8.0	8.0
Colour	8.0	8.0	8.5
Clarity	4.0^b	7.0^a	8.5^a
Bitterness	6.1^b	6.3^b	8.2^a
Flavour	7.2	7.5	7.9

Mean values in a row denoted by different superscripts are significantly different (p>0.05)

hops are shown in Table 3. The results showed that no remarkable difference was observed in the acceptance of beer brewed with the substitutes and the commercial hop in terms of foam formation and retention, colour and flavour. Bitterness was rated lower in THS 1 and THS 2 beer samples. Clarity was poor in case of THS 1 beer.

Bitterness in beer has been attribuied to the total resin constituents (i.e. α-and β-acids) of the hop (Hough 1980). Since no marked difference was observed in total resin contents of THS 1, THS 2 and commercial hops tested (Table 1), significant differences that were observed in the degree of bitterness of beer samples (Tables 2 and 3) were unexpected. The remarkable reduction of bitterness of beer due to the use of both blends of vegetables might have been due to their significantly lower α-acid contents. The results of present study tended to confirm earlier reports that the α-acids, is a major determinant of the source of the bitter character (Iso-alpha acids, produced during wort boiling by a benzilic or acyloin rearrangement) of beer brewed with fresh hops (Verzele 1979; Benton 1984).

The non-significantly lower tannin contents of the two blends tested (Table 1) seemed to suggest that significantly higher haze formation (Table 2) and poorer clarity of beer sample brewed with THS 1 (Table 3) was not due to tannin. Rather, it might be due to other sources as suggested by Moll (1987) and that the filtration system in use at Sona Breweries Plc for clarification of wort produced with the commercial hop tested was inefficient for wort produced with THS 1 and THS 2. Haze formation results from insoluble compounds produced through reaction and cross-linking of tannins with protein molecules during mashing (Daiber 1975; Doherty et al. 1987). In addition, hydrolysis of starches and proteins are retarded and consequently, the wort derived will contain partly hydrolysed substances, which give viscous wort and slow down wort and beer filtration (Aisen and Muts 1987). With an inefficient filtration process, haze develops. Haze in beer may also be due to the presence of inorganic elements, organic elements (especially oxalates), phenolic and polyphenolic substances (Moll 1987).

Degree of attenuation is an indication of how readily hydrolysable is the starch base and consequently, relative availability of fermentable sugars (Ugboaja et al. 1991). Higher degree of attenuation was obtained for beer brewed with THS 1 and THS 2 that had lower contents of tannin (Table 1), which might have been due to less amount of sorghum starch reacting with tannin. Since malted sorghum was the starch base for beer produced with both blends and commercial hop, its relative availability will be a function of the extent to which the starch complexes with tannin and consequently the retardation and/or prevention of its hydrolysis (Daiber 1975; Doherty et al. 1987).

Higher foam head retention was observed in beer brewed with the blends of vegetables as hop materials, their significantly higher fat contents (Table 1) not withstanding. This seemed to suggest that the beer samples had capacities to foam adequately. Furthermore, the addition of foam stabiliser (Biofoam) in the ingredient formulation at the level of inclusion for beer brewing at Sona Breweries Plc was sufficient to maintain satisfactory foam head retention of beer brewed with test blends. Foaming behaviour in beer is due mainly to amount of beer proteins, the major foaming agents, and their interaction with lipids, metal ions and charged polysaccharides (Ugboaja et al. 1991). The interaction of fats with foaming principles leads to collapse of foam bubbles.

Conclusion

From the results, it may be concluded that blends of Utazi, Bitter leaf and Bitter cola in ratios established through linear programming i.e. 1:6:2.3 and 0:1:2 possess characteristics similar to those of and they offer remarkable replacement potentials for commercial hops in sorghum-based larger beer brewing. However, the use of the vegetbale blends will require an efficient filtration system for production of beer of accetable clarity.

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