Kaffir Beer

by

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INTRODUCTION.

It is with considerable satisfaction that I write a short introduction to this thesis presented by the author for the Master of Science Degree of the University of the Witwatersrand.

The work which has gone into the preparation of this thesis is, to the best of my knowledge, the first really scientific investigation of the process of Kaffir Beer brewing, and was undertaken by the author with a view to finding out in how far the technical development of the brewing of European beer could be made applicable to the large-scale brewing of Kaffir Beer. The work involved necessitated research into a large number of factors, such as the numerous varieties of kaffir corn used in the process, the variations in malting practice, etc., and it is particularly pleasing that the author, while engaged in the daily multifarious duties of municipal service, should have found time to undertake the large amount of detailed work which was necessary to arrive at his final conclusions.

The thanks of both the author and myself are due to the City Council of Johannesburg, which has published this volume. It is a great pleasure to both of us, who have the privilege of serving the City Council, to feel that the work of those placed under them should receive such recognition.

I trust that this volume will be of assistance to all others engaged in the municipal service in South Africa whose duties are concerned with the production of a standard hygienic product for consumption of the non-European community which they serve.

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KAFFIR BEER.

This dissertation attempts to offer a preliminary survey of Kaffir Beer in its broad outline, under the following headings:

KAFFIR BEER.

1. Historical.

Kaffir Beer must be one of the oldest fermentation products. Sorghum, the giant millet, was cultivated as far back as 700 B.C., as shown by bas reliefs (now in the British Museum) taken from the palace of Sennacharib at Ninevah. The Ancients would fairly certainly have made fermented gruels of one sort or another from this cultivated grain, and such gruels probably resembled our present Kaffir Beers.

There are numerous native drinks in South Africa, such as Kaffir Beer (Tshwala, Joala, Utywala), Leting, Marewu (Mahow), all made from grain, and also fermented fruit drinks such as Merula Beer (Ukanya).

These drinks are both food and drink to the natives, and play an important part in their tribal life. Beer drinks are held at the schools of initiation for boys and girls, at courtships, at weddings, at funerals, at the sowing and gathering of crops. Beer drinks, too, are often held as a means of settling quarrels.

Ingredients and methods of manufacture of the fermented-grain drinks vary according to the predominating types of corn grown. Malted mealies are used in the Eastern Transvaal for a beer known as Hlama; types of millet, such as rapoko (Eleusine coracana) are used in Rhodesia; but native connoisseurs prefer beers made entirely or largely from kaffir corn (Sorghum vulgare, mabele). It is this ingredient which is largely used in South African Kaffir Beer Breweries.

On 1st January, 1938, the large scale manufacture and sale of Kaffir Beer by many municipalities was begun, thus starting a sociological enterprise of much importance. Prior to this Kaffir Beer had been made and sold by the Town Council of Durban for some years.

The South African Chemical Institute held a symposium on Kaffir Beer, at Kelvin House, Johannesburg, on 22nd March, 1938. (The four papers which were read are given in the Institute's Journal, Vol. XXI, No. 2, July, 1938.) At this symposium it was shown how little work had been done from the scientific aspect on brewing Kaffir Beer, either from the chemical or biological aspect.

Almost overnight a primitive domestic craft became a large-scale modern undertaking, without the necessary scientific investigation to standardise all raw materials, manufacturing processes, and hence the resulting products, as has been done in the European brewing industry. It has, perhaps, been unfortunate to have called the kaffir corn brew a " beer," as it differs greatly from the European beer, and many standardised processes for the latter have not been applicable in the case of Kaffir Beer.

A study of Kaffir Beer has thus been started from the very beginning, firstly in a broad outline. It was begun for the Johannesburg Municipality in the municipal breweries and at the bio-chemical laboratory. Results so far are given in this dissertation. The work was, unfortunately, interrupted by the war.

2. The Processes Involved in Making Kaffir Beer.

The ingredients used in making Kaffir Beer vary. For Johannesburg municipal purposes kaffir corn (Sorghum), malted kaffir corn, and mealie meal only have been considered so far as raw materials.

The corn is " malted " by steeping it in water, and then allowing it to germinate, keeping it moist. When the radicles and plumules have developed, the corn is dried and crushed for use. (This resembles malting of barley for European beer.)

A typical recipe for making Kaffir Beer is as follows:

1. Mix 70 lbs. mealie meal with 70 lbs. crushed kaffir corn and 70 lbs. crushed kaffir corn malt. When mixed, add boiling water to make an easily stirred mash (about 70 gallons water). After stirring, allow to stand (24 hours or more) until the mash is well soured.

2. Cook the soured mash thoroughly, adding water as required, to give a thin porridge. Allow this to cool.

3. When cold, add a further 80 lbs. crushed kaffir corn malt, stir well, and allow to ferment (2 days or longer).

This will give about 100 gallons beer. It is strained before drinking.

Mealie meal is sometimes omitted altogether; or crushed kaffir corn may be omitted. Other grains may also be used.

" Mahow " is another drink prepared by making a thin mealie meal porridge, cooling somewhat and stirring in a little wheaten flour. The mixture sours on standing for some hours (due to lactic acid formation), and is then consumed.

Illicit beers are often produced by unscrupulous persons in European towns for sale to the Bantu in the slums. These " beers " are, in many cases, vile concoctions, adulterated with methylated spirits, or with carbide added to give extra " kick." Such liquors are not considered at all in this dissertation.

A well-brewed Kaffir Beer is quite a pleasant, healthy beverage. It is both food and drink to the native, and is certainly one of the most appreciated parts of the diet as issued in many compounds to-day.

3. Kaffir Corn.

Many varieties of kaffir corn (Sorghum, native " Amebele " or " Mabele ") are obtainable, and it is not yet known which will prove the best—both from the farmers' point of view and from that of brewing.

Considerable variations in kaffir corn as purchased have been found in respect to colour, size, freedom from broken corns, difficulty in removing the husks, and extraneous matter. The corn is graded into four classes, K1, K2, K3, and K4.

K1 is a good quality white corn, dry, reasonably clean, containing not more than 5 per cent. red, pink or defective corns.

K2 is a good quality pink or red corn, dry, with not more than 10 per cent of white or defective corns.

K3 is a good quality mixed dry corn, including any kaffir corn which cannot be classed as white or pink, and with not more than 10 per cent. of defective corns.

K4 includes all kaffir corn not classed in a higher grade, dry and containing not more than 40 per cent. of defective corns.

In the above classification the term " dry " is very vague. Freedom from extraneous matter and husk, and the germinative capacity are disregarded—all important points from a brewer's point of view. The generous allowance of 40 per cent. of defective corns in the K4 grade should certainly prevent the use of this grade of corn for malting.

Most brewers, used to primitive methods, dismiss the corn question by the easy statement " a red corn is best," or " a white corn is best," and are quite astonished when told of the many varieties of kaffir corn—upwards of 100 are known and classified.

In October, 1939, 128 varieties of kaffir corn were planted out at the Cydna Disposal Works as a preliminary trial. These were kindly supplied by Mr. F. X. Laubscher, Potchefstroom College of Agriculture. It is hoped to determine which of these varieties are suitable for this particular climate, and of these, which are most suitable for making Kaffir Beer.

Preliminary Brews with Samples of Kaffir Corn.

In June, 1939, four different varieties of corn were examined for beer making, with the following results:

(1) Corn from Kliptown Malt Yard.

A mixed corn (K3), fairly regular in size, with few (2 per cent. to 3 per cent.) defective berries. Weight of 1,000 berries equals 23·8 gms.

(2, 3 and 4) Corns from Potchefstroom.

(2) Odongae (Scheepers).

Not very regular in size, mainly white, with a few red and a few greenish berries, with 9 per cent. to 10 per cent. of defective berries. Weight of 1,000 berries equals 29·4 gms.

(3) Hegari (Rooi Lama).

Regular in size, mottled in colour (red, brown, dark brown and white), with few broken or defective corns (4 per cent. to 5 per cent.). Weight of 1,000 berries equals 26·5 gms.

(4) Bird Proof (Bontaar).

Small corns, regular in size, colour brown and uniform, with few (2 per cent. to 3 per cent.) defective berries. Weight of 1,000 berries equals 15·9 gms.

Malting.

(a) In a germination test the following results were obtained, the corns having been steeped overnight in water, and then allowed to germinate on damp filter paper:

	1	2	3	4
Sample	Ex Kliptown	Odongae	Hegari	Bird Proof
Germination Time (Days)	5	7	4	7
Per cent Germination	87	57	88	67

Maximum air temperature during test equals 84°F.

Minimum air temperature during test equals 63°F.

Average air temperature during test equals approximately 70°F.

(b) In malting, the corns were steeped in water for 48 hours, and then allowed to germinate. Odongae and Bird Proof again showed low percentage germination and slower growth. Mould growths developed rapidly on Hegari, possibly due to the presence of loose husks.

Kliptown corn and Hegari were considered sufficiently sprouted at the end of five days, and were then dried in the open air.

Odongae was set out for drying after eight days, and Bird Proof after nine days. The malting was done in the laboratory courtyard where day temperatures were much warmer and night temperatures much lower than in the indoor germination test.

Drying was commenced when the plumule in each case had grown to about an inch in length.

Brewing.

After drying, the malted corns were crushed. Some of the original dry corns were also crushed, and four beers brewed from the respective samples, using equal quantities. At completion, the resulting beers were screened through No. 30 mesh, and examined.

Results.

In both acid and fermentation stages, Kliptown and Hegari corns produced more rapid results than the other corns. In all cases the time was somewhat slow, owing to the low average temperatures.

The beer from Hegari had the most colour (pink); then, in order came Kliptown, Odongae and Bird Proof.

Alcohol and Acidity.

	1	2	3	4
Sample	Ex Kliptown	Odongae	Hegari	Bird Proof
Gms. Alcohol per 100 ccs.	2·8	2·8	2·8	2·5
Acidity (as gms. lactic acid per 100 ccs.	0·54	0·52	0·50	0·45

Taste of Beers.

It was considered of great importance that the finished beers should be tasted by various natives, especially by those natives at the municipal brewery who were considered by the brewery staff to be competent judges of Kaffir Beer. How varied and vague the native tastes are can be judged from the results, which could give no clue as to which was the best of the beers.

For example, one native employee of the municipal brewery decided that the best beer was from Bird Proof—a corn finding apparently little favour amongst natives. On being told that the beer was from this type of corn, he changed his opinion, placing this beer third. He then stated that No. 1 beer (ex Kliptown) was the best, whereas No. 2 (ex Odongae) was no good " watery, rubbish beer." The second employee from the brewery, on the other hand, called No. 2 very good, and placed it first in order of preference.

Natives from the public at the brewery, and natives from the laboratory, could give no better information.

The results of information from eight different natives was:

Best beer, each sample—2 votes.

Worst beer, each sample—2 votes.

In colour, too, no proper decision was given. Some natives preferred the pink Hegari corn beer; others said that colour did not matter, taste alone being the deciding factor. One native " expert " from the brewery insisted that the variation in colour was due to more or less mealie meal being added—whereas no mealie meal at all had been used in any of the beers.

Conclusions.

It appeared that palatable beers may be brewed from all four varieties.

Because of the slowness of germination and low percentage germination, Odongae and Bird Proof must be regarded with less favour than Hegari.

It would, however, be unfair to condemn these two varieties from a single small sample, and repeated trials will have to be made on a large scale.

Further Samples of Corn.

The above results being most inconclusive, it was decided to investigate the kaffir corn question more fully. Fifteen further varieties of corn were obtained from Mr. Loubscher, Potchefstroom, and examined by methods similar to those used for barley and barley malt in the European brewing industry. Insufficient quantities of these corns were obtained for beer brewing.

Later, small quantities of each of 128 varieties of corn were obtained and planted out, as mentioned earlier. A description of the crops obtained follows later.

The results of the analyses of the fifteen varieties mentioned above are given in the accompanying tables. There is too little data to decide which are the most suitable varieties; but Red Durra (336) and White Durra (337) seem very good types of corn.

The 1,000 corn weight, regarded as an important test in the purchase of malting barley, varies greatly with the different types of kaffir corn. No. 10 in the accompanying table (Atlas Sunrise), for example, gives a figure just half that of No. 11 (Glenbuys). No conclusions have as yet been drawn as to a relation between the weight of 1,000 corns and the quantity of extract obtainable.

Germination rate should be regular for good malting corns. Much irregularity occurs with certain types of corn, as shown in the second of the following tables:

Special Samples of Kaffir Corn.

Number and Description.	Original Corn.		Per cent. Moisture on Corn as Crushed.	Per cent on Samples after Drying.				
	Per cent. Germination.	1,000 corn Weight (gms).		Ash.	CCl_4 Extract (Fat).	Crude Protein Nx6·25	Crude Fibre.	Carbo-hydrate by Difference.
1. Feterita	87	33·5	10·8	1·5	4·2	14·9	2·2	77·2
2. Greytown Red 330	91	28·8	11·2	1·3	3·9	12·5	1·4	80·9
3. Virginia White	92	21·0	10·8	1·4	3·7	13·0	2·2	79·7
4. Glenelf	91	27·0	10·8	1·6	4·4	12·2	2·2	79·6
5. Ntweka 37/334	84	22·1	10·6	1·3	3·8	13·2	2·4	79·3
6. Makanya F.C.I.	91	30·3	11·4	1·4	3·8	12·9	1·9	80·0
7. Red Durra (Bas)	96	36·6	10·8	1·4	4·2	11·3	1·7	80·4
8. White Durra (Bas) 337	97	36·2	11·0	1·2	4·9	12·3	1·4	80·2
9. Natal Red 328	87	24·6	11·2	1·3	3·8	11·6	1·2	82·1
10. Atlas Sunrise	92	18·6	10·6	1·3	4·6	11·5	1·4	81·2
11. Glenbuys 358	93	37·2	10·6	1·4	4·2	10·9	1·7	81·8
12. Cernuum 511/514	95	29·7	10·6	1·7	3·7	13·7	2·2	78·7
13. 37 R 9	73	23·2	10·0	1·5	4·6	11·7	1·7	80·5
14. 37 R 37	87	26·2	10·8	1·5	4·0	11·6	1·4	81·5
15. 37 R 1	92	21·1	10·6	1·7	3·9	10·2	1·4	82·8

The germination rate of the corns varied, as shown by the following:

No.	Description.	Per cent. Germination. After Three Days.	After Five Days.	Factor.
1.	Feterita	86	87	1·01
8.	White Durra	96	97	1·01
4.	Glenelf	80	91	1·13
15.	37 R 1	74	92	1·24
14.	37 R 37	54	87	1·62
13.	37 R 9	40	73	1·82

Standard hot water extracts and cold water extracts as used for barley malt in the brewing industry, yielded the following results:

Corn No.	Hot Water Extract. S.G.	pH.	Acidity as gms. Lactic Acid per 100 ccs.	Reducing Sugars as Maltose gms. per 100 ccs.	Cold Water Extract. S.G.	pH.	Acidity as gms. Lactic Acid per 100 ccs.	Reducing Sugars as gms. Maltose per 100 ccs.
1. ...	1002·8	6·3	0·046	0·22	1002·7	6·5	0·050	0·21
2. ...	1002·6	6·3	0·036	0·05	1002·5	6·4	0·036	0·16
3. ...	1002·3	6·3	0·039	0·08	1002·5	6·4	0·036	0·14
4. ...	1002·5	6·4	0·035	0·04	1002·7	6·4	0·040	0·21
5. ...	1003·4	6·3	0·040	0·14	1002·8	6·4	0·043	0·23
6. ...	1004·2	6·2	0·050	0·42	1003·3	6·4	0·050	0·39
7. ...	1002·7	6·3	0·040	0·07	1002·9	6·4	0·047	0·05
8. ...	1002·9	6·4	0·040	0·07	1002·8	6·4	0·040	0·05
9. ...	1002·7	6·4	0·046	0·09	1002·2	6·5	0·038	0·17
10. ...	1002·7	6·3	0·046	0·11	1002·7	6·4	0·036	0·19
11. ...	1002·4	6·3	0·046	0·07	1002·2	6·6	0·031	0·15
12. ...	1002·5	6·3	0·050	0·10	1002·4	6·6	0·025	0·19
13. ...	1002·5	6·5	0·050	0·09	1002·3	6·8	0·031	0·18
14. ...	1002·5	6·5	0·045	0·08	1002·2	6·8	0·031	0·14
15. ...	1002·8	6·3	0·050	0·09	1002·5	6·6	0·032	0·18

In all cases the polarimetric reading (2 dm. tube) of the extract was negligible on the instrument available.

The specific gravity is given at 60°F/60°F, water being taken as 1,000.

Corn Planted at Cydna Disposal Works.

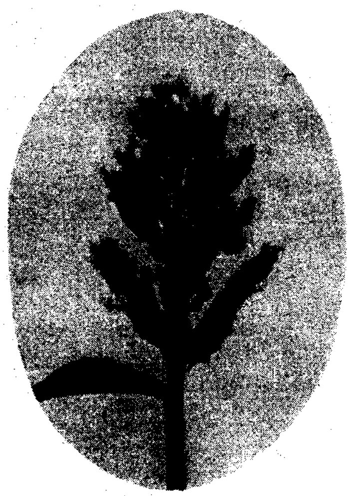
128 varieties of kaffir corn were planted in October, 1939, on a patch of ground near the Cydna laboratory. The soil had been fertilised with digested sewage sludge during the winter months of 1939, and had been irrigated with water containing some sewage works humus, and well ploughed. The treatment given seemed to be insufficient, as the soil appeared to lack humus, and caked readily, at the time of planting.

Seed germination on the whole was poor, and many varieties were replanted after three weeks.

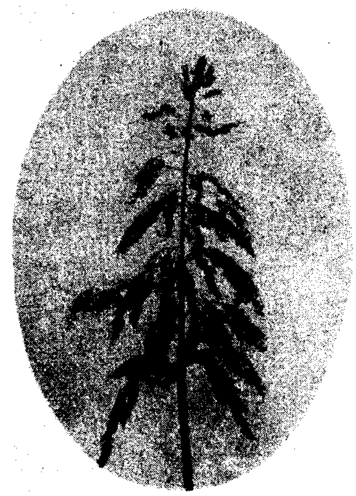
Good results were obtained from rows 65 to 74, where road spoils (excavated outside of Cydna) had once been tipped. Rows 57 to 64 and 116 to 128 were on ground where wattle trees had been growing the previous summer, and in these the results were very poor.

Various pests did much damage to the young ears; and birds attacked the riper ears.

Ears for seed were selected at appropriate times and covered with paper bags as a protection against cross pollination. Accompanying photographs show some of the many variations in types of ears.

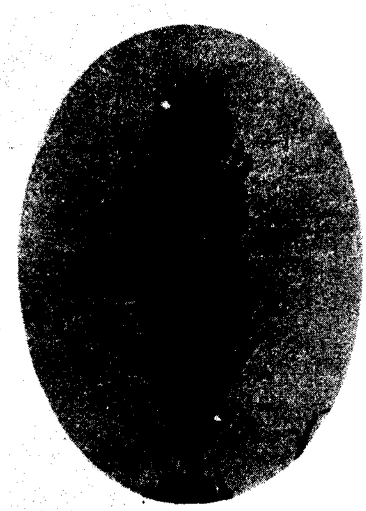


Corn No. 15.

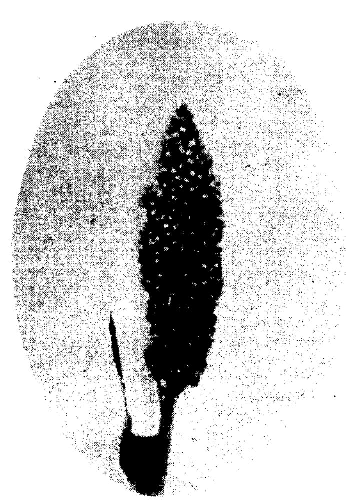


Corn No. 27.

Corn No. 54.



Corn No. 69.



Corn No. 85.

PHOTOGRAPHS SHOWING VARIATIONS IN KAFFIR CORN EARS.

4. Malting.

Sorting.

Before steeping barley for malting purposes, the grain is screened and fanned to remove stones, husks, broken corns, stalks, and other foreign matter. Little attention is paid to this in making kaffir corn malt. The corn is usually transferred from bags as received directly into tanks for steeping.

Experiments have shown that much of the foreign matter tends to develop moulds during the process of malting, and that moulds impart an unpleasant flavour to the subsequent beers. Thus it is advisable to sort out the sound corns, by some process such as is used in European breweries, and use these only for malting purposes.

Washing and Steeping.

It is not customary to wash kaffir corn before steeping. A good washing of the corn prior to steeping is definitely beneficial in reducing tendencies to mould growth, and has in all experiments resulted in a much cleaner malt. However, both in the souring and fermentation stages in brewing Kaffir Beer, reliance is placed on the malt for introducing the necessary organisms to carry out the processes involved. Too thorough washing of the corn before malting appears to remove most of the desirable organisms, and results in a malt which, while appearing to be clean and of a high grade, will be rather inactive in the processes as at present conducted.

During steeping, the corn absorbs sufficient water to enable it to grow when subsequently placed on the malting floor. If the corn is left too long in water it becomes sour, and eventually rots. Changing the steeping water during the course of steeping helps to keep the corns fresh.

The optimum temperature for steeping has not yet been determined; but it appears to be above 60°F—higher than that for barley malt. Samples of kaffir corn have been found to contain from 10 to 15 per cent. of moisture. This is increased to 35 per cent. at the end of the steeping. At temperatures below 60°F this process takes upwards of 24 hours, while at 80°F about 15 hours seem to be sufficient. Most laboratory steepings have been done for 24 hours at 70°F to 75°F, these conditions being found satisfactory.

Corns taken from a malt yard, where the germination figure was usually between 70 and 75 per cent., on being properly sorted, washed, and steeped, gave subsequent germination figures upwards of 85 per cent.

Germination.

Examination of malting processes so far have shown that malting of corn can best be carried out under conditions where temperature and humidity are kept under control. A good deal of heat is generated during the process of germination. A temperature of 131°F (55°C) has been obtained in a batch of malt two feet deep in a drum, and this caused premature withering of the malt in the middle of the drum. Carbon-dioxide is also generated during the process. A good circulation of fresh, moist air is necessary for controlled malting. Much success has been achieved on the small scale by blowing moist air through a batch of malt kept in a constant temperature incubator (68°F), the resulting malt showing very even germination throughout the batch; air was blown from underneath.

In malt yards inspected so far, the top layers of corn malt very poorly because of:

1. Rapid drying out,
2. excessive heat from sunshine, or
3. excessive cooling, due to much evaporation of water at the surface, especially on windy days.

On account of the generation of heat, malting as conducted at present at the municipal malt yard cannot be done in layers deeper than about 9 inches. With proper ventilation, much deeper layers of corn may possibly be used. Malting in layers 18 inches deep has proved successful in an experiment on the small scale, blowing moist air from underneath.

Turning of the corn by shovels or forks during the early stages of germination has not been found to have any deleterious effects, but rather to have helped in maintaining even growth. This is contrary to native custom. If germination is carried far, long rootlets and shoots tender to be broken off readily when the corn is disturbed, and premature withering occurs. Most natives seem to prefer to continue the malting of corn until both radicles and plumules exceed an inch in length, i.e. far longer than is advantageous for barley malt.

Drying.

Most kaffir corn malt is dried in the open air—a cheap method, but unsatisfactory on the large scale. During long rainy spells much of the malt is spoiled. Artificial drying has been done very successfully in the laboratory at varying temperatures. Above 150°F, and more especially above 180°F, prolonged drying destroys to a large extent the wild yeasts and other organisms present on the malt, and this results in much slower souring and alcoholic fermentation when the beer is made. Experiments have shown that artificial drying as carried out with barley malt can be recommended for all large scale Kaffir Beer brewing. This will also result in more constant moisture contents. Random samples of open-air dried malt used in the municipal brewery have had moisture contents varying from 8 per cent. to 16 per cent. This is not satisfactory where consistency in output is required.

Use of Undried Malt.

Quite satisfactory beers have been made from malt before it is dried, but such damp malt after crushing has been found to develop bad mould growths very rapidly. Drying is essential for storage purposes. Further, special types of crushers are necessary for damp malt.

Shoots.

The presence or absence of the " shoots " (radicles and plumules) from the malt has no bearing on the resulting beers, in so far as present laboratory experiments have shown, except where the shoots are very long, when the beer tends to be bitter.

In the production of barley malt, the radicles are removed after drying; but the plumules —here called acrospires—are retained, as in their growth they travel along the length of the grain underneath the husk before emerging, and malting is stopped before they emerge. The radicles contain a larger percentage of nitrogen (protein) than the remaining barley corns, and this nitrogen is objectionable on account of its producing a cloudiness in the resulting beers. No such objection can arise with Kaffir Beer, and it would be impossible to remove only the radicles and leave the plumules.

Unmalted kaffir corn contains from 10 per cent. to 15 per cent. of crude protein; malted kaffir corn (including the shoots) much the same, whereas the shoots alone contain from 25 per cent. to 30 per cent. (an analysis is shown in the next table). The exact effect of this on Kaffir Beer has not yet been determined. It is also noteworthy that the sugars obtained from the shoots are laevo-rotatory.

Kaffir Beer has been found to have low antiscorbutic value. (Dr. Fox.) Experiments will be needed to determine whether removal of the shoots from the malt will have an effect on this, as well as on the other vitamins in the beer.

Degree of Crushing.

The malt as at present used at the municipal brewery—as well as the unmalted corn—is crushed coarsely. Experiments indicate that it may be crushed finer than at present, as finer crushing gives more extract of the malt in the beer (an analysis is shown in the next table), and a greater total solids content. For example, beers brewed under similar conditions gave, after screening the final beers through 30 mesh:

		Total Solids.
1.	Coarse malt and corn	10·0 grms. per 100 ccs.
2.	Medium malt and corn	10·6 grms. per 100 ccs.
3.	Fine malt and corn	11·3 grms per 100 ccs.

In the third sample the malt and corn were both crushed to pass No. 20 mesh before use.

Successful beers have also been brewed in which all ingredients have been crushed to pass the same screen as that usually used for the finished beer (No. 30 mesh). In this case there was no beer " waste " or screenings. The resulting beer, however, was slightly more bitter than usual—probably owing to the inclusion of all the husks and shoots in the finished product. Beers containing mealie meal have not so much waste screening as those without mealie meal—owing to the degree of fineness of the mealie meal usually employed. (This is referred to again later under " Total solids content of beers.")

Table to Show Effect of Degree of Crushing and Effect of " Shoots " on a Sample of Malted Kaffir Corn.

	Malt from Municipal Malt Yard Coarse-crushed at Yard.	Same Malt Crushed Finer at Laboratory.	Same Malt without Shoots Crushed Fine.	Shoots from Same Malt Crushed Fine.
Ash as percentage of dry sample ...	1·23	1·23	0·94	5·70
Fat as percentage of dry sample ...	1·6	2·1	1·8	2·3
Fibre as percentage of dry sample ...	6·63	5·14	4·01	12·5
Protein (N x 6·25) as percentage of dry sample	11·1	11·2	10·0	27·7
Cold Water Extract.				
S.G. (Water equals 1,000)	1006·6	1008·8	1006·5	1024·0
Reducing sugars (as gms. maltose per 100 ccs.)	1·30	2·00	1·27	4·92
Acidity (as gms. lactic acid per 100 ccs.)	0·083	0·099	0·059	0·513
pH	5·65	5·68	5·68	5·52
Polarisation, 2 dm. tube	1·7 D	4·0 D	4·4 D	7·0 L
Iodine reaction	Brown	Brown	Brown	Brown
Hot Water Extract.				
S.G. (Water equals 1,000)	1018·1	1023·9	1022·8	1025·2
Reducing sugars (as gms. maltose per 100 ccs.)	4·49	6·35	5·39	5·29
Acidity (as gms. lactic acid per 100 ccs.)	0·094	0·099	0·060	0·53
pH	5·61	5·64	5·83	5·33
Polarisation, 2 dm. tube	19·6 D	35·2 D	31·0 D	7·8 L
Iodine reaction	Brown	Brown	Brown	Brown
Diastatic power, °L	11·0	12·5	12·6	Less than 2
Maltose by starch conversion, per cent.	71·1	68·4	76·4	7·0

The " maltose by starch conversion " is given as the percentage of the hot-water extract maltose obtained by conversion of starch during the hot-water extraction, i.e.

$$\frac{\text{H.W. Maltose} - \text{C.W. Maltose}}{\text{H.W. Maltose}} \times \frac{100}{1}$$

The shoots gave by far the darkest coloured extracts (dark brown).

Chemical Changes in Malting.

No detailed information can as yet be given as to the changes taking place in kaffir corn on malting. An intensive study of this is contemplated at a later date. The following, however, have been noticed.

1. There is a definite formation of sugar as malting proceeds, and a definite increase in diastatic activity. A standard hot water extract of unmalted corn shows much starch in solution, whereas a similar extract from well-malted corn gives no starch reaction.

2. The acidity of the extract increases with increase in malting.

3. Unmalted corn has a very slight liquefying power. This increases as malting proceeds, indicating a definite development of the liquefying enzymes.

4. Diastatic activity increases as malting proceeds.

5. There is a reduction in the fat content of the corn as malting proceeds, and a rise in the cellulosic (crude fibre) content.

A preliminary set of analysis figures is here quoted.

	Unmalted Corn.	Well-malted Corn.
pH of extract	6·5	5·4
Acidity of extract (as lactic acid) per cent.	0·03	0·10
Crude protein (N x 6·25) per cent.	11·1	12·5
Carbon tetrachloride extract (Fat) per cent.	3·6	2·5
Crude fibre, per cent.	1·6	2·4
Reducing sugars (as maltose) per cent.	0·1	5·6
Diastatic activity, °L	Less than 2	12

The extracts were standard malt extracts, 50 gms. to 500 ccs. of water.

A fuller series of analyses on a sample of corn at various stages in malting is given in the following table.

The table shows progressive changes as malting proceeds; but these become irregular when the radicles and plumules reach a length of an inch or longer (at about the end of the sixth day in the table).

TABLE SHOWING CHANGES TAKING PLACE DURING MALTING OF A SAMPLE OF KAFFIR CORN UNDER CONTROLLED CONDITIONS AT 52° TO 60°F, SAMPLES BEING WITHDRAWN DAILY AND DRIED FOR ANALYSIS.

	Original Unmalted Corn.	After One Day.	After Two Days.	After Three Days.	After Four Days.	After Five Days.	After Six Days.	After Seven Days.	After Eight Days.	After Nine Days.
Ash, per cent. of dry sample	1·14	1·17	1·12	1·12	1·12	1·17	1·14	1·13	1·15	1·14
Fat, per cent. of dry sample (CCl_4 extract)	2·8	1·9	1·4	1·8	2·9	2·1	2·2	2·3	2·3	2·2
Fibre, per cent. of dry sample	2·48	2·17	2·71	3·31	3·60	3·74	3·47	3·67	5·07	6·05
Protein (N x 6·25)	11·1	11·7	11·9	12·2	12·0	11·6	11·7	11·6	12·1	12·1
Cold Water Extract.										
S.G. (water = 1,000)	1001·89	1002·61	1003·60	1004·09	1004·99	1005·65	1005·70	1005·83	1006·49	1006·84
Reducing sugars as gms. maltose per 100 ccs.	0·114	0·386	0·616	0·729	0·956	1·093	1·131	1·149	1·169	1·261
Acidity as gms. lactic acid per 100 ccs. ...	0·018	0·022	0·031	0·036	0·054	0·060	0·074	0·063	0·081	0·086
pH	6·69	6·45	6·25	6·11	5·98	5·92	5·88	5·92	5·92	5·83
Polarisation, 2 dm. tube	1·2	2·0	3·2	3·1	3·8	3·6	3·6	3·4	3·4	3·7
Colour of extract	Very Pale	Darkens Progressively, especially from 4 days onwards								
Hot Water Extract.										
S.G. (Water = 1,000)	1003·71	1007·21	1009·75	1010·71	1018·97	1022·82	1023·09	1021·14	1022·96	1022·98
Reducing sugars as gms. maltose per 100 ccs.	0·118	0·446	1·591	2·176	3·911	4·816	5·491	5·182	5·425	5·880
Acidity as gms. lactic acid per 100 ccs. ...	0·027	0·027	0·034	0·041	0·076	0·090	0·103	0·085	0·063	0·077
pH	6·48	6·40	6·19	6·08	5·74	5·70	5·61	5·78	5·95	5·78
Polarisation, 2 dm. tube	5·4	13·4	14·2	20·0	29·4	35·0	33·0	29·8	31·2	29·6
Iodine reaction	Blue	Blue	Violet	Red Brown with Violet Tinge	Brown	Brown	Brown	Brown	Brown	Brown
Diastatic Power, °L	Less than 2	Less than 2	3	4	6	8·5	9·0	9·0	9·5	9·9
Maltose by starch conversion, per cent. ...	3·4	13·5	61·4	66·5	75·5	77·3	79·4	77·8	78·6	78·5
Total solids, gms. per 100 ccs	0·96	1·87	2·52	2·77	4·91	5·91	5·98	5·48	5·94	5·95
Total maltose, per cent. of total solids ...	12··3	23·9	63·0	78·4	79·6	81·5	91·8	84·6	91·2	98·8

Notes.

1. " Maltose by starch conversion."

Maltose in the hot water extract is greater than that in the cold water extract. The difference is recorded as " maltose by conversion of starch," and is given as a percentage of the hot water extract maltose. (See page 10.)

2. " Total solids, gms. per 100 ccs."

This is difficult to determine by direct evaporation of a known volume of hot water extract, as it is troublesome to dry a sugar-solution without charring. The figure is obtained by the standard brewery method of dividing the excess gravity above 1,000 of the hot water extract by a solution factor of 3·86. This is the factor used for barley malt extracts, and has been found to be a close approximation in the case of kaffir corn extracts, a few samples of extracts having been dried over sulphuric acid in a vacuum desiccator in order to determine the solution factor.

5. **Brewing.**

The brewing of Kaffir Beer involves the following processes:

Mashing, souring, cooking, cooling, alcoholic fermentation, straining.

No culture of the fermenting organisms is added as yeast is added in European brewing, but reliance is placed on organisms naturally present, both for souring and for alcoholic fermentation.

Mashing.

In European brewing, mashing is a carefully controlled process. Some brewers assert that the alcohol content of beer can be adjusted by variations in mashing conditions, especially temperature. With Kaffir Beer, little attempt is made at real control.

Mashing at the Johannesburg municipal brewery is at present carried out by running boiling water on to a mixture of malted and unmalted corn in wooden vats, and stirring. The temperature of the mix is then usually about 180°F. The mash cools slowly, becoming about 120°F after 24 hours and 100°F after 48 hours, when the mash is often sour enough for cooking.

At Durban, the process is somewhat different. Raw grain is mixed with cold water, and the mash then boiled to gelatinise the starch. The mash is cooled to about 160°F, and the malt then stirred in. Souring takes 16 to 24 hours, as compared to Johannesburg's 48 hours or more.

Other variations in the procedure also occur at some of the Rand mine compounds.

Whichever mashing process is used does not so far seem to affect the resulting product to any great extent; but mashing directly with boiling water has the disadvantage of causing " lumping " of the grain and meal used, and consequent troublesome stirring. The gelatinisation of the starch by boiling water, causing " lumping " around unmoistened meal, is somewhat inhibited when malt is mixed with the unmalted grain before adding the water. Good malt does not gelatinise readily, but has instead a liquefying action on gelatinised starch. (This is referred to again under " Alcoholic Fermentation." It is difficult to make a porridge from malt, as large quantities must be used to make a thick product.) On the other hand, over-heating or boiling of the mash with the malt already present will destroy the yeasts and acidifying bacteria.

Optimum mashing conditions cannot as yet be given, except to state that mashing in the cold is of no use.

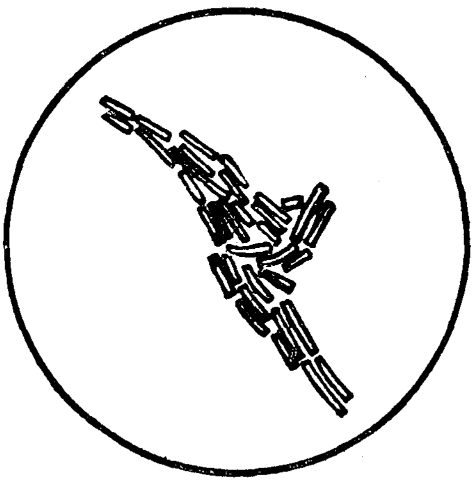
Souring or Acid Fermentation.

In brewing Kaffir Beer, two distinct fermentations occur. Firstly, an acid fermentation. Secondly, after cooking (which destroys the acid-forming organisms which have developed) and cooling, an alcoholic fermentation.

Microscopical examination shows that the souring is due to a number of acid forming bacteria, short and long rods, cocci, and others. Prominent among these are lactic acid bacteria. The alcoholic fermentation is due to great numbers of yeast cells, and is accompanied by much evolution of gas. (See photographs.)

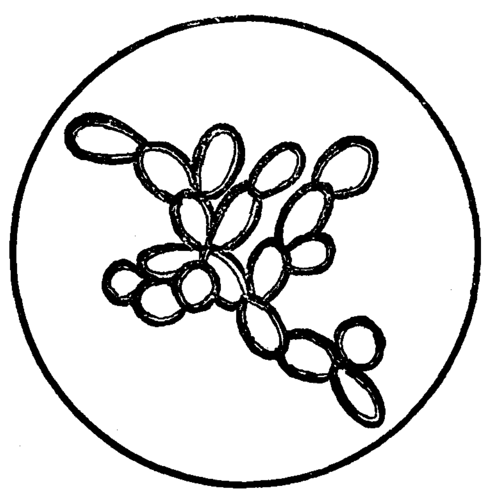
It is a mistake to call the souring stage " yeast," as appears to be in general use. Ordinary yeast does not form during this stage. If any does grow, it is certainly destroyed by the subsequent cooking.

The acidity is due mainly to lactic acid-forming bacteria. The acid in a well-soured mash consists mainly of lactic acid (non-volatile) of about 0·6 per cent. (0·6 gms. lactic acid per 100 ccs. mash) and a small quantity of acetic acid (volatile) seldom exceeding 0·1 per cent.



Lactic Acid Bacteria.
(From Souring Stage.)

MICRO-ORGANISMS PRESENT IN KAFFIR BEER.



Yeasts.
(From Alcohol Fermentation Stage.)

The acidity appears to a slight extent in the malt extract; but the acids are mainly formed from sugars, partly present in the malt, and partly formed from the starch of the ingredients used in the mash by some type of diastatic action. The presence of the acids lowers the pH of the mash from its original value (about pH 6·0) to pH 3·2 to 3·6, and then the organisms cease producing further acid. If the mash is not cooked soon after reaching this stage, objectionable mould growths develop rapidly. This has been very obvious in the souring vats at the municipal brewery. Some measure of careful control at this stage will prevent mould growth or destroy mould infestation. Excessive growths may in time prove to be very troublesome in a brewery with wooden vats (as at Johannesburg), as such vats soon become infected with mould. Washing the vats occasionally with sulphurous acid, and hosing them with steam, have both helped in keeping mould under control in Johannesburg.

A small quantity of alcohol develops during the souring process, but it is of no account in the brewing process, as it seldom reaches even 0·5 per cent. This alcohol forms during the latter part of the souring, when the mash is cooler. A few yeast cells can then be detected under the microscope. The alcohol is boiled off during cooking.

The souring process proceeds equally well whether mealie meal or raw corn or a mixture of these is used together with the malt. Too coarse grinding results in a longer time necessary for formation of the required acid. The addition of sugar (sucrose) speeds up the process to a slight extent, but does not result in the formation of more acid. Both the above bear out the advantages of fairly fine crushing to give more extract. Soured mashes have been obtained from hot water and a mixture of mealie meal and unmalted kaffir corn, but only after a long period (upwards of a week).

Souring proceeds best at warm temperatures. The optimum temperature has not yet been determined; but it may be somewhere about 120°F, the optimum temperature for lactic acid bacteria culture. Souring at blood temperature (98·4°F) is certainly faster than at 80°F, without deleterious effect. A mash examined at the municipal brewery had an initial temperature (after addition of the boiling water and stirring) of 180°F. Cooling was very slow, and at the end of 28 hours, when souring was almost complete, the temperature after stirring was 100°F. It was noticeable that the thick mass at the bottom of the 100 gallon wooden vat was much warmer than the liquid at the top, prior to stirring.

Pitching and Addition of Acids.

In attempts to reduce the time for the souring stage, various experiments have been tried. The organisms necessary for the chemical and physical changes required are present in the ingredients used (chiefly in the malt) in a somewhat latent state. By adding these organisms in a well-developed state, the souring proceeds much faster. This can be achieved by adding to a mash a quantity of previously well-soured mash. With a 10 per cent. such addition, souring has been achieved in as little as six hours in some cases.

The addition of a pure lactic acid culture to a mash has only a small effect in reducing the souring time. The addition of such a culture together with sugar (sucrose or glucose) has a more marked effect.

The souring stage has been omitted altogether by adding to a mash sufficient lactic acid to produce a pH 3·8. After immediate cooking and fermentation, a good, apparently normal beer resulted. Natives even enjoyed a beer so prepared, but substituting hydrochloric acid for lactic acid. Acetic acid did not prove popular, and was largely boiled away during cooking. Lemon juice produced a new flavour, which was not popular with the natives.

The above experiments led to a trial of reducing the quantity of malt used for the initial mash. In a series of experiments, using the process of pitching from a previously soured mash, the quantity of malt used was reduced steadily in successive brews (a portion of each being retained before cooking to sour the next in the series until no malt at all was being used). Acidification proceeded in all cases, but was not as fast with little or no malt as when more malt was used. The resulting beers (after cooking the mash, cooling, and adding malt for the alcoholic fermentation) were all consumed readily, but with less relish when no malt had been used in the souring. The experiment was tried with mealie meal, with kaffir corn and with mealie meal—kaffir corn mixtures. On a larger scale at the municipal brewery, the complete omission of malt did not give a pleasing beer.

A combination of temperature control and pitching will certainly result in a saving of time and malt, and a more regular product both as to time and acidity. Care will be necessary to pitch only with clean, well-soured mashes, and not to use mouldy ones.

Cooking.

When the mash has been sufficiently soured, it is cooked thoroughly. This has a two-fold object. Firstly, the starch has to be completely gelatinised so that it can later be converted by some sort of diastatic action to sugar. Secondly, the acidifying bacteria produced during the souring process are not desired during the alcoholic fermentation; and so the mash must be sterilised.

It has been suggested that the cooking, in presence of the acid, converts much of the starch into sugar (as is done in the glucose industry), but this has not been borne out by experiments, even when the mash has been cooked under 15 lbs. pressure for two to three hours.

Cooking is best done in steam jacketed pots, as the mash becomes thick and very liable to burn. It is customary to cook for two hours, or sometimes even longer, especially in Johannesburg, where water boils at 201°F (94·5°C). Experiments have been tried to shorten the cooking time by using pressure cooking. At 10 lbs. pressure in an autoclave, successful cooking of soured mashes has been accomplished without stirring in 30 to 50 minutes.

Cooling.

The time of cooling could certainly be shortened to a great extent from two days or longer taken at present at the municipal brewery, by some method of artificial cooling, or even the use of shallow, thin-metal trays. This would prevent possible infection from unwelcome air-borne organisms during this stage, as happens when the mash remains exposed for long periods, and would increase the output of the brewery.

After cooking, an experimental brew of 30 gallons was cooled in a water-jacketed iron pot within two hours, the mixture being well stirred and a free circulation of water provided. Subsequent addition of malt resulted, after fermentation, in a normal beer. The old tradition of some natives that the porridge must not be disturbed while cooling seems to be without foundation.

The beer can readily be stored at this stage (cooked, cooled porridge) if the vats containing the porridge are kept clean and screened from possible air-borne infection. In a well-designed brewery, cooling should in any case be carried out in a separate room, where the atmosphere can be kept free from yeasts and bacteria present in the dust arising when handling malt. (Storage of beer is dealt with later.)

Alcoholic Fermentation.

After cooling, a quantity of malt is stirred into the " porridge." The first effect of this is a liquefying action (producing dextrine), which takes place within a few minutes if stirring is thorough. The liquefaction is said to be due to α amylase (C. H. Acharya, B. V. Nath) present in the malt.

The action of this amylase with unmalted corn takes place, but only very slowly. A gelatinised starch paste is liquefied by crushed corn after variable periods exceeding one hour, whereas a similar paste loses all gelatinous properties and becomes completely liquefied within two or three minutes when crushed malt is stirred into it. Malting thus has a marked effect in developing the amylase.

This amylase has been found to have an optimum activity at pH values 4·0 to 6·0 and is rapidly inactivated by boiling. Kaffir corn malt is richer in this enzyme than barley malt obtained from one of the local European breweries.

The next stage in the process is a saccharifying one. Some sugar forms during the first (souring) process, and some is present in the malt added for the alcoholic fermentation. Diastatic action of the malt increases this quantity, e.g. analysis on a sample of fermenting beer gave:

Reducing sugar (as maltose) on the liquefied mass

1. Immediately after stirring in the malt, 4·0 per cent.
2. Six hours later, 10·0 per cent.

This diastatic action is slower than similar action brought about by barley malt. It has an optimum pH range between 4·0 and 6·0, and is destroyed by boiling. It is said to be due to the enzyme β amylase. (C. H. Acharya.) Diastatic power of kaffir corn malt as measured by the standard method of the Institute of Brewing is lower than that for barley malt. A sample of the latter gave a value of 35° Lintner, and this appears to be fairly constant for locally produced barley malts; whereas numerous samples of kaffir corn malt gave values varying from 3° to 18° Lintner. This obviously calls for standardisation in the process of malting. Unmalted corn has negligible diastatic activity.

After the formation of sugar, fermentation begins. This is due to the development of a variety of yeasts introduced with the malt. Predominating types depend on the temperature and duration of fermentation. High temperatures (above 90°F) favour the development of the acidifying bacteria as well.

E. M. Doidge did some research on the flora of Kaffir Beer, and the recent war interrupted some further work by the municipal microbiologist.

The quantity of alcohol formed depends on the time and temperature of fermentation, but it is not permitted to exceed 3·0 gms. ethyl alcohol per 100 ccs. of beer in the product as sold to the natives. Controlled fermentation below 66°F under slight pressure results in a product with an attractive " Head " when poured.

The fermentation must be carried out at lower temperatures than those used during the souring. At blood temperature (98·4°F) lactic acid also forms, resulting in sour beers, with acidities as high as 1 per cent. lactic acid. It is most important, for this reason, to cool the mass thoroughly before adding the malt for alcoholic fermentation.

Fermentation will proceed below 50°F, but only very slowly, upwards of two weeks being necessary.

The optimum temperature is as yet uncertain, and depends on the types of yeasts present, and on the taste required in the final beer, but it appears to be about 70°F, i.e. below prevailing summer temperatures. If " pitching " is used, as described below, this temperature may be reduced with beneficial effect on the resulting product, as fewer side reactions will occur.

Yeast.

Attempts to bring about fermentation with brewer's and proprietary brands of yeast have so far been unsuccessful. As mentioned above, the cooked porridge must first be liquefied, followed by formation of sugars, before fermentation commences. Commercial yeasts do not contain the liquefying or saccharifying enzymes necessary for these processes.

Pitching with Previously-made Beers.

After the addition of sufficient malt to cause the liquefaction of the porridge, the addition of a previously completed beer speeds up the fermentation process to a great extent (as in speeding the souring stage by pitching with soured mash). The process of pitching at this stage is tried sometimes by the natives themselves, especially in making Leting. Care must be taken, however, not to pitch with an old or sour beer, or the resulting product will also be sour. The beer screenings are also effective for pitching purposes, if from a fresh beer.

Beer Brewed within Twenty-four Hours.

Using the process of pitching in both the souring and the alcoholic fermentation stages, a hundred gallon beer brew was carried out experimentally in 24 hours, including 6 hours for cooling. The beer was quite successful. Such rapid brewing would need careful control if carried out on the large scale.

Old Beers.

Old beers develop further acidity, and show a fall in alcohol content. The acid formed at this stage is mainly acetic acid, from the alcohol. Such an old beer from the municipal brewery, which the natives refused to purchase, gave an analysis of

Volatile acid: 0·60 gms. acetic acid per 100 ccs. beer.

Non-volatile acid: 0·63 gms. lactic acid per 100 ccs. beer.

Alcohol: 2·4 gms. per 100 ccs. beer.

A normal beer sampled at the same time gave:

Volatile acid: 0·08 per cent. acetic acid.

Non-volatile acid: 0·42 per cent. lactic acid.

Alcohol: 2·0 per cent.

Attempts to "revive" old beers have not been successful. Experiments tried by the staff of the municipal brewery, in which old beers were boiled, cooled and then stirred up with fresh malt, did not meet with success as far as the natives were concerned.. Boiling drove off the volatile acids and alcohol, allowing further formation of acid and alcohol on re-addition of malt. An example of a beer resulting from such treatment gave:

Volatile acid: 0·39 per cent. acetic acid.

Non-volatile acid: 0·66 per cent. lactic acid.

Alcohol: 3·2 per cent.

The high acetic acid content was unfavourable to the flavour.

Straining.

As beers are made with crushed corn and malt, including the husks and shoots, straining is necessary before drinking. Straining is done in various ways, from the primitive use of some type of "cheese" cloth, or wire gauge (of about 20 meshes to the inch) to various mechanical devices. A centrifugal type of strainer is much used on the large scale, but has the disadvantage that the centrifugal action entirely removes the gas from the beer. A screw type of strainer or squeezer is not as fast as a centrifugal one, but does not remove the gas.

Straining removes much of the solid matter, particularly if the corn is crushed too coarsely, and also much of the yeast. The resulting beer is somewhat flat, and must be allowed to stand for a while so that the yeast can continue the fermentation and provide further gas to give the beer a better appearance and more palatable flavour. Allowance must be made for this secondary fermentation, and thus it is necessary to strain a beer before it is fully fermented. Otherwise there may be insufficient nutritive matter for the yeast, and the beer will remain flat after straining.

After the secondary fermentation, the beer must be consumed as soon as practicable, or the effect of unwanted bacteria will soon become pronounced. Some of these begin to act on the alcohol, forming acetic acid, and the beer becomes "sour."

Storage of Beer.

Good beers can readily be stored for some days by refrigeration. By cooling to and keeping at 50°F, beers which have been slightly sweet, i.e. not fully fermented, have been kept upwards of a week before use. At this low temperature fermentation does proceed, but very slowly. No reason can be seen for any objection to storage at such low temperatures if storage is required, as none of the food value or medicinal qualities of the beers will be destroyed.

When Kaffir Beer is in an active state of fermentation the solid matter is held in suspension by the carbon dioxide gas produced, and this is how the consumer demands it. Cold storage slows down the fermentation, and after some days the solid matter may tend to settle. On warming the beer at this stage (natives do not like cold beer), some of the gas comes out of solution and brings the solid matter back into suspension, especially with a little stirring. If the cold storage is carried out in closed vessels, a slight pressure will be produced, and the greater quantity of gas in solution will ensure the solid matter coming into suspension upon tapping and warming the beer to the temperature desired by the consumer, and produce also a fine "head."

After storage in an open vessel at 45°F for a week, beer was also obtained in a satisfactory state of suspension by addition of carbon dioxide from a cylinder, without in the least impairing the flavour, but rather adding to it.

ANALYSIS OF A BEER THROUGHOUT ITS BREWING.

Souring.

	On Mixing.	After 24 Hours.	After 48 Hours.
Temperature	176°F	120°F	100°F
Specific Gravity of Filtrate	1032·7	1040·2	1042·2
pH	6·0	3·5	3·3
Acidity (as Lactice Acid) per cent.	0·09	0·70	1·02
Alcohol, per cent	Nil	0·2	0·4
Sugars (as Maltose) per cent.	2·0	3·0	3·0

The product had a white scum forming at the end of 48 hours. It was cooked at this stage, and subsequently cooled. Water was added during the cooking to replace that lost by evaporation, and to keep the mass from becoming too thick. The increase in volume was approximately 80 per cent.

The following day malt was added and the process then gave:

Alcohol Fermentation.

	On Addition of Malt.	After 6 Hours.	After 24 Hours.
Temperature	72°F	73°F	75°F
Specific Gravity of Filtrate	1040·3	1042·4	1018·0
Sugars (as Maltose) per cent.	3·5	9·6	4·2
pH	3·8	3·8	3·6
Acidity (as Lactic Acid) per cent.	0·50	0·50	0·62
Alcohol, per cent.	Nil	Nil	2·5

The beer at the end of 24 hours was strained, and judged to be suitable for drinking, though perhaps a little " sweet " for the native palate, the samplers preferring more alcohol development.

TOTAL SOLIDS CONTENT OF BEERS.

The average total solids content of the beer for the period from the opening of the brewery (1st January, 1938) to the end of March, 1938, during which period mealie meal was included in the beer, was:

Total solids: 12·09 gms. per 100 ccs. beer.

For the period 1st April, 1938, to 31st December, 1938, during which no mealie meal was used, the average was:

Total solids: 9·98 gms. per 100 ccs. beer.

For the year 1939 no mealie meal was used, and during the last seven months the beer was strained through one or other of two types of straining machines. The average during the year was:

Total solids: 9·02 gms. per 100 ccs. beer.

The above averages are taken from figures determined once a week on the routine samples.

The ash averaged about 10 per cent. of the total solids (0·46 per cent. of the beer).

It appears from the above test, that for equal weights of meal used, beers including mealie meal generally result in a greater total solids content, and hence greater food value and less waste screenings. This is no doubt due to the mealie meal used being in a much finer state than the kaffir corn at present used at the brewery, in spite of the thorough cooking, and bears out the results given under " malting—degree of crushing." (See page 9.)

Use of Mealie Meal.

A series of beers brewed from:

1. Malt and kaffir corn.

2. Malt and mealie meal.

3. Malt and mealie meal and kaffir corn, and keeping conditions as closely similar as possible, have always resulted in the laboratory and Cydna works natives preferring beers from the third mixture (malt, mealie meal and raw corn). It is noteworthy in this connection that such a mixture is used in the Durban municipal brewery.

FOOD VALUE OF KAFFIR BEER.

The food value of Kaffir Beer varies greatly. The food is mainly carbohydrate (starch and sugars), giving the beer a calorific value of about 500 calories per pint (depending largely on the total solids content). The lactic acid is also a beneficial food, making the beer comparable in this respect with sour milk. The alcohol, not above 3 gms. per 100 ccs. in the beer as sold, also acts as a food, being readily absorbed by the body from the usual quantity of beer consumed (alcohol in small quantities acts as a fuel, with a calorific value intermediate between that of starches and fats). The beer also contains fats and proteins in small quantities, and a variable amount of " roughage " (crude fibre), the last-named depending, as described earlier, on the degrees of crushing of the original corn and malt. A comparison with milk will be somewhat as follows:

	Kaffir Beer.	Milk.
Protein (per cent.) ...	1·4	3·5
Fat (per cent.)	0·4	4·0
Calories (per pint) ...	400	420

Attempts to increase the protein value by including nitrogenous meals—soya bean and peanut—in the mash gave rise to objectionable odours during the cooking, and not very satisfactory beers.

Vitamins.

Dr. Fox, of the South African Institute for Medical Research, has shown that the beer brewed according to methods used in the municipal brewery, does contain small quantities of vitamin C (Anti-scorbutic). One or two quarts of beer per day will probably contain the minimum daily requirement of this vitamin. (It is noteworthy that the two-quart measure is the most popular at the brewery.)

Some natives drink a mixture of Kaffir Beer and some cheap mineral water. Such natives would probably enjoy a ginger beer—Kaffir Beer mixture, and it is an easy matter to brew a most palatable ginger beer, containing uncooked lemon juice, rich in vitamin C. Such ginger beers have been brewed in the municipal laboratory, being fermented by yeast taken from Kaffir Beer vats, and when mixed with Kaffir Beer gave an enjoyable, palatable mixture.

Some pigeons which were fed on a diet of polished rice showed typical " head retraction " symptoms after three weeks, and when dosed with about 4 ccs. of Kaffir Beer recovered. Dr. Fox and Mr. Barnes, of the Institute for Medical Research, have carried out experiments with pigeons proving the presence in the beer of a cure for neuritis. It is hoped to continue these, using the bradycardia method on rats, and chemical examination as well (as far as possible).

It is not surprising to find members of the vitamin B group in Kaffir Beer, as it contains much live yeast, not being filtered and pasteurised as is done with European beer.

Medicinal Value.

Mention may be made here of work begun during 1939 on the possible curative value of Kaffir Beer for ulcers and other stomach troubles. This is being carried out by the Medical Faculty of the University of the Witwatersrand in conjunction with the Johannesburg General Hospital. Many Europeans also purchase the Kaffir Beer for stomach troubles. Encouraging results have been obtained in many cases.

CORROSION OF VESSELS HOLDING BEER.

Ordinary iron vessels are rapidly corroded when used to hold the final brewery product.

Aluminium is much better. A small aluminium vessel, which was filled with beer daily, being well rinsed with water between each filling, showed a loss in weight of only 0·5 per cent. after a year.

Stainless steel samples placed in fresh samples of beer daily, being also well rinsed with water before insertion in the beer each day, showed negligible loss in weight after one year, and remained bright where originally polished.

The high acid content of Kaffir Beer necessitates careful thought being given to vessels to be employed in a brewery.

Stainless steel would be satisfactory, if its price were not prohibitive, for souring, cooking, fermentation and storage.

Prolonged contact with iron produces a metallic taste in the beer, and galvanised iron produces an even worse flavour. Tinned iron is better, but it is doubtful how long the tinning will last. Copper, as used in the boiling vessel in European breweries, needs continued trials before being recommended; but copper will probably be most satisfactory for a cooling vessel.

The use of hard-wood vessels for souring, wrought-iron for cooking vessels, and hard-wood vessels for fermentation and storage, appears to be in common use. For the last two, slate, and more recently, glazed tiles, have been tried on some mines; but corrosion of the cement at the joints has been rapid. Glass-enamel lined iron vessels are very satisfactory. Some of the newer types of acid-resisting varnishes also need trial, and would probably be most economical.

KAFFIR BEER WASTE.

Analysis of Kaffir Beer waste (screenings) show the waste to consist, after drying, of approximately:

	Per cent. by Weight.
Moisture	10
Ash	2
Protein (N x 6·25)	18
Fat	5
Crude Fibre	5
Carbohydrate (by difference)	60

Calorific value: 4 to 5 calories per gm.

Analysis of the Ash:

	Per cent. by Weight of Ash.
Iron oxide and alumina (Fe_2O_3 + Al_2O_3)	40
Calcium oxide (CaO)	1
Magnesium oxide (MgO)	1
Phosphoric oxide (P_2O_5)	14
Potash (K_2O)	trace
Chlorides (Cl)	trace

This will probably show much variation, according to the locality in which the corn is grown.

Beer Waste as Cattle Feed.

At the Delta Sewage Works, observations have shown that cattle relish the beer waste screenings if fresh, and thrive on it. Waste is also removed from Kaffir Beer breweries for cattle feed, and also as pig feed.

Beer Waste for Human Consumption.

Samples of beer screenings after sun-drying and crushing to -20 mesh have been used in various cooking experiments.

Used alone, the waste makes a sour porridge, and poor scones, etc., with an objectionably sour smell during cooking processes.

Used with flour in proportions not higher than 1 part waste to 2 parts flour, quite good baking results, very palatable even to Europeans.

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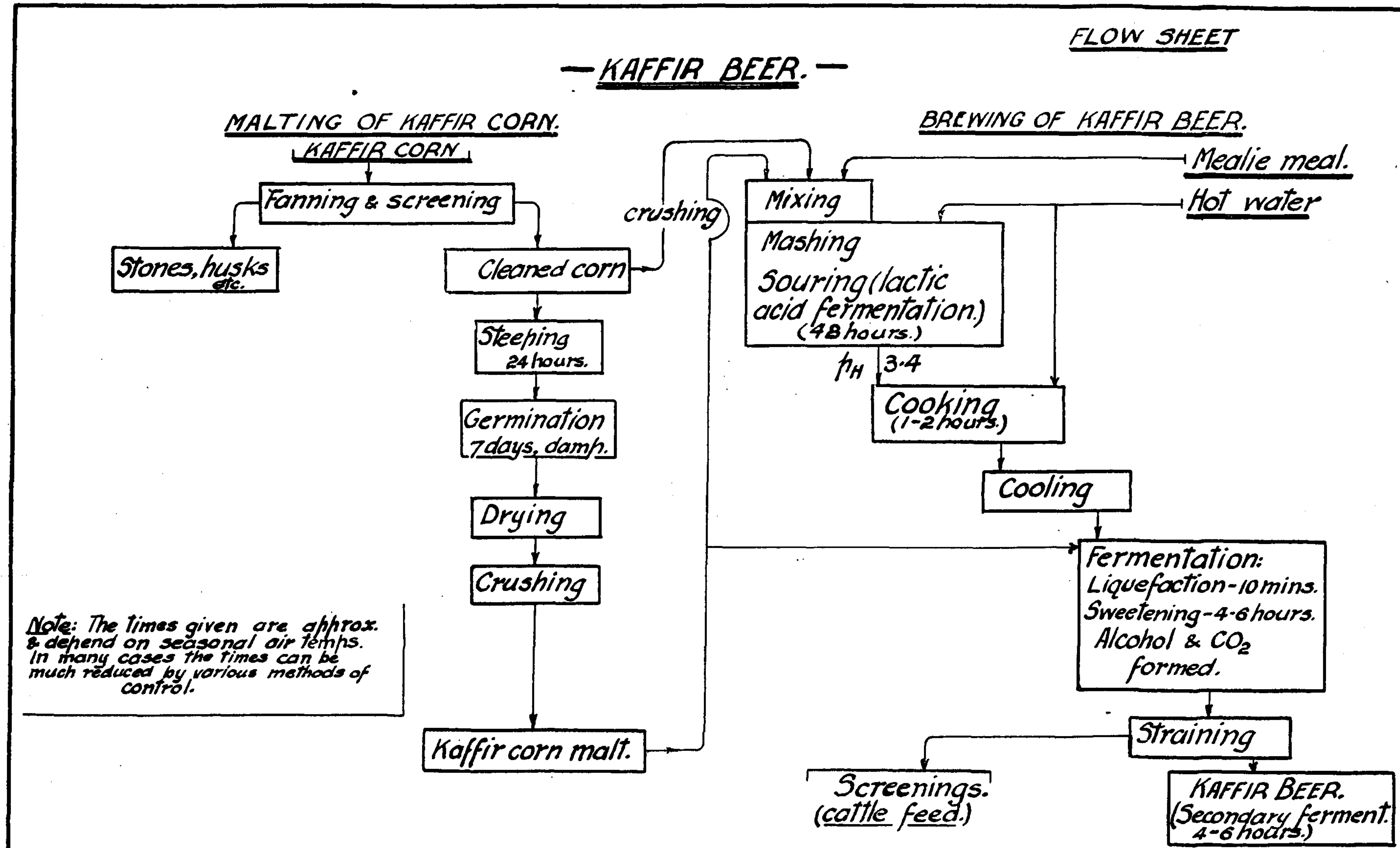
FLOW SHEET
— KAFFIR BEER. —
MALTING OF KAFFIR CORN.
KAFFIR CORN
Fanning & screening
Stones, husks etc.
Cleaned corn
Steeping 24 hours.
Germination 7 days, damp.
Drying
Crushing
Kaffir corn malt.
crushing
BREWING OF KAFFIR BEER.
Mealie meal.
Hot water
Mixing
Mashing
Souring (lactic acid fermentation) (48 hours.)
pH 3·4
Cooking (1-2 hours.)
Cooling
Fermentation:
Liquefaction - 10 mins.
Sweetening - 4-6 hours.
Alcohol & CO2 formed.
Straining
Screenings. (cattle feed.)
KAFFIR BEER. (Secondary ferment. 4-6 hours.)
Note: The times given are approx. & depend on seasonal air temps. In many cases the times can be much reduced by various methods of control.