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SOME QUALITY ASPECTS OF LOCALLY MANUFACTURED MARMALADES

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SUMMARY

By adopting good manufacturing practices and by application of technology, the quality and appearance of marmalade produced from local raw materials has been improved to match or even surpass imported products. A recipe for marmalade, using local oranges, has been formulated.

INTRODUCTION

It is a common knowledge that jams, marmalades and preserves produced locally are not of the highest quality. Except, perhaps in institutions, higher prices do not appear to outweigh qualitative considerations when consumer preferences are considered. Hence the more expensive imported brands of these goods are preferentially bought by discerning and discriminating households.

The most common defects of Ghana marmalades can be classified under the following headings:

1. Texture
2. Flavour
3. Colour

These parameters have collectively affected the quality of local marmalades to the extent that two batches of the same brand are hardly the same.

TEXTURE

Usually, the gel structure is destroyed due to a number of reasons, the most common being:

(a) Overcooking: This results from high boiling temperatures and prolonged boiling probably due to too large a batch size of wrong matching of the ingredients.
Overcooking destroys pectin and consequently the ability of the marmalade to set properly. Batches which have been subjected to severe cooking end up as syrupy, sticky products generally lacking the flavour and aroma of the fruit. It is of interest to note that a pectin gel is elastic, can be cut clearly with a knife and does not adhere to a glass rod. A syrup of high viscosity, on the other hand is not elastic, cannot be cut clearly and when a glass rod is thrust into it and withdrawn the syrup adheres to it and is pulled out as long threads (Morris 1933).

(b) Insufficient Pectin Content:
Another cause of wrong texture is inadequacy of pectin in the batch. The sole reliance on the natural pectin in the oranges and other citrus fruits results in insufficient amount of pectin in the final product to enable proper gel formation. Usually the orange juice and pectin from the fruit sources are extracted with considerable valumes of water, thereby introducing a degree of dilution. The total soluble solids of straight local orange juice has been found to range from 8.5% to 12% while that of juice extracted for marmalade production is known to range from 4.0% to 5.5%.

If no pectin is added to reinforce the natural pectin (which may be extensively destroyed by overcooking) then the chances of good gel formation is prejucided to start with. The alternative is to use larger quantities of sugar to achieve jellification. This also affects the flavour and will be discussed.

WRONG pH

By now it has been generally accepted that the strength and nature of a pectin - sugar - acid gel is dependent on the hydrogenion concentration (pH) and not on the total acidity as expressed by titration measurements.
The pH range within which gel formation occurs is comparatively narrow. For each type of pectin and for each sugar concentration there is a corresponding pH value for optimum jellification. Table I illustrates percentage soluble solids and corresponding pH values for optimum jellification.

Table I Percentage Soluble Solids and Corresponding pH values For Optimum Jellification

Soluble Solids %	pH
75 - 85	3.2 - 3.5
72 - 75	3.1 - 3.4
68 - 72	3.0 - 3.3
64 - 68	2.9 - 3.1
60 - 64	2.8 - 3.0
55 - 60	2.6 - 2.8

Source - Bulmers Pectin p.8

FLAVOUR

(a) Sweetness

Table 2 shows the percentage soluble solids of four samples of orange marmalades to range from 77% to 81.7% compared with 70.6% for two samples of an imported brand. This local brand and the others tend to be highly sugary. The necessity for higher sugar content due to low pectin level has already been mentioned. Further, high temperatures and long boiling can result in a high rate of inversion thereby increasing the final soluble solids content.

$$\underset{342}{C_{12}H_{22}O_{11}} + \underset{18}{H_2O} \qquad \underset{180}{C_6H_{12}O_6} + \underset{180}{C_6H_2O_6}$$

$$360$$

1 mole	1 mole	1 mole	1 mole
sucrose	water	glucose	fructose
		(Invert Sugar)	

(b) Sourness

Some of the local products also tend to be sour or acid to the taste. This is due to the stage of maturity of the fruit used and also to the proportion of lemon juice which is generally very acidic. It is relevant to note that lemon juice is added to the orange juice to lower the pH of the marmalade to the region of optimum jellification.

(c) Fruit Flavour

Protracted boiling has a deleterious effect on the aroma and flavour of the fruit from which the marmalade is manufactured. It is therefore desirable to match the various ingredients in such a way that cooking time is reduced to the minimum.

Table 2

Extent of variation in some properties of one Brand of Locally Produced Marmalade

LOCAL BRAND			
Sample	% SS	pH	Reducing Sugars
1 (orange)	81.7	3.6	39.7
2 (orange)	77.0	3.5	-
3 (orange)	78.0	3.65	54
4 (orange)	79.4	4.2	49

IMPORTED BRAND		
Sample	% SS	pH
1 (orange)	70.6	2.95
2	70.6	2.95

Source - Analytical Section, Food Research Institute

(d) Bitterness

While bitterness may not necessarily constitute a defect it is not agreable to everybody. Taste panel organised at the Food Research Institute has revealed two categories of preferences. One group of this panel prefered the bitter tasting marmalade and the other group strongly disliked it. Further it is believed that children, who are the major consumers of marmalade rather than adults, prefer the sweet (non bitter) type. At present only one section of the marmalade eating population (bitter group) is being catered for.

CAUSES OF BITTERNESS IN ORANGE MARMALADES

Substances responsible for some of the bitterness developing in the juice of oranges are located chiefly in the carpellary membranes, the vascular bundles, the spongy pith and the spongy tissue (albedo) of the peel. The seeds also contain limonin which is intensely bitter (Tressler & Joslyn 1961). It is believed that there is a non bitter precursor of limonin, perhaps a lactone acid or a compound of the diacid or lactone acid such as a glycoside (Emerson 1948). Under the influence of the acid in the juice the non bitter precursor is converted into bitter limonin.

It would be relevant to relate the method of marmalade manufacture to the taste of the product. In order to take advantage of the naturally occuring pectin in the citrus fruit, the oranges are cut up and the pieces, including seeds boiled with water. The extract is later strained and used for making marmalade. It must be remembered that both the pectin and the bitter limonin or its non bitter precursor are located in the same tissues and the above method of pectin and juice extraction is by no means selective.

COLOUR

A wide range of colours is usually exhibited in marmalades on the shelves of local shops. These colour variations are found within the same brand of a product. Though metal ions have been reported to cause discoloration in jams and other fruit products (Morris 1933b) the cause of darkening of these local products can safely be attributed to high boiling temperatures and protracted boiling periods which vary from batch to batch. Too large a batch size may account for this. The various ingredients also have to be matched correctly so as to minimize boiling time.

RECIPE FORMULATION

Recipe formulation for jams, marmalades and preserves takes into account the various properties of all the ingredients and the recipe can be varied to suit the manufacturer's desire. The following recipe is an example of the properties that might be aimed at in a batch of marmalade.

Intended properties of the final Product

Soluble solids 69%
Fruit content 40%
pH on a 50% solution by weight 3.0 - 3.3
Size of batch ———— 3Kg.
Nature of set ———— Medium - firm

Ingredients to be used

Fruit (oranges) ———— 10.5% soluble solids SS
Sugar ———— Sucrose
Pectin ——— Bulmers Pectin Medium Rapid set Type 114 150 x SAG
Preservative ———— Sorbic acid
Type of boiling ———— Open (Not vacuum).

In order to match the various ingredients properly so as to achieve a predetermined result, it is necessary to make allowance for changes that would take place during the boiling process. The quantity of sugar to be used has to be calculated so as to make room for increased sugar content in the final product due to inversion.

Calculations of Sugar Required

Total weight of soluble solids required from all ingredients

$\frac{1}{100}$ x % SS x batch size

Thus for a 3Kg batch

$$= \frac{69}{100} \times 3Kg$$

$$= \underline{2.07\ kg}$$

Soluble solids to be provided by the fruit:

$$= \frac{1}{100} \times \%\ SS \text{ in fruit x weight of fruit}$$

$$= \frac{1}{100} \times \frac{10.5}{1} \times \frac{1}{10Ø} \times 4Ø \times 3$$

$$= \underline{0.126\ kg}$$

Amount of Pectin to be used = 0.015 kg

Amount of acid to be used = 0.008 kg

Total amount of added sugar required in the finished product will be:

Total weight of soluble solids - [SS in fruit + SS in in pectin + SS in acid]

$$= 2.07 - (0.126 + 0.015 + 0.008)\ kg$$

$$= (2.07 - 0.149)\ kg$$

$$= \underline{1.921\ kg}$$

At 69% SS the final marmalade should contain 11 - 38% of invert sugar if crystallization is to be prevented. Taking 20% as suitable $\frac{20}{100}$ x 3 kg = 0.6 kg of invert sugar is required.

But, when sucrose is inverted the final weight of invert sugar is greater than the initial weight of the sucrose.

$C_{12}H_{22}O_{11}$	+	H_2O	$C_6H_{12}O_6$	+	$C_6H_{12}O_6$
1 molecule Sucrose		1 molecule Water	Fructose 1 molecule		Glucose 1 molecule
342g	+	18g	180g		180g

360g of invert sugar.

Thus $\frac{342}{360}$ x 0.6 = 0.567 kg of sucrose is needed to provide 0.6g of invert sugar.

∴ Amount of sugar required = 1.921 - (0.6 - 0.567)
= 1.888 kg.

EXPERIMENTAL

SHREDDED RIND

The shredded material was prepared from uniformly ripe (yellow) oranges. The shredded was boiled for 1 hour with sufficient water to cover. Any loss of water was made good by the addition of more water. The material was drained after boiling and kept in the refrigerator for future use.

DISSOLVING PECTIN

Pectin was thoroughly mixed with five times its weight of sugar. The mixture was dissolved in water twenty four times the weight of the pectin at a temperature between 71°C - 76°C (160°F - 170°F). The water was stirred vigorously with a mechanical stirrer as the pectin - sugar mixture was poured into it in a continuous stream.

Stirring continued until all the pectin was dissolved. The solution was brought to the boil and then kept for future use.

GENERAL STEPS IN COOKING

The steps adopted in cooking the marmalade were the general steps that could be found in any handbook on marmalade production and were as follows:

1. A known quantity of filtered juice was measured into an open boiling pan.
2. A calculated quantity of shredded rind and water were added.
3. The contents of the pan were brought to the boil.
4. Pectin solution was added and the mixture was allowed to boil for about three minutes.
5. A calculated quantity of sugar was added.
6. The mixture was allowed to boil to the required percentage soluble solids.
7. Boiling was stopped.
8. Acid and preservative were added.
9. Marmalade was cooled and then poured into 1lb jar and allowed to set.

TEXTURE STUDIES

Three kilogram batches of marmalade were prepared in order to determine the quantity of pectin needed for a good set. Different pectin levels were therefore used aiming at a medium to firm set. Bulmer's Pectin Type 114 150SAG - Medium Rapid Set was used.

Batch I

Juice was extracted from oranges by reaming half fruits on a Kenwood food Mixing machine. The juice was measured for percentage soluble solids and pH which were 10.5% and pH 3.5 respectively. One thousand two hundred grams of this juice corresponding to 40% of a three kilogram batch was used in the preparation of the marmalade. The properties aimed at in the final product were:

Size of batch - 3kg
Percentage soluble solids - 69%
Fruit content (juice) - 40%
pH on a 50% solution by weight - 3.0 - 3.3
Citric acid - sufficient to reduced pH to desired level.

Based on the principles outlined in recipe formulation the quantity of sugar to be used was calculated to be 1888g. Eight grams of citric acid monohydrate were added to reduce the final pH to 3.3. No extra pectin was added. The marmalade was poured and allowed to set.

Batch 2

The fruit was cut into pieces and covered with sufficient water in a boiling pan. It was brought to the boil and the juice was decanted after 20 minutes boiling. Extraction was repeated and the two fractions bulked. The percentage soluble solids of the extract was 4.5%. This solution was used in preparation of batch two without the addition of extra pectin.

Batch 3

This batch of marmalade was prepared with orange juice extracted by reaming the fruit. The percentage soluble solids was 10.5%. 30g. of Bulmers Pectin Type 114 150SAG - was added as reinforcement.

Batch 4 - was prepared with orange juice with the addition of 20g of Pectin as in Batch 3.

Batch 5 - Fifteen grams of the Pectin was added.

Batch 6 - Ten grams of Pectin was added.

OBSERVATIONS

The results obtained from the experiments are tabulated below.

Table 3. Effect of different pectin levels on the nature of set of 6 batches of marmalade

Batch No.	Size of batch	Quantity of Pectin added g	Nature of set
1	3kg	0	Too weak - almost running
2	"	0	Too weak - running
3	"	30g	Too firm - difficult to spread
4	"	20g	Less firm than batch 3 but considered too firm
5	"	15g	Medium to firm set considered just right spread easily and melts easily in the mouth
6	"	10	Considered too weak a set

Four other batches of marmalade were prepared using 15g of pectin with the fruit juice having % SS as 8%, 8.5%, 9.5 % 10.5% and the nature of set was considered right in all cases. It was concluded that a 3kg batch would need roughly 0.015kg of pectin of the type used for correct gel formation. The other conditions are assumed to be right.

pH

It is possible, by mixing juices from different citrus fruits to produce a marmalade with correct pH and therefore good chances of correct gel formation. This is the practice in local factories. The method though suitable for small scale or household production has its limitations, for if a recipe is followed then any change in fruit quality will mean a variation in quality of the final product unless special precautionary measures are taken to safeguard a standard quality. Unfortunately local factories lack the facilities for quality control. Hence pH of marmalades are likely to vary from batch to batch (Table 2).
On a large scale, therefore, where standardisation of quality is the hall mark of success, it is easier to control pH with natural acids like citric, tartaric, malic, lactic, phosphoric and fumaric. Citric acid is about the most used acid and it is the one which is most frequently present in fruit (Genu Pectin p.23). Moreover, it is a good technological practice that the acid should be the last item to be added to the batch. But if fruit juices are compounded from different sources as mentioned then acidification can no longer be the last step.

Batches of marmalade were prepared using different quantities of citric acid in order to determine the quantity of acid needed to adjust the pH to the region of optimum jellification.

For three kilogram batches, 12g, 10g, 9g, 8g and 5g of citric acid monohydrate were used. Nine grams of the acid gave the most consistent result of keeping the pH of a 50% solution of the marmalade within the region of 3.0 - 3.3. Eight grams was also satisfactory. With oranges purchased on different dates and from different sources the following results were obtained using 9g of citric acid for acidification.

Table 4. pH level of 3kg batch of marmalade using 9g of citric acid monohydrate for acidification

Batch No.	pH
1	pH 3.15
2	pH 3.00
3	pH 3.40
4	pH 3.20
5	pH 2.90
6	pH 3.15

Bitter Flavour

Since the bitter flavour is not acceptable to all marmalade consumers, it was decided to look into means of either eliminating or reducing the bitterness. Four batches of marmalade were prepared using different techniques.

Batch I - Bitter batch

Clean oranges were cut up into pieces, covered with sufficient water and boiled for 20 minutes. The juice was decanted.

There was a second extraction and the two fractions were bulked. A 4.5% soluble solids solution was obtained. It was very bitter. This solution was used to produce marmalade.

Batch 2 - Sweet (Non bitter) batch

Clean oranges were cut into halves and reamed on a Kenwood reamer and the sweet non-bitter juice (SS.10.5%) was used in preparation of a batch of marmalade.

Batch 3

One part of bitter juice used in Batch One was mixed with one part of sweet juice used for batch two for the preparation of marmalade.

Batch 4

One part of the bitter juice (Batch I) was mixed with two parts of sweet juice (Batch 2) for preparation of marmalade.

OBSERVATIONS

The marmalade produced from juice extracted by boiling the fruit was very bitter and was objectionable to those who disliked the bitter flavour.

The product from the sweet juice (Batch 2) had no bitter flavour at all. It was very acceptable to people who disliked the bitter flavour but not acceptable to those who prefer bitterness. The 1:1 mixture (Batch 3) had more of the bitterness than the 1:2 mixture (Batch 4). But batch 4 was acceptable to both, those who liked the bitter flavour and those who liked the sweet (non bitter) flavour.

COLOUR

Non uniformity of colour in different batches of the same brand is undesirable. It is therefore very important to reduce colour variation between different batches to the minimum. If the various steps in production are standardized, then the chances of achieving minimum colour variations are brighter. The cooking process is essentially one of concentration, during which excess water is boiled off. Browning reactions take place during this stage and the longer the boiling the darker the end product. In order to standardized colour, therefore, equivalent quantities of water have to be evaporated every time. To establish the quantity of water that must be evaporated in order to achieve a good colour, 6kg batches of marmalade were produced with varying quantities of water added to each batch. The quantity of water included that used in dissolving the pectin.

Ingredients used were:

Juice (8.5%SS)	-	3kg (50% of batch)
Sugar	-	3.785kg
Pectin	-	0.030kg
Citric acid	-	0.018g
Sorbic acid	-	0.0015g.

Table 5 shows the quantity of water added to a batch and comment on the corresponding colour of the finished product.

Table 5. Quantity of Water added to a 6kg Batch and the extent of Browning in the End Product

Quantity of Water g	Comment on Colour
720g	Light coloured product
920g	Light coloured but darker than above
1120g	Light brown colour (acceptable)
1320g	Very acceptable colour
1420g	Very acceptable brown colour but lighter than a popular imported brand
1520g	Brown colour equal to the imported brand

Four other batches were prepared with the addition of 1500g of water using fruit juice from the same batch of oranges. The 4 batches were very uniform in colour. It was therefore concluded that a 6kg batch of marmalade using the ingredients listed in the above proportions would require the addition of about 1.5kg of water in order to achieve a good colour. Though this figure could vary for other batch sizes it might nevertheless serve as a useful guide.

APPEARANCE OF JELLY

Two batches of marmalade were produced. One batch was made with juice which had been strained through non adsorbent cotton wool. The other batch was made with juice which had been filtered under vacuum through Postlip Filter Paper (Evans Adlard & Co. Ltd.), using super cel hyflo as filter aid.

Observations

The jelly of marmalade produced from the filtered juice was very clear and attractive while that produced from juice which was only strained was opaque and not so much attractive. The former was even more attractive than a very popular imported brand. Filtration as a means of enhancing appearance is therefore strongly recommended.

RECIPE

Based on the results obtained from the various experiments the following recipe is suggested for a 6kg batch of marmalade.

RECIPE FOR A 6KG BATCH OF MARMALADE

STAGE I - JUICE EXTRACTION

A 1) ORANGES (ABOUT 30)
2) WASH ORANGES
3) CUT UP FRUIT INTO PIECES
4) BOIL PIECES WITH SUFFICIENT WATER TO COVER
5) POUR OFF JUICE AFTER ABOUT 20 MINUTES BOILING
6) ADD ANOTHER ROUND OF WATER FOR A SECOND EXTRACTION AND COMBINE THE TWO EXTRACTS
7) ALLOW JUICE TO SETTLE
8) POUR OFF CLEAR JUICE AND DISCARD SEDIMENT
9) FILTER THE JUICE UNDER VACUUM USING FILTER AID - JUICE "A"
10) KEEP JUICE "A" (BITTER JUICE) FOR NEXT STAGE (THIS JUICE HAS A SOLUBLE SOLID CONTENT OF ABOUT 4.5%).

B 11) ORANGES (ABOUT 50)
12) EXTRACT JUICE FROM FRUIT EITHER BY PRESSING OR REAMING ON A SUITABLE MACHINE
13) BOIL JUICE FOR 3 MINUTES TO INACTIVATE ENZYMES
14) ALLOW TO SETTLE
15) POUR OFF CLEAR JUICE AND DISCARD SEDIMENT
16) FILTER JUICE UNDER VACUUM USING FILTER AID - JUICE "B"
17) KEEP JUICE "B" (SWEET JUICE) FOR NEXT STAGE.

STAGE 2

18) WEIGH 1KG OF JUICE "A" (BITTER JUICE)
19) WEIGH 2KG OF JUICE "B" (SWEET JUICE)
20) COMBINE THE SWEET AND BITTER JUICES TO GIVE A MIXTURE OF APPROXIMATELY 8.5% SOLUBLE SOLIDS
21) ADD 680ML OF WATER
22) ADD ENOUGH OF PRE BOILED SHREDDED MATERIAL (PIECES OF RIND - 120G - 160G)
23) BRING TO THE BOIL.

24) ADD 30G - 32G BULMERS PECTIN MEDIUM RAPID SET TYPE 114 150 x SAG OR TYPE 121 SLOW SET 150 x SAG OR ANY OTHER SUITABLE PECTIN. THE PECTIN IS MIXED WITH FIVE TIMES ITS WEIGHT OF SUGAR (150G - 160G) AND DISSOLVED IN 24 TIMES ITS WEIGHT OF WATER I.E. 720ML OF WATER.
25) ADD 3785G OF SUGAR
26) STIR WELL FOR COMPLETE DISSOLUTION
27) BOIL TO 69% SOLUBLE SOLIDS
28) ADD 18G OF CITRIC ACID MONOHYDRATE
29) ADD 1.5G OF SORBIC ACID (PRESERVATIVE)
30) ALLOW TO COOL AND POUR.

DISCUSSION

Results obtained from the experiments clearly indicated that the use of pectin is an essential practice for controlling the nature of set of jelly marmalades. This has been over looked by local manufacturers with the result that they have very limited control over jellification in their products. An interesting point, however, is that the label of the Ghana Cannery Corporation products carries pectin as an additive, a fact underpinning the importance of this compound.

Pure natural acids like citric acid should substitute for other citrus juices in controlling pH of the final product. Use of these acids will ensure a more uniform pH and taste in the products. Further, they will be more convenient to use as the quantity of it used can be exactly known at any time whereas the quality of lemons vary with season and it may not be possible to determine the amount of acid added from fruit sources. The added advantage of acidifying the marmalade at the last stage in the cooking process is another strong point in favour of these acids.

By compounding orange juice extracted by (a) boiling oranges and (b) reaming or pressing it is possible to reduce the bitter flavour in marmalades or even completely climinate it by using only juice extracted by reaming or pressing the fruit. Boiling can be controlled so as to prevent destruction of fruit flavour, standardize colour and enhance correct gel formation by preventing pectin degradation.

Good filtration of the juice gives a bright, clear jelly and since appearance is an important attribute of quality a little extra effort in this direction will be worthwhile.

CONCLUSION

By adopting good manufacturing practice and the application of technology, the appearance and quality of locally produced marmalades, using local raw materials can be considerably improved. Results obtained in the laboratory clearly show that top quality marmalade can be produced locally, even for the export market. A recipe for marmalade has been formulated for local oranges.