



**MAURITIUS RESEARCH COUNCIL**  
INNOVATION FOR TECHNOLOGY

**DEVELOPMENT OF A PROCESSING  
PACKAGE FOR PICKLING ONION  
IN RODRIGUES**

**Final Report**

*March 2004*

**MAURITIUS RESEARCH COUNCIL**

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# MAURITIUS RESEARCH COUNCIL FINAL REPORT

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## SUMMARY

The objective of this project is to develop a high- value added onion pickle product, with a reasonable shelf life for marketing and using small-scale processing technologies for the informal food sector and women entrepreneurs in Rodrigues. Onion varieties, Blanc de Galmi (white), Yellow Dessex (yellow) and No Flaye (red) of bulb of diameter 15-25 mm have been found to be most suitable for pickling. Onion peeling can be less irritant to the eye and facilitated by blanching the onions in hot water (95-98°C) for 1-2 minutes and dipping in cold water for 5 minutes. Pungency is reduced by fermenting peeled onions in a 8-10% NaCl w/v solution for 24-36 hours while browning is minimised by using a combination of 500 ppm citric acid and 300 ppm ascorbic acid. Product stabilisation is achieved by hot filling of jars with pickling solution at 85°C followed by pasteurisation at 80°C for 3-4 minutes. The taste of the onion pickles has been significantly improved by the use of red chilli, ginger and garlic or Rodriguan green chilli and local garlic.

## **INTRODUCTION**

Onion is an important cash crop in Rodrigues. Onion production is seasonal and the main harvest season is from October to November. Onion is mainly grown for fresh consumption in Rodrigues. The annual production is of the order of 400 – 450 tonnes over an acreage of 35 – 50 hectares. The annual onion consumption in Rodrigues is around 200 tonnes and the surplus production (200 – 250 tonnes) is exported towards Mauritius.

'Local Red' is the main variety grown, although there is increasing trend to grow Veronique/ G22 during the recent years. With years of selection, the 'Local Red' variety has developed exclusive characteristics, which include a special taste and a relatively long conservation time (NSSSP, 2003). Small 'Local Red' onions (less than 25 mm diameter) are not purchased by Agricultural Marketing Board as per its market standards. Thus, growers have no alternative other than disposing of the small bulbs or keeping them as sets for the following year's planting season. These lead to substantial post harvest losses. However, these small onions have a great potential for processing as they can be processed into pickles, which may become a potential high-value product for export (NSSSP, 2003).

Onion pickling is a rather new concept in Rodrigues. But around the globe, the trade of onions pickled in brine is already established. Imports of onion pickles from abroad are quite considerable in Mauritius. These pickles are mostly consumed as appetisers in hotels, restaurants and cocktail parties. Thus, producing onion pickles can substitute for the ever-increasing food import bill in Mauritius and help in diversifying the Rodriguan economy through the creation of small and medium agribusinesses. Furthermore, onion pickles can be marketed as a high-value added product to the many tourists visiting Rodrigues Island.

This study was initiated after the field visit on 'Analysis of Research Needs in Rodrigues' conducted by MRC in 1999. One of the recommendations of the field visit report was the rehabilitation of 'Local Red' onion plantations with the aim of producing pickled onions. In this line, this project aims at developing a self-stable, high-value added onion pickle product, with a reasonable shelf life for marketing, with emphasis laid upon small-scale processing technologies for the informal food sector and women entrepreneurs in Rodrigues.

## **PROJECT OBJECTIVES**

### **Main objectives**

The main objectives of the project were to:

1. Develop food processing protocols for the making of
  - a. Onion pickles in brine/ vinegar
  - b. Onion pickles in oil and spices;
2. Determine the right size of onion bulbs, variety of onion, salt and vinegar concentration for pickling solution, and suitable packaging system for commercialising self-stable onion pickles;
3. Develop a food processing protocol for producing high-value added onion pickles with ample product differentiation on the market; and
4. Disseminate the technologies developed to growers of onions, women entrepreneurs and potential food processors.

### **Sub-objectives**

The sub-objectives of the project were to:

#### Objective 1

Determine the appropriate seed sowing densities for the production of onion sets of different size categories;

#### Objective 2

Determine the right concentration of table salt and vinegar for the pickling of different types of onion;

#### Objective 3

Determine the suitable size category of onion sets for pickling in brine and vinegar;

#### Objective 4

Identify suitable onion varieties for pickling small onion bulbs in brine and vinegar;

#### Objective 5

Evaluate the potential of several locally available produce for value addition to onion pickles; and

#### Objective 6

Train onion growers, women entrepreneurs, and potential food processors on the techniques and principles of onion pickling.

## 1.0 PART I

### 1.1 Objective 1

To determine the optimum seed sowing densities for the production of onion sets of desired size categories for pickling

### 1.2 Researchable activities

- 1.2.1 Field trial at Richelieu Crop Research Station (CRS) on the effect of different seed sowing densities on the size of onion sets
- 1.2.2 Field trial at Oyster Bay, Rodrigues on the effect of different seed sowing densities on the size of onion sets

### 1.3 Methodology

#### 1.3.1 Researchable Activity 1

Six different varieties of onion (Blanc de Galmi, No Flaye, Local Red, Nun 7292, Nun 7294, and Star 5504) were sown on the 4<sup>th</sup> October 2001 at 3 different sowing densities (4, 10, and 18 g/ m<sup>2</sup>) to produce onion sets of different size categories. The experiment was laid in a split plot design with varieties as main plots and sowing densities as sub plots. Experimental plot sizes were of one square meter and replicated three times.

Onion sets were harvested on the 13<sup>th</sup> December 2001 at Richelieu CRS. The number of onion sets and weight of sets under different size categories (<15 mm; 15-25mm and >25mm), as well as the total yield of sets (kg/ m<sup>2</sup>) was recorded as per variety x sowing density treatment.

#### 1.3.2 Researchable Activity 2

Six varieties of onion (Blanc de Galmi, No Flaye, Local Red, Nun 7292, Yellow Dessex and El Brown) were sown on the 26<sup>th</sup> October 2001 at 3 different sowing densities (**Table 1.3.2**) to produce onion sets of different size categories (5-10 mm, 10-15 mm, 15-25 mm, and greater than 25 mm). The experiment was laid in a split plot design with varieties as main plots and sowing densities as sub plots. Experimental plot sizes were of one square meter and replicated three times.



Table 1.3.2: Variety x sowing density treatments used in the field experiment at Oyster Bay

Varieties	Sowing densities (g/ m <sup>2</sup> ), after adjusting for % of unviable seeds
El Brown	4,10, and 18
No Flaye	5.32, 13.3, and 23.9
Nun 7292	7.1, 17.5, and 31.5
Yellow Dessex	4.5, 11.5, and 19.3
Local Red	4.7, 11.7, and 20.9
Blanc de Galmi	4.3, 10.7, and 19.3

Onion sets were harvested on the 16<sup>th</sup> January 2002 at Oyster Bay, Rodrigues. The number of onion sets and weight of sets under different size categories (<15 mm; 15-25mm and >25mm), as well as the total yield of sets (kg/ m<sup>2</sup>) was recorded as per variety x sowing density treatment.

## 1.4 Results and Discussion

### 1.4.1 Total yield of sets

The mean yield of sets (kg/m<sup>2</sup>) from the six onion varieties evaluated in Rodrigues is illustrated in the table below:

Table 1.4.1: Mean yield of onion sets from six varieties evaluated in Rodrigues

Varieties	Mean yield of sets in kg/ m <sup>2</sup> #
Nun 7292	2.71 <sup>a</sup>
Yellow Dessex	2.33 <sup>b</sup>
Blanc de Galmi	1.99 <sup>c</sup>
No Flaye	1.76 <sup>d</sup>
Local Red	1.27 <sup>e</sup>
Early Lockyer Brown (El Brown)	1.08 <sup>e</sup>

# Mean yield of sets followed by the same letter are not significantly different at 5% level of significance

There were significant differences at 5% level in the total yield of sets among the onion varieties evaluated in Rodrigues. The highest yield of sets was obtained from the large-onion-bulb producing varieties, Nun 7292, Yellow Dessex, and Blanc de Galmi. No Flaye was a moderate yielder of onions sets as it usually produces medium sized onions, while Local Red and El Brown were low yielders. The low yield from Local Red can be explained by the fact that this variety produces small onion bulbs.

#### 1.4.2: Yield of onion sets at different sowing densities

Table 1.4.2: Yield of onion sets for varieties sown at different sowing densities (Richelieu CRS)

Variety	Yield of onion sets in kg		
	<i>Unadjusted Sowing Density in g/ m<sup>2</sup></i>		
	<u>4</u>	<u>10</u>	<u>18</u>
Blanc de Galmi	1.17	1.33	0.90
Local Red	NA	NA	1.08
No Flaye	0.69	1.16	1.42
Nun 7292	0.60	1.18	1.13
Nun 7294	2.09	1.92	0.98
Star 5504	1.14	1.14	0.81

Table 1.4.3: Yield of onion sets for varieties sown at different sowing densities (Oyster Bay, Rodrigues)

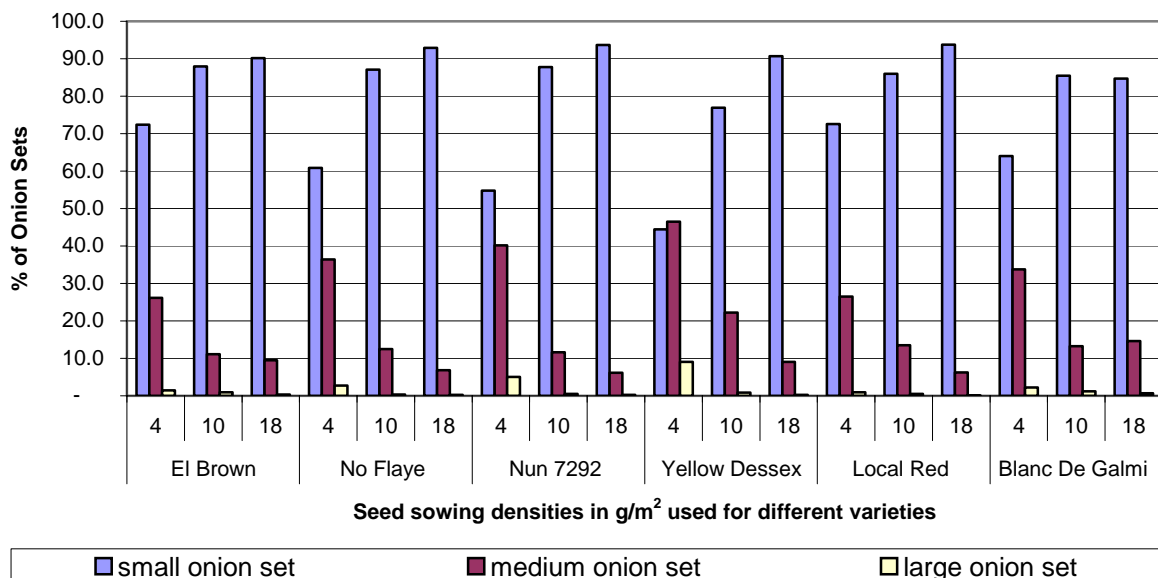
Variety	Yield of onion sets in kg/m <sup>2</sup>		
	<i>Unadjusted Sowing Density in g/ m<sup>2</sup></i>		
	<u>4</u>	<u>10</u>	<u>18</u>
Blanc de Galmi	2.07	2.03	1.85
Local Red	1.18	1.30	1.31
No Flaye	1.57	2.15	1.55
Nun 7292	3.03	2.46	2.63
Yellow Dessex	2.45	2.49	2.04
El Brown	0.99	1.20	1.07

At Richelieu CRS, high yield of sets was obtained from variety Nun 7294. Blanc de Galmi, No Flaye, Nun 7292, Star 5504 produced a moderate yield of sets, while Local Red produced a low yield (Table 1.4.2). In Rodrigues, Blanc de Galmi, Yellow Dessex, Nun 7292, No Flaye produced a high yield of onion sets (above 1.5 kg/ m<sup>2</sup>). A moderate yield was obtained from variety Local Red, while El Brown produced the least yield of sets (Table 1.4.3).

The lower yield of sets at Richelieu CRS can be explained by the poor quality of seeds that were available on the station. In fact, after conducting the germination tests, it was found that the sowing density had to be significantly altered to reach the desired theoretical sowing densities of 4, 10, and 18 g seeds per m<sup>2</sup>. Because of this problem, the results from the Rodriguan plots will be used for further analysis henceforth.

### 1.4.3 Effect of sowing densities on size of onion sets

Figure 1.4.3: Percentage of Onion Sets in Different Size Categories

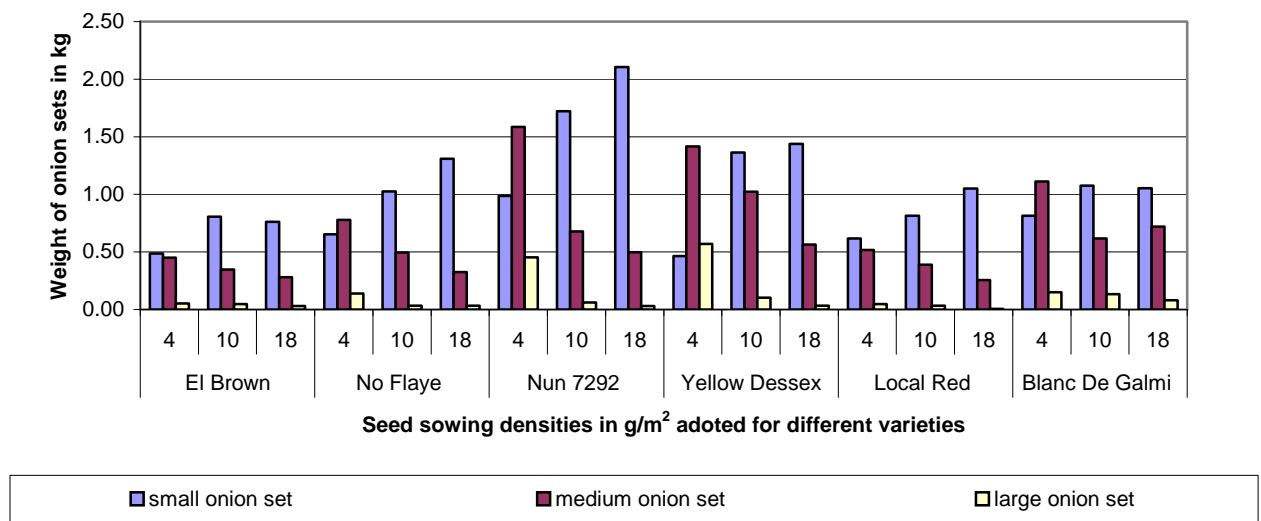


The percentage of onion sets in the small size category (< 15 mm in diameter) increases upon increasing the sowing density from 4 g/ m<sup>2</sup> to 18 g/ m<sup>2</sup> (Figure 1.4.3) for all the varieties under study, while the percentage of onion sets in the medium size category (15-25 mm) decreases with increasing sowing density. This can be explained by higher competition among plants for nutrient and water at higher plant densities. The varieties that produced considerable amount of sets (>30%) in the desired size category (15-25 mm) for pickling were: No Flaye, Nun7292, Yellow Dessex and Blanc de Galmi. The sowing density that produced the highest number of sets in the 15-15 mm size category was 4 g seeds per m<sup>2</sup>.

### 1.4.4 Effect of sowing densities on total weight of sets

Figure 1.4.4 shows that the greatest weights of sets in the desired size category for pickling were obtained for varieties Nun 7292, Yellow Dessex, and Blanc de Galmi. The sowing densities that produced the greatest weight of sets in the desired size category for pickling was 4 g/ m<sup>2</sup> for all the above mentioned varieties.

Figure 1.4.4: Weight of onion sets falling in different size categories



### Conclusions

- The highest yield of sets was obtained from Nun 7292, Yellow Dessex, and Blanc de Galmi
- No Flaye was a moderate yielder of onions sets, while Local Red was a low yielder.
- The varieties that produced large amount of sets in the desired size category (15-25 mm) for pickling were: No Flaye, Nun7292, Yellow Dessex and Blanc de Galmi.
- The sowing density that produced the largest amount of sets in the 15-25 mm size category was 4 g per m<sup>2</sup>.

## 2.0 PART II

### 2.1 Objective 2

To determine the right concentration of table salt and vinegar for pickling different types of onion

### 2.2 Researchable activities

Lab. experiment on the determination of the optimum brine and/or vinegar concentration for pickling of red, yellow and white onions

Mini-trial 1: Effect of different salt concentrations (8%, 10% and 12% NaCl w/v) and different fermentation periods (18, 24, 30 hours) on the pungency of onions during the fermentation process (prior to pickling)

Mini-trial 2: Effect of 2 vinegar concentrations (0% and 1.5% acetic acid) on onion pungency of red and yellow onions during the fermentation process (prior to pickling)

Experiment 3: Effect of different salt (4% and 8% NaCl w/v) and vinegar concentrations (1.5% and 3% acetic acid) on the physico-chemical characteristics and visual quality assessment (appearance) of pickled red, yellow and white onions

### 2.3 Methodology

#### 2.3.1 Mini-trial 1

A 9-treatment mini-trial consisting of 3 levels of salt concentration (8%, 10% and 12% NaCl weight-by-volume basis) and 3 levels of fermentation periods (18, 24, 30 hours) was conducted in February 2002 to assess their effect on onion pungency. Onion sets of the variety No Flaye were peeled as per steps 1 – 5 of the protocol for making onion pickle (**Annex 1**). Different fermentation solutions were prepared from salt and water. Three pre-sterilised beakers were each filled with some 750 g of washed and peeled onions, which was then completely submerged with the pickling brine solution of three different concentrations (8%, 10% and 12% NaCl weight-by-volume basis). The three beakers were kept in a clean, cool and dry place for fermentation. Trained sensory evaluators assessed the pungency of pickled onions at different time intervals (18, 24, 30 hours).

### 2.3.2 Mini-trial 2

A 4-treatment mini-trial comprising of 2 varieties and 2 levels of vinegar concentration was carried out on the 25<sup>th</sup> Feb 2002 in order to assess the effect of 2 vinegar concentrations (0% and 1.5% acetic acid) on onion pungency of 2 types of onion (red and yellow) during the fermentation process. Onion sets were peeled as per steps 1 – 5 of the onion pickle protocol (**Annex 1**). Two different fermentation solutions were prepared from vinegar and water; one solution containing only water while the other one containing ½ L water and ½ L vinegar. Four pre-sterilised jars were each filled with 250 g of peeled and washed onions.

The mini-trial was set as follows:

- Jar 1: Peeled red onions covered with water (0% acetic acid)
- Jar 2: Peeled red onions covered with diluted vinegar (1.5% acetic acid)
- Jar 3: Peeled yellow onions covered with water (0% acetic acid)
- Jar 4: Peeled yellow onions covered with diluted vinegar (1.5% acetic acid)

The four jars were kept in a clean, cool and dry place for some 30 hours. Trained sensory evaluators assessed the pungency of pickled onions. Trained sensory evaluators assessed the pungency of pickled onions at the end of the fermentation period.

### 2.3.3 Experiment 3

- A complete experiment was conducted to investigate the effect of different salt (4% and 8% NaCl w/v) and vinegar concentrations (1.5% and 3% acetic acid) on the organoleptic quality of pickled red, yellow and white onions
- A 12-treatment experiment (2 NaCl concentrations x 2 vinegar concentrations x 3 types of onion) with three replicates was carried out to find the best treatment combination for pickling onions, based on physico-chemical analyses and visual quality assessment (appearance). Terminology adopted for the four treatments for each type of onion was as follows:
  - o A: 4% salt weight-by- volume; 3% acetic acid
  - o B: 8% salt weight-by- volume; 3% acetic acid
  - o C: 4% salt weight-by- volume; 1.5% acetic acid
  - o D: 8% salt weight-by- volume; 1.5% acetic acid

- Main parameters of assessment: pH, salinity, % Total soluble solids (TSS), titrable acidity and clarity of pickling solution, % TSS, skin colour, colour brightness, firmness, and browning of pickled onions, and cap bulging (indicating presence of fermentative micro-organisms)

## 2.4 Results and Discussion

### 2.4.1 Indicative results from Mini-trial 1

- When the fermentation period exceeded 48 hours under ambient temperature (25°-27°C), spoilage of the fermented onions (white scum) resulted.
- Significant reduction in onion pungency was obtained when the fermentation solution contained 8-10% salt (weight by volume). Too high table salt concentration in the fermentation solution required desalinisation of onions by dipping in boiled and cooled water.
- Fermentation of peeled onions over a period of 30 – 48 hours under ambient conditions reduced onion pungency considerably.

### 2.4.2 Indicative results from Mini-trial 2

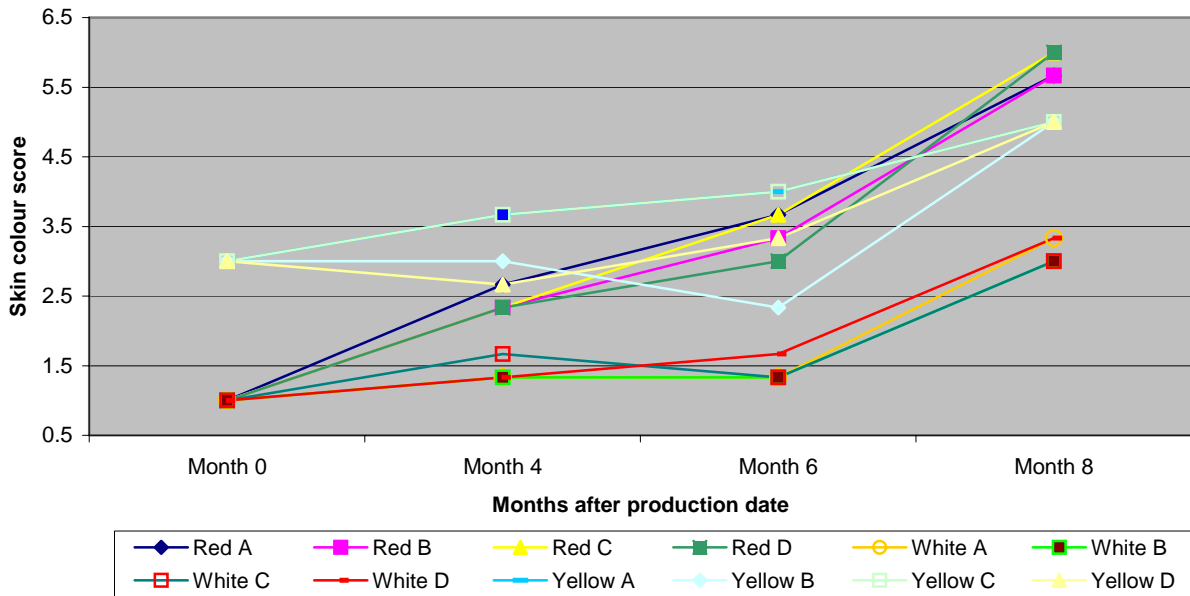
Table 2.4.2: Effect of the type of onions and fermenting solutions on onion spoilage

Type of onion; type of fermenting solution	Percentage of bulbs spoilt			Rotten onion odour (yes/no)
	Rep 1	Rep 2	Rep 3	
Yellow; brine	100	100	100	Yes
Yellow; diluted vinegar	0	0	0	No
Red; brine	50	100	100	Yes
Red; diluted vinegar	0	0	20	No (except in replicate 3)

Following mini-trial 1, it was imperative to reduce the spoilage of onions during fermentation. One means of doing so would be to acidify the fermenting medium. Thus vinegar was added to the fermenting solution and this had the effect of reducing onion spoilage (Table 2.4.2).

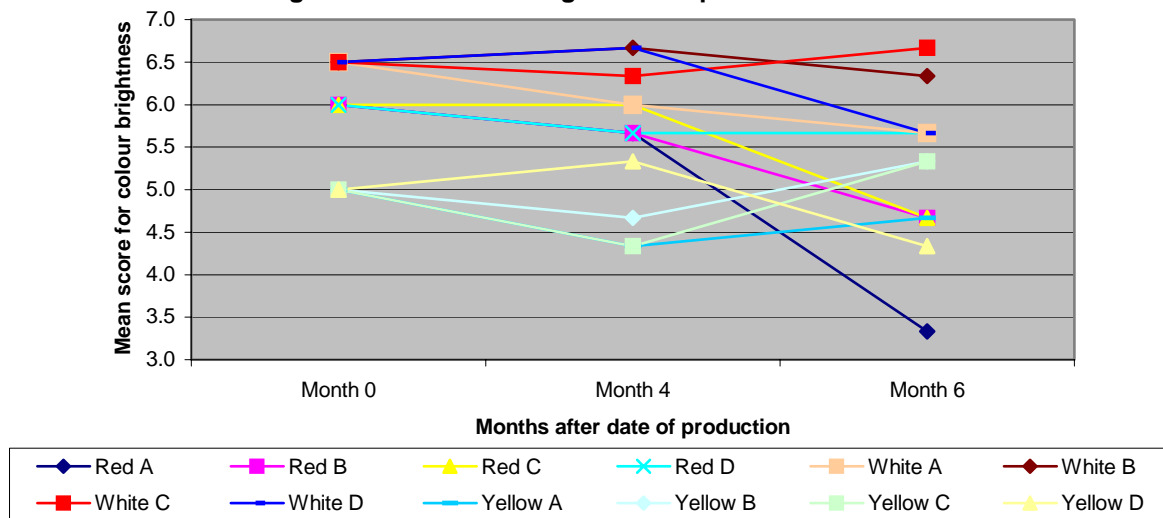
2.4.3: Effect of different salt and vinegar concentrations of pickling solution on appearance

**Figure 2.4.1: Skin Colour of onions**



A mean score colour of less or equal 4.0 is judged acceptable for onion pickles. The colour of pickled white onions was acceptable throughout the period under study (Figure 2.4.1). The colour of pickled red and yellow onions was acceptable up to 6 months after date of production. No significant difference has been observed among treatments A, B, C & D for all types of onion evaluated, which implies that the salt and vinegar concentrations evaluated did not influence skin colour of different types of onions.

**Figure 2.4.3: Colour brightness of pickled onions**

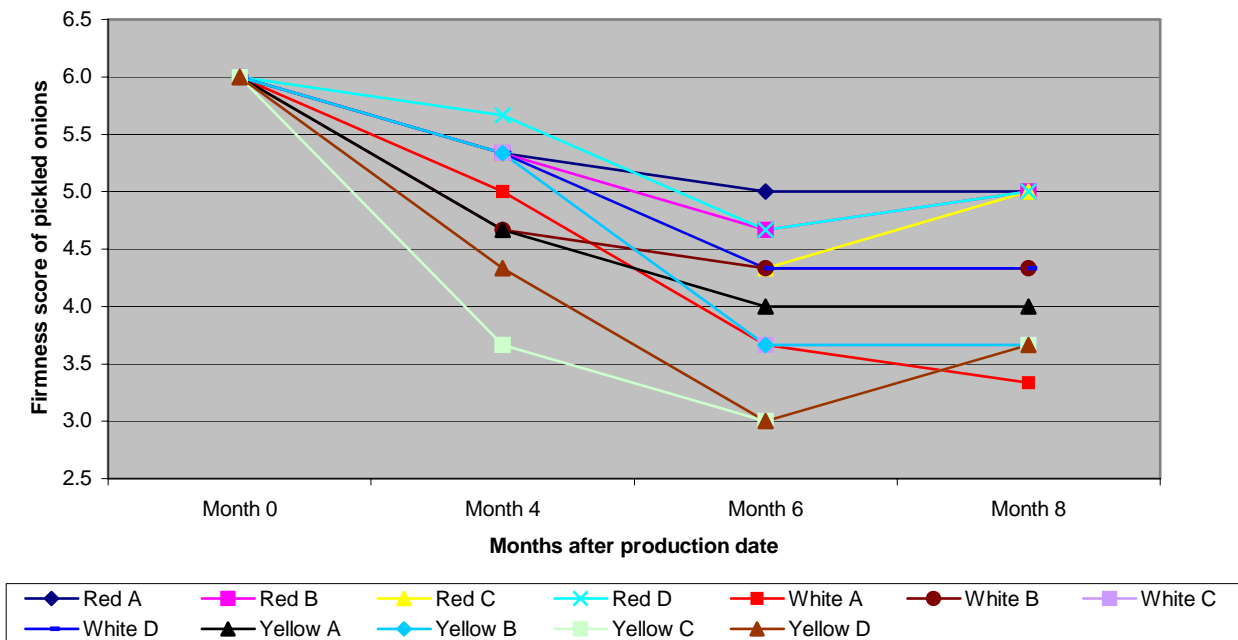




Colour brightness indicates extent of light reflection or absorption. High extent of light reflection implies a bright appearance, while great extent of light absorption signifies dull appearance. **Figure 2.4.3** shows that pickled white onions have a very bright appearance and maintained this appearance 6 months after production date. Pickled red onions had initially a bright appearance, which subsequently became dull 4 months after date of production. Although the appearance of pickled yellow onions was not very bright, they maintained the initial appearance 6 months after the date of production.

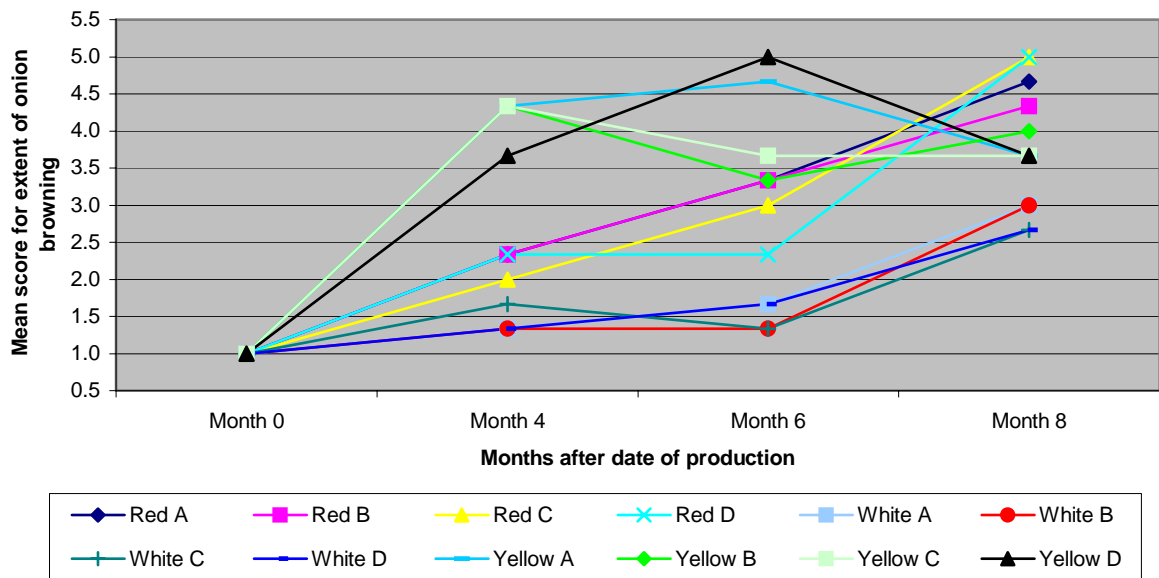
No bulging of cap (indicating microbial spoilage by fermentative bacteria and yeasts) was observed throughout the study for all the 108 replicates, except for 1 replicate of yellow onion pickle at the fourth month stage.

**Figure 2.4.4: Firmness of pickled onions**



The different treatments (different salt and vinegar concentrations) did not influence the firmness of pickled onions. In general, white and yellow onions tend to lose their firmness after pickling. Pickled red onions tend to resist loss in firmness (**Figure 2.4.4**).

Figure 2.4.5: Extent of browning in pickled onions



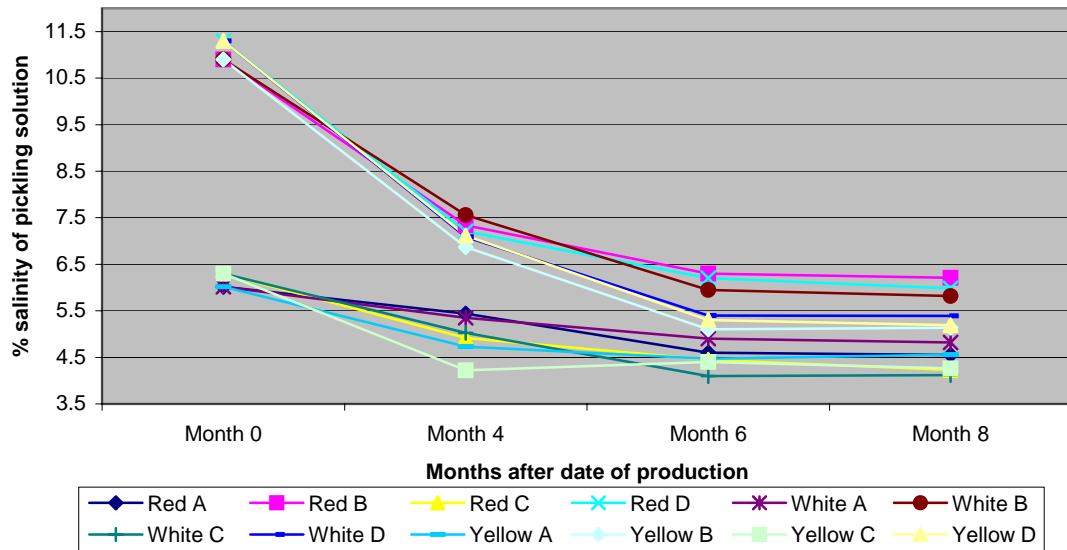
Browning was least in pickled white onions and throughout the study browning was below the critical score of 3.0 (Figure 2.4.5). Greater extent of browning was observed in pickled yellow onions, whereby the browning level was above the critical level four months after the date of production. From month 0 to month 6, browning of pickled red onions was less than that of pickled yellow onions. However, 8 months after date of production, there was no considerable difference between level of browning between pickled red and yellow onions. Again no significant differences have been observed among the different salt and vinegar concentration treatments on the level of browning of onions.

2.4.4: Effect of different salt and vinegar concentrations of pickling solution on physico-chemical attributes

*pH of pickling solutions*

The salt and vinegar concentrations under study did not significantly influence the pH of the pickling solutions. In all treatments, the pH of the pickles was below 4.0, indicating little risk of bacterial spoilage (for example, botulism). The Food Act 1998 requires a pH of less than 4.6 for low-acid foods.

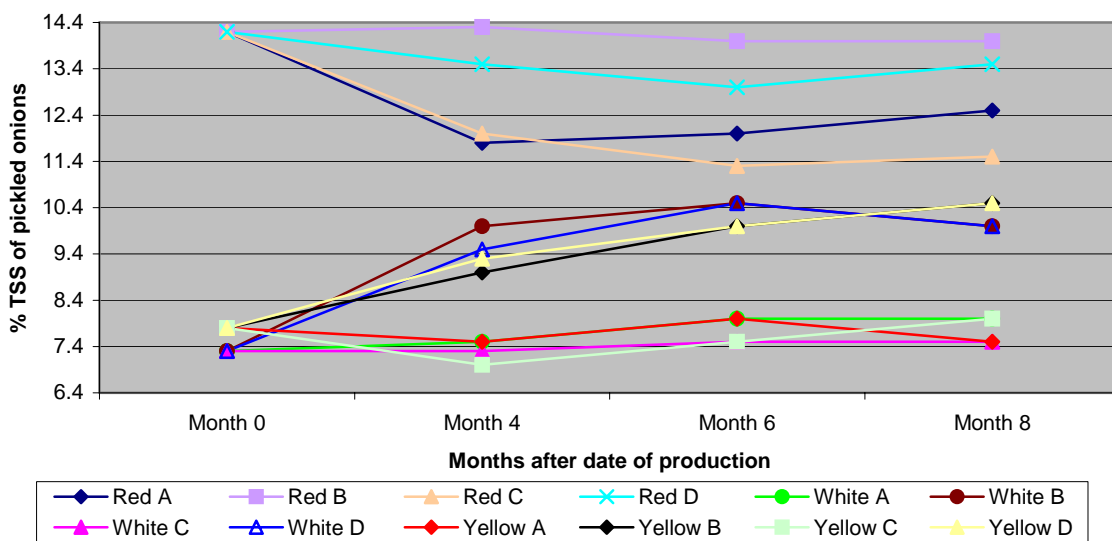
Figure 2.4.6: Salinity of pickling solution



*Salinity of pickling solution*

Salinity of pickles, measured as percent NaCl, decreases over time due to dilution effect caused by the presence of onions in the pickling solution. The pickling solution contains higher salt level compared to fermented onions and thus table salt ions diffused away from the pickling solution to the onions. Hence, the decrease in salinity of the pickling solution. Although, the difference in salinity between the 4% salt treatment and 8% salt treatment diminishes by the end of shelf life, pickles from 8% salt solution are much saltier to the taste.

Figure 2.4.7: Percentage Total Soluble Solids of Pickled Onions

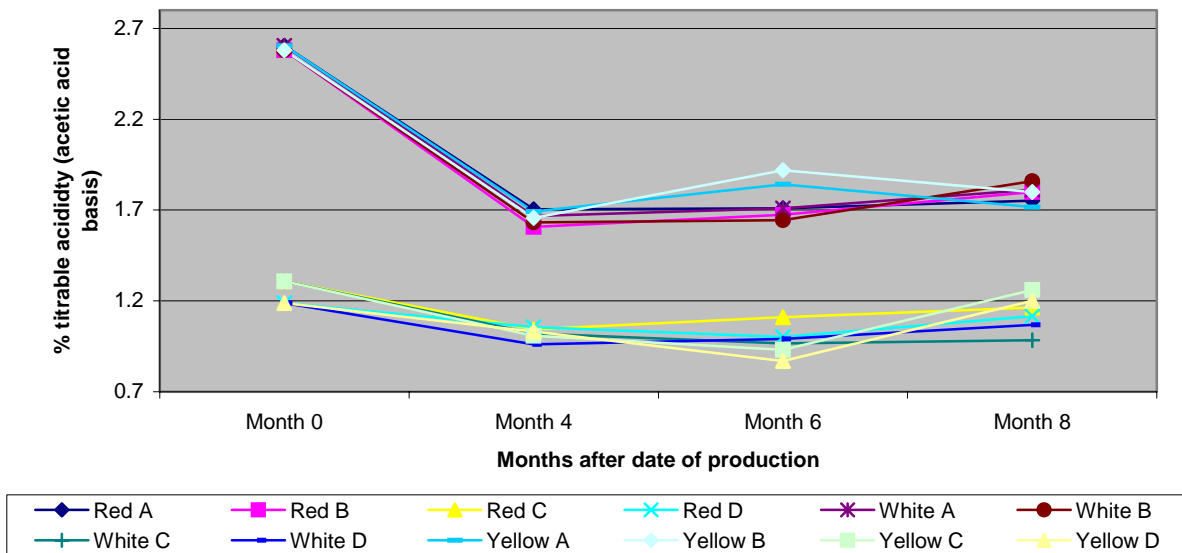


*% TSS of onion*

% TSS, as measured by a hand refractometer, is influenced by the amount of salt and sugar present in the pickling solution. Treatments A & C contain less salt (4% table salt w/v) and this explains why white A, white C, yellow A, and yellow C have lower %TSS (**Figure 2.4.7**). Treatments B & D contain more salt (8% table salt w/v) and this explains why white B, white D, yellow B, and yellow D have higher %TSS. Red A and Red C have much higher % TSS due to the inherently high % TSS of red onions. In fact, all treatments containing red onions had higher % TSS.

*% TA of pickling solution*

**Figure 2.4.8: Titrable acidity of pickling solution**



Titrable acidity of pickling solution was computed on acetic acid basis because of the pre-dominance of this acid in vinegar. Treatments A & B contained higher levels of acetic acid (3% v/v) and this explain the higher values of titrable acidity obtained for red A, red B, white A, white B, yellow A and yellow B. To the taste, these treatments produced sour pickles, which were not appreciated by most tasters.

## 2.5 Conclusions

On basis of the results presented and discussed in part II, the following conclusions may be drawn:

- Diluted vinegar containing 8-10% table salt (w/v basis) need to be used for fermenting peeled onions in order to reduce their pungency.
- Fermentation of peeled onions can be carried out over a period of 30 – 48 hours under ambient conditions (25°-27°C).
- Treatments adopted were effective in minimising the major spoilage problems of pickles since no microbial spoilage by fermentative bacteria and yeasts was observed during the study.
- Treatments A, B, C, and D did not influence significantly the visual quality attributes (skin colour, browning and colour brightness) of pickled onions
- Percent salinity and percent titrable acidity of pickling solution as well as %TSS of pickled onions were however markedly influenced by the treatments A, B, C, and D.
- Treatment A and B (3% acetic acid in pickling solution) resulted in higher percent titrable acidity, which resulted in sour onion pickles
- Treatment B and D (8% table salt in pickling solution) resulted in higher percent salinity, which led to salty pickles
- 1.5% acetic acid (v/v) and 4% table salt (w/v) are recommended for the preparation of the pickling solution

### 3.0 PART III

#### 3.1 Objective

To determine the right size of sets for onion pickling in brine and vinegar

#### 3.2 Researchable activities

Experiment: Effect of 3 different size categories of onion sets on pickling of red and yellow onions

#### 3.3 Methodology

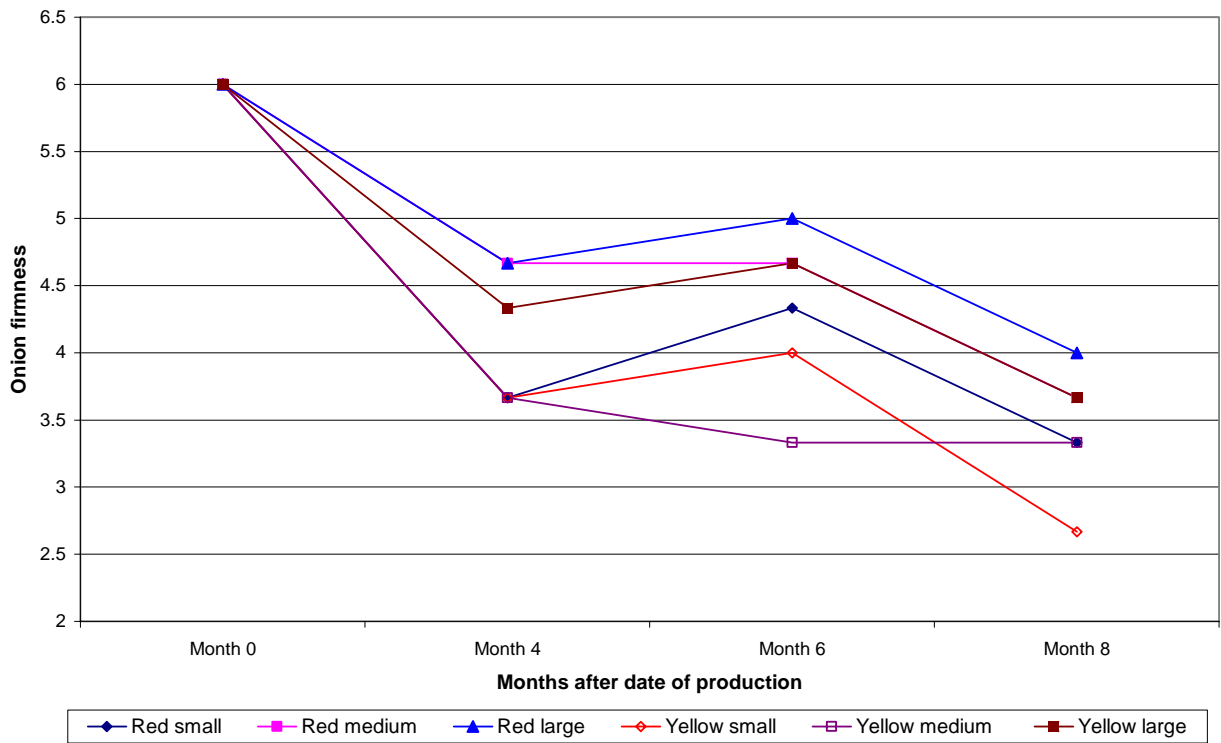
The experiment was conducted using onion sets produced from activities 1.2.1 & 1.2.2. Onion sets from 2 different varieties (Local red and Galil) and 3 different size categories (< 15 mm, 15 – 25 mm, > 25 mm in diameter) were peeled after blanching them in boiling hot water for 1-2 minutes. The sets were dipped in cold water for 5 minutes, prior to peel removal. Peeled onions were washed under running water and then fermented for 24-36 hours in diluted vinegar containing 10% (w/v) table salt. Thereafter, the peeled onions were pickled in brine/vinegar and bottled in jars for visual quality assessment and sensory evaluation. The main parameters of assessment were % TSS of onion, onion firmness, level of onion browning, skin colour, salinity, pH, titrable acidity, clarity/ turbidity and % TSS of pickling solution.

#### 3.4 Results and Discussion

##### 3.4.1 Onion firmness

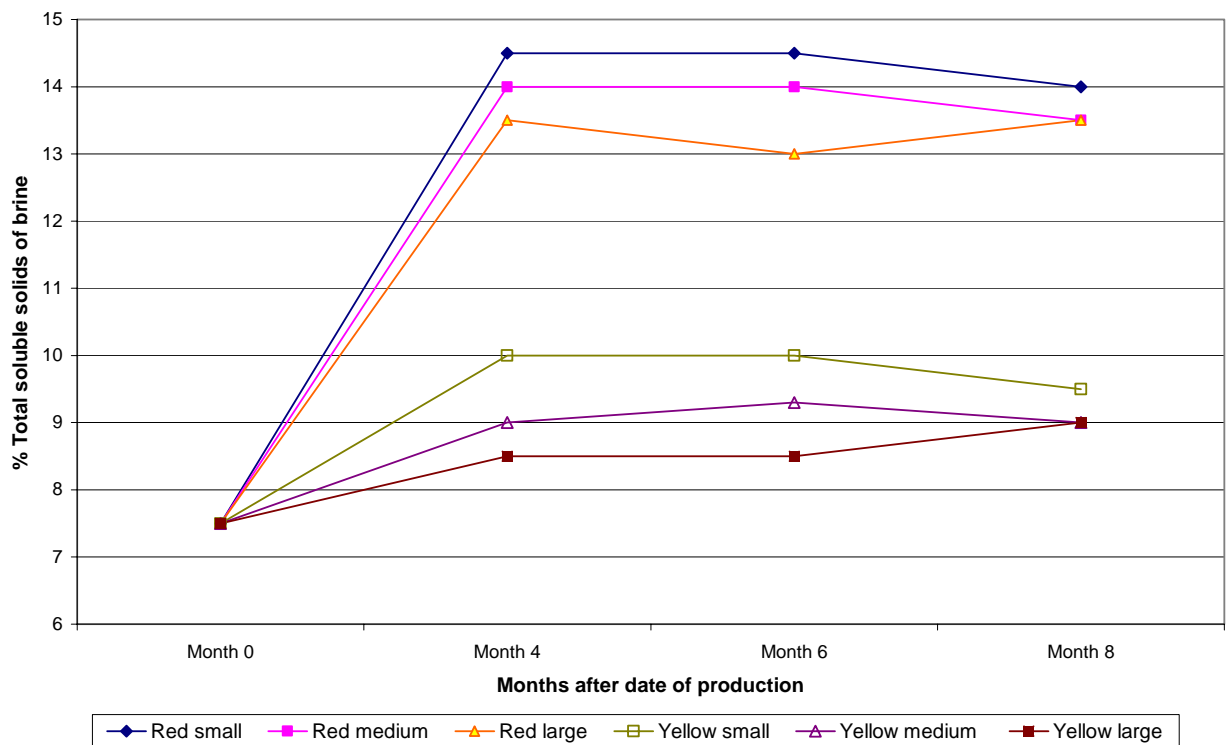
As illustrated in **Figure 3.4.1**, pickled red onions were firmer than pickled yellow onions. This may be attributed to the more compact scale leaves in the red onion bulbs (low to moderate yielder) compared to the less compact scale leaves in the yellow onion bulbs (high yielding variety). In general, the large pickled onions were firmer than the small sized pickled onions.

Figure 3.4.1 Onion Firmness of Different Size of Onion Sets Pickled in Brine



3.4.2 % TSS of pickling solution and pickled onions

Figure 3.4.2: % Total Soluble Solids of Brine from Onion Pickles



The % TSS of the pickling solution increased over time due to movement of soluble solids from the onion bulbs to the pickling solution. The fermented onions had higher % TSS than the pickling solution before bottling. The % TSS of brine from the large-sized onion pickles was much lower than those from small-sized pickles. This can be explained by the fact that small-sized onions presented a larger surface area than large size onions for diffusion of soluble solids. Hence higher % of soluble solids was recorded in brine from small-sized onions. Similar trends were observed on the readings of % TSS of pickled onions.

#### 3.4.3 Titration acidity of pickling solution

Titration acidity measured in % acetic acid decreased over time due to the dilution effect caused by the non-acidic onions in the acidic pickling solution. No specific trend was observed with respect to the size of the onion sets used.

#### 3.4.4 pH of pickling solution

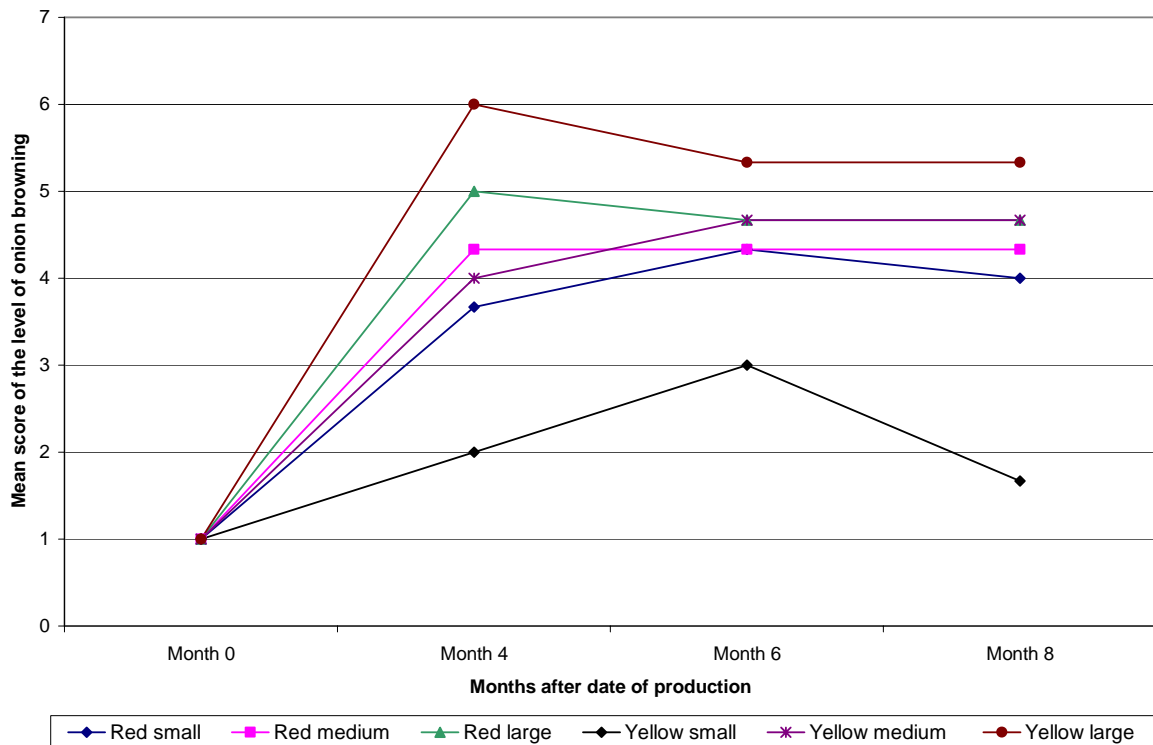
The pH of onion pickles was less than 3.7 throughout the experiment. This minimises the risk of bacterial spoilage. The pH of the pickling solution was not influenced by the size of sets used. The pH of solution from red onion pickles was generally higher than those from pickled yellow onions.

#### 3.4.5 Level of onion browning

Large pickled onions underwent enzymatic browning to a greater extent compared to small pickled onions (**Figure 3.4.3**). Medium-sized pickled onions had undergone browning close to the acceptable limit of 4.0. Enzymatic browning is due to the enzyme polyphenoloxidase (PPO), which can be destroyed by heat and has lower activity at low pH. The fact that small-sized onions present larger surface areas may explain the rapid destruction of the PPO enzyme during hot filling and pasteurisation of the onion pickles. Consequently, little browning is likely to occur in small-sized pickled onions.



Figure 3.4.3: Level of onion browning in pickled onions of different size categories



### 3.5 Overall Discussion

Based on the results presented in the above sections, it can be argued that neither large-sized onions nor small-sized onions have definite advantages for pickle making. With regard to onion firmness, the large-sized pickled onions were firmer than the small sized pickled onions. However, large-sized pickled onions underwent enzymatic browning to a greater extent compared to small pickled onions, while medium-sized pickled onions had undergone browning to an acceptable limit. On basis of product appearance (acceptable level of browning), medium-sized onions would be preferred for pickle making. Moreover, medium-sized onions would ensure quick onion fermentation and pungency reduction compared to larger-sized onion bulbs. Although small-sized pickled onions have the latter advantages, 2-3 pickled onions need to be taken at one go for a mouthful intake during pickle consumption. On the other hand, one medium-size pickled onion suffices for a mouthful intake. Other disadvantages of small sized onions include high labour cost for peeling and high percentage of waste in terms of peels compared to medium-sized and large-sized onions.

### **3.6 Conclusions**

Medium-sized onions (15-25 mm) are appropriate for pickle making because of:

- Better appearance (lower level of browning) in bottle jars
- Moderate labour cost for peeling
- Lower percentage of waste compared to small-sized onions
- Acceptable onion firmness after pickling
- Rapid fermentation and quick pungency reduction
- Appropriate size for a mouthful intake

## **PART IV**

### **Objective 4**

To evaluate the potential of different onion varieties for making onion pickles

#### **5.1 Researchable activities**

##### **Activity 6A: Field trial: Production of onion sets of different onion varieties for pickling (variety evaluation experiment)**

Nine promising varieties (Blanc de Galmi, Crystal PRR, Veronique, No Flaye, Local Red, Capri F1, Star 5504, Galil, and Yellow Dessex) were sown using the broadcast sowing method at a rate of 4-12 g per m<sup>2</sup> to produce onion sets of the desired size (15-25 mm diameter). Characteristics of these onion varieties are annexed (**Annex 2**)

Onion pungency, taste, salt content, texture, colour, overall appearance, °Brix, acidity, and shelf life will be the main parameters of assessment for the pickles

### **Methodology**

#### **Composition of fermenting solution**

0.5 L water

0.5 L vinegar

100 g salt (10% w/v)

1 g citric acid per litre of diluted vinegar (0.1% weight by volume basis)

0.5 g ascorbic acid per litre of diluted vinegar (0.05% weight by volume basis)

### **Results and Discussion**

A score of less or equal 4.0 for skin colour was judged acceptable in the study. Skin colour of white onion pickles was acceptable 8 months after date of production. The skin colour of white onion pickles was very

good to excellent during the first 6 months of storage, with negligible browning 6 months after the date of production. Skin colour of pickled yellow onions and red onions was acceptable up to 6 months after the date of production. Six months after date of production, pickled yellow onions and red onions underwent browning leading to the pickles being unmarketable.

Physico-chemical analysis of onion pickles made from different varieties of onions

	pH	Salinity of brine (g NaCl in 100 ml)	% TSS of brine	% TSS of onion	Turbidity of brine in FTU	Titration acidity of brine (g acetic acid in 100 ml)
No Flaye	3.7 <sup>#</sup>	8.9	10.3	10.3	32.9	1.06
Veronique	3.6	8.5	9.6	9.7	26.4	1.13
Capri F1	3.7	11.4	13.3	13.6	27.7	1.07
Y. Dessex	3.4	6.2	7.2	7.2	34.7	1.10
Galil	3.4	6.3	7.2	7.4	410.3	1.10
Blanc de Galmi	3.5	7.8	8.8	9.3	21.3	1.00

# All values presented in table are the mean of 3 replicates (n=3)

Analysis was carried out 4 months after production date

Observations made on onion pickles made from different varieties of onions:

	Parameters under study						
	Product appearance	Skin colour	Level of Browning	Clarity of brine	Onion firmness	Taste	Overall Acceptability
No Flaye	5.0 <sup>#</sup>	5.3	5.3	5.3	6.3	4.7	5.3
Veronique	2.7	2.3	2.3	3.0	5.3	NT	3.3
Capri F1	1.7	1.3	2.0	2.0	4.3	NT	2.3
Y. Dessex	5.3	5.7	5.0	5.7	4.7	5.7	5.3

<b>Galil</b>	3.7	3.3	2.7	2.3	2.7	3.3	<b>3.3</b>
<b>Blanc de Galmi</b>	6.0	6.3	6.3	6.7	5.0	6.3	<b>6.3</b>

# All values presented in the table are the mean of 3 replicates (n=3)

Degree of liking scores on a scale of 1 – 7 was used.

1: dislike very much

4: neither like nor dislike

7: like very much

2: dislike

5: like a little

3: dislike a little

6: like

### Conclusions

- Skin colour of white onion pickles was acceptable 8 months after date of production.
- Blanc de Galmi was the onion cultivar most appreciated in pickle.

## **PART V**

### **5.0 Background**

There are several means to add value to onions pickled in brine and vinegar. These include the use of red chillies, ginger, Rodriguan lime, lemongrass, local garlic and other locally available herbs/spices. In the present study, the first five were evaluated in view of developing high-value added onion pickles

#### **5.1 Objective 5**

To evaluate the potential of locally available produce for developing high-value added onion pickles

#### **5.2 Researchable activities**

5.2.1 Field trial: Production of onion sets for the value-addition experiment

5.2.2 Laboratory trials: Devise ways to add 5 locally available produce (Red chilli, Rodriguan chilli, ginger, local garlic, and Rodriguan lime) to onion pickles

5.2.3 Laboratory trials: Evaluation of the potential of locally available produce for developing high-value added onion pickles

#### **5.3 Methodology**

##### **5.3.1 Field trial**

Six onion varieties (chosen on basis of size uniformity, skin colour, °Brix, shape and yield) were sown at a rate of 18-20 g of seeds per m<sup>2</sup> using the broadcast method to produce sets of a desired size category (15-25 mm) at Richelieu CRS. The sets were harvested on the 9<sup>th</sup> January 2003 and were used for activities 5.3.2 and 5.3.3.

##### **5.3.2 Laboratory trial**

Laboratory trials were conducted in order to devise ways to add 5 locally available raw materials (Red chilli, Rodriguan small chilli, ginger, local garlic, and Rodriguan lime) to onion pickles. The protocol for making onion pickle (brine/vinegar) was used as a baseline (**Annex 3**). In order to add the above-mentioned raw materials to onion pickle, the latter had to be fermented in brine/vinegar. The concentrations of table salt

and vinegar used as well as the duration of fermentation are raw material specific. These are laid down in the table below:

Raw material	Salt concentration (% w/v)	Vinegar concentration (% acetic acid)	Duration of fermentation (days)
Chilli	8	1.5	4
Ginger	8	1.5	4
Garlic	6	1.5	4
Lime (1 <sup>st</sup> fermentation)	10	0	7
Lime (2 <sup>nd</sup> fermentation)	8	0	7

The fermented raw materials are diced (except Rodriguan chilli) and added to fermented onions in pre-sterilised jars before hot filling.

### 5.3.3 Laboratory trial

7 different formulations of high-value added onion pickles have been tried on the 4<sup>th</sup> April 2003 before starting the value addition experiment. These were as follows

	F1	F2	F3	F4	F5	F6	F7
Rodriguan green chilli			3%	3%	8%		Control
Red chilli		3%				4%	
Ginger	2%*	2%			4%	1.5%	
Garlic	3%	3%		3%	8%	3%	

\* on weight-by-weight basis

Out of the 7 formulations, Formulation 4 (F4) and Formulation 6 (F6) were kept for further experimentation because high level of appreciation by onion pickles tasters. Another formulation comprising of lemongrass, Rodriguan lime, and Rodriguan chilli was developed. Due to unavailability of lemongrass, it was not possible to experiment intensively on this commodity.

Pickles were made as per **Annex 3** (value addition protocol). The composition of the high-value added onion pickles was as follows:

0.5 L vinegar

0.5 L water

1 g citric acid (0.1% weight by volume basis)

25 g sugar (2.5 % weight-by-volume basis)

40 g salt (4 % weight-by-volume basis)

0.3 g ascorbic acid per litre of diluted vinegar (0.03% weight by volume basis)

Fermented local produce as per % composition given above

Parameters of assessment were appearance, hardness, crunchiness, sourness, sweetness, bitterness, chemical heat and flavour content. Trained panellists conducted the sensory evaluation of onion pickles.

Effect of ginger, garlic and chilli on the sensory quality of onion pickle after value addition was evaluated. Value-added onion pickle was compared to ordinary onion pickle on the basis of appeal, hardness, crunchiness, sourness, saltiness, bitterness and chemical heat. The questionnaire used for sensory evaluation is annexed (Annex 4).

## 5.4 Results and Discussion

### 5.4.1 Evaluation of different produce to add value to onion pickles

Table 5.4.1: Comparison of the different value-addition treatments based on organoleptic characterisation

	<b>Rod. chilli + garlic</b>	<b>Red chilli + garlic + ginger</b>	<b>rod chilli + lemongrass + lime</b>	<b>Control (without value addition)</b>
<b>Product appeal</b>	5.1	4.4	4.9	5.1
<b>Clarity of brine</b>	1.5	2.8	2.4	2.0
<b>Extent of browning</b>	2.6	2.9	3.3	2.6
<b>Firmness</b>	4.5	4.9	4.4	4.9
<b>Crunchiness</b>	4.0	4.3	3.4	4.4
<b>Sourness</b>	2.5	3.4	3.0	2.8
<b>Bitterness</b>	1.9	3.1	3.0	1.8
<b>Sweetness</b>	1.3	1.8	1.5	3.0
<b>OVERALL ACCEPTABILITY</b>	<b>6.0</b>	<b>4.8</b>	<b>4.6</b>	<b>4.5</b>
<b>Standard Error of mean overall acceptability</b>	<b>0.2</b>	<b>0.1</b>	<b>0.2</b>	<b>0.2</b>



5.4.2 Physico-chemical analysis of value-addition treatments

5.4.3 Organoleptic characterisation of the best high-value added onion pickle

Table 5.4.2: Comparison of the different value-addition treatments based on physico-chemical analyses

	pH	Salinity of brine (g NaCl in 100 ml)	% TSS of brine	% TSS of onion	Turbidity of brine in FTU	Titration acidity of brine (g acetic acid 100 ml)
<b>Rodriguan chilli + garlic</b>	2.92	9.13	10.25	10.17	22.90	1.11
<b>Red chilli + garlic + ginger</b>	3.50	7.23	8.17	8.00	22.05	1.12
<b>Lime + Lemongrass + red chilli</b>	3.33	9.00	10.50	10.50	31.22	1.24
<b>Control (no value addition)</b>	3.50	10.67	11.58	11.58	8.50	1.16

B. de Galmi remains white or almost white after 8 months of storage

Rod. Chilli, garlic and ginger reduces the sourness due to vinegar and imparts a very nice bland of hot taste to the pickle

Ginger imparts a dominant taste to the pickle stronger than the garlic taste. Some people may like the strong ginger taste while others may prefer onion pickle with garlic taste without ginger taste

Rod. Lime leaves a bitter and strong sour taste when added to onion pickle

Rod. Lime also predominates the lemongrass taste such that the latter taste cannot be detected

The two most acceptable treatments: Rod green chilli + garlic = Red chilli + ginger + garlic

Table 5.4.3: Organoleptic characterisation of white onion pickle containing Rodriguan chilli and local garlic

Organoleptic Characteristics	Mean Score *	Standard Error of Mean Score
Product appeal	5.6	0.19
Firmness	3.7	0.19
Crunchiness	6.1	0.23
Sourness	2.8	0.37
Saltiness	4.8	0.36

Bitterness	1.5	0.19
Hot taste	3.3	0.35

\*  $n = 12$  (number of replicates)

#### 5.4.4 Benchmarking of the developed product against commercially available onion pickles

The best formulation of high-value added pickle – white onions in brine & vinegar with Rodriguan small green chilies and local garlic – was benchmarked against similar commercially available onion pickles. Readings for pH, and turbidity of pickling solution fall within the range of values obtained for commercially available onion pickles. The readings for % salinity, % TSS, and titrable acidity of the pickling solution and % TSS of pickled onions differed slightly. This can be explained by the fact that the formulation developed at AREU used slightly higher concentration of salt and lower concentration of vinegar. The higher concentration of salt used resulted in higher values of % salinity of pickling solution, % TSS of the pickling solution and % TSS of pickled onions.

Table 5.4.4: Benchmarking of the high-value added onion pickle developed at AREU against commercially available onion pickles

	Pickle Developed at AREU	Range of values from commercial pickles	Commercial Pickle 1 (Tramier)	Commercial Pickle 2 (El Serpis)	Commercial Pickle 3 (Delieuze)
pH	3.2	2.9 – 3.2	2.9	2.9	3.2
% Salinity	7.6	5.8 – 6.2	6.2	5.8	5.8
% TSS of brine	9.0	6.5 – 7.0	7.0	6.5	6.5
%TSS of onion	9.0	6.5 – 7.0	7.0	6.5	6.5
Titrable acidity in g acetic acid per 100ml	1.35	2.80 – 3.14	2.80	2.83	3.14
Turbidity in FTU	47.9	20.9 – 67.0	20.9	39.3	67.0

*Note: The three commercial samples represent 3 brands, which were chosen randomly from 6 different brands of onion pickle available on the market. ( $n = 3$ )*

Commercially available pickles made use of white vinegar of high concentration (around 4% acetic acid) and this resulted in higher values for titrable acidity, which imparts a very sour taste to these pickles. The locally formulated pickles had much lower % of acetic acid, making them much less sour. The lower % acetic acid

in the formulation developed at AREU ensures a pH of 3.2, which is well below the pH of pickle (pH of 4.6) recommended by the Food Act.

## **Conclusions**

- Make sure to cover the onions with solution properly leaving a headspace of 6-8 mm. Otherwise browning may occur
- Rod. chilli, garlic and ginger reduces the sourness due to the presence of the vinegar and imparts and very appealing bland of hot taste to the pickle
- B. de Galmi pickle remains white or almost white even 8 months after storage
- Ginger imparts a prominent taste to the pickle, which is stronger than the garlic taste. However both tastes were appreciated. But nevertheless the % composition of garlic should be higher than that of ginger if both are used
- Rod. lime leaves a bitter taste and a lime flavour with some degree of sourness
- Rod. lime predominates the existence of lemongrass such that the latter could not be detected by smell
- Lime in the value addition experiment tends to render the pickling solution a bit viscous
- Two most acceptable taste in the value addition experiment: (Rodriguan chilli + garlic) and (red chilli + ginger + garlic)
- No Flaye requires 10% brine for up to 3 days v/s yellow and white varieties. The red variety No Flaye is very pungent.

## PART VI

## 6.1 Objective

To train onion growers, women entrepreneurs, and potential food processors on the techniques and principles of onion pickling.

## 6.2 Activities

6.2.1 Training Activity 1

The first training course on 'Techniques and principles of Onion Pickling' was delivered to some 28 Rodriguan growers and food processing entrepreneurs at the National Handicraft Promotion Agency (NHPA) Training centre, Malabar, Rodrigues. The course was delivered between 14<sup>th</sup> to 17<sup>th</sup> May 2002. A copy of the training programme is annexed herewith (**Annex 5**). Practical classes were held in the Food Processing Room of the NHPA Centre.

6.2.2 Training Activity 2

The second training course on 'Value Addition to Onion Pickles: Techniques & Principles' was delivered to some 25 Rodriguan growers and food processing entrepreneurs at Antene Universitaire, Citronelle, Rodrigues. The course was delivered from 23<sup>rd</sup> to 26<sup>th</sup> February 2004. A copy of the training programme is annexed (**Annex 6**). Practical classes were conducted at Enterprise Mange-Tout, Citronelle.

6.2.3 Other Training Activities

Table 6.2.3: Summary on the Onion Pickling Training Courses Delivered

Course title	Dates	Beneficiaries	Number of participants
Onion Processing Possibilities	13 Dec. 2001	Belle Mare Water User's Cooperative and Sept Cascades Grower Association	8
Onion Pickling: Techniques and Principles (Malabar)	13-17 May 2002	Onion growers & food processors in Rodrigues	28
Onion Processing Possibilities	26 Nov. 2002	Belle Mare Water User's Cooperative	6
Onion Processing Possibilities	28 Nov. 2002	Belle Mare Water User's Cooperative and Bestfarm Co. Ltd.	12
Value addition to onion pickles: Techniques & Principles (Citronelle)	23-26 Feb 2004	Onion growers & food processors in Rodrigues, Leve Deboute Association, IVTB and extension officers	25

## **Methodology**

The training courses were designed in such a way that they reinforce the practical skills of the participants for the preparation of onion pickles. The theory classes laid emphasis on quality, food safety, and hygiene and sanitation aspects. The following techniques were demonstrated during the course:

1. Onion peeling
2. Bottling (jar sterilisation, filling, and conditioning)
3. Onion fermentation in brine
4. Preparation of pickling solution
5. Hot-filling and pasteurisation of onion pickles
6. Value addition to onion pickles

Furthermore, the steps (unit operations) involved in the following food processing protocols were illustrated:

1. Onion pickle (brine/ vinegar)
2. Traditional Indian onion pickle (oil & spices)
3. Value-added onion pickle

## **Discussion**

Two training courses were delivered in Rodrigues, namely at the Antene Universitaire (Citronelle) and at the National Handicraft Promotion Agency Training Centre (Malabar). The training courses included lectures, which were highly packed with drawings, figures, diagrams and photo plates. Lectures were made as short as possible with challenging topics for class discussion to increase class participation and interaction. These were done to retain the interest of participants. Video sessions on hygiene, sanitation and safe processing of foods as well as hands-on demonstrations, whereby the participants undertook some of the processes involved in pickling were also incorporated in the training course. The second training course included a PowerPoint slide show to illustrate the practices of onion pickling at the Food Processing Laboratory of AREU. The training courses were thus very practical-oriented, making use of the maximum number of visual aids.

The training sessions help in disseminating technologies developed during the course of this project and the direct contact between the Principal Investigator and the participants enables the latter to overcome their fears and uncertainties pertaining to the commercial production of onion pickles

## **Conclusions**

- Five training courses pertaining to onion pickling were undertaken during the course of this project
- Some 79 participants (53 in Rodrigues and 26 in Mauritius) benefited from the training courses on the principles and techniques of onion pickling
- The training courses delivered were practical-oriented, making use of a maximum number of visual aids and incorporating practical sessions to develop hands-on skills on onion pickling techniques

## **Recommendations**

- The course materials used for the delivery of training courses should be compiled in an electronic version (for example CD-ROMs) for the training of women entrepreneurs/ potential food processors
- A training course on onion pickling should be delivered once every year in Rodrigues to promote entrepreneurship and value addition in Rodrigues

## PART VII - MISCELLANEOUS ACTIVITIES

### Activity 1: Yield calculation for onion pickle in brine/ vinegar

From 1 kg of sets (15-25mm size category),

666 ± 22 g of onion pickle (drained weight) was obtained

960 ± 34 g of onion pickle (net weight) was obtained – excluding jar weight

A higher yield is expected when larger sized bulbs are used for pickle making, as there is little loss in terms of peels. On the other hand, small-sized onions tend to produce a high mass of waste in terms of onion peels. This was illustrated by the following experiments conducted on Blanc de Galmi and No Flaye sets. Onion pickles were prepared as per protocol in **Annex1**.

#### Experiment on Blanc de Galmi on the 9<sup>th</sup> March 2004

855 g of 10-15 mm Blanc de Galmi bulbs yielded 314 g of onion pickles drained weight

Thus, 1 kg of 10-15 mm Blanc de Galmi bulbs would yield 368 g of onion pickles drained weight

#### Experiment on No Flaye on the 20<sup>th</sup> April 2004

828.5 g of 20-25 mm No Flaye bulbs yielded 3 \* 225 g of onion pickles drained weight

Thus, 1 kg of 20-25 mm No Flaye bulbs would yield 815 g of onion pickles drained weight

### Activity 2: Development of a protocol for the making of the traditional Indian onion pickle using oil & spices

#### Methodology

- Protocols to make traditional fruit and vegetable pickle using oil and spices were retrieved from the Internet, books, periodicals & other publications
- Food processing protocols that make use of locally available raw materials were selected.
- Pickles were produced following the procedures set in the selected protocols and the pickles were evaluated in the Food Processing Laboratory with aim to compare the pre-selected protocols
- Based on the feedback received, the protocols were slightly modified and adapted
- Thereafter, the modified protocol was tested and a sensory evaluation was undertaken to compare the product developed with the one available commercially.

## Results

The protocol is attached hereto as **Annex 1**.

The formulation developed during the course of this project compares favourably with the one available commercially, except on three attributes. The commercially available onion pickle was sweeter and hotter in taste, while its colour was less appealing to the one developed at AREU.

## Conclusions & Recommendations

The protocol developed in the present study can be successfully used to produce onion pickles (oil & spices) on a commercial scale. There are ample opportunities for value addition to the Traditional Indian Pickle through the use of Rodriguan lime, green chilli and local garlic.

### **Activity 3: Analysis of onion pickles**

#### Methodology

Proximate analysis of 2 types of onion pickles was conducted. Water activity, percent moisture and vitamin C content were determined on fresh weight basis in the Food Processing Lab. of AREU. Protein (%), Ether Extract (%), Fibre (%), Total Ash (%), and Carbohydrates by difference (%) were determined on dry weight basis by the Agricultural Chemistry Division of the Min. of Agriculture, Food Technology and Natural Resources. Onion pickles were drained from the pickling medium. Part of the pickled onions was used for the determination of water activity, % moisture and vitamin C content. The rest was dried to constant mass in an oven at 70°C. The dried onions were then ground and homogenised, packed in HDPE pouches before sent for analysis in three replicates.

#### Results

The results obtained are tabulated in **Table 7.3.1** below. Water activity and % moisture of onion pickles in brine were higher compared to onion pickles in oil and spices. This may explain the longer shelf life of onion pickles in oil and spices (above 1 year) compared to onion pickle in brine (8 months). Higher water activity values imply greater availability of water for product deterioration including microbial spoilage and enzymatic browning.

A very high % of ether extract (indicative of total fats) was recorded for onion pickles in oil and spices, which is attributed to the presence of oil in this type of pickle. Higher ash % in onion pickle in brine may be attributed to higher salt content in its pickling medium. Onion pickle in brine had higher salinity values compared to onion pickle in oil & spices. This is because onions for the latter pickles are fermented and



then pickled in oil and spices with little amount of salt added, whereas onions for the brine pickles are fermented and then bottled in a pickling solution containing 4% table salt (w/v basis).

Table 7.3.1: Proximate analysis on onion pickles (dry weight basis, unless otherwise stated)

	Onion pickled in brine & vinegar	Onion pickled in oil and spices
Water activity – fresh weight basis	0.97-0.98	0.93-0.94
Moisture (%) – fresh weight basis	88.7	80.0
Vitamin C – fresh weight basis	120-170 ppm	NA
Protein (%)	7.62	10.4
Ether extract (%)	0.43	10.5
Fibre (%)	2.28	2.91
Ash (%)	33.2	28.2
Carbohydrates by difference (%)	58.8	50.9

### Conclusions

- Onion pickles in brine/vinegar contain higher moisture % and they have higher water activity values, as well as higher total ash % values compared to onion pickles in oil and spices
- By virtue of their lower water activity values, onion pickles in oil and spices are expected to have longer shelf life compared to onion pickles in brine/ vinegar.
- Onion pickles in oil and spices have higher ether extract, which indicates higher fats content.

## CONCLUSIONS

### Part 1

- The highest yield of sets was obtained from Nun 7292, Yellow Dessex, and Blanc de Galmi
- No Flaye was a moderate yielder of onions sets, while Local Red was a low yielder.
- The varieties that produced large amount of sets in the desired size category (15-15 mm) for pickling were: No Flaye, Nun7292, Yellow Dessex and Blanc de Galmi.
- The sowing density that produced the largest amount of sets in the 15-25 mm size category was 4 g/ m<sup>2</sup>.

### Part 2

- Diluted vinegar containing 8-10% table salt (w/v basis) need to be used for fermenting peeled onions in order to reduce their pungency.
- Fermentation of peeled onions should last for a period of 30 – 48 hours under ambient conditions (25°-27°C).
- Treatments adopted were effective in minimising the major spoilage problems of pickles since no microbial spoilage by fermentative bacteria and yeasts was observed during the study.
- Treatments A, B, C, and D did not influence significantly the visual quality attributes (skin colour, browning and colour brightness) of pickled onions
- Percent salinity and percent titrable acidity of pickling solution as well as %TSS of pickled onions were however markedly influenced by the treatments A, B, C, and D.
- Treatment A and B (3% acetic acid in pickling solution) resulted in higher percent titrable acidity, which resulted in sour onion pickles
- Treatment B and D (8% table salt in pickling solution) resulted in higher percent salinity, which led to salty pickles
- 1.5% acetic acid (v/v) and 4% table salt (w/v) are recommended for the preparation of the pickling solution

### Part 3

Medium-sized onions (15-25 mm) are appropriate for pickle making because of:

- Better appearance (lower level of browning) in bottle jars
- Moderate labour cost for peeling
- Lower percentage of waste compared to small-sized onions
- Acceptable onion firmness after pickling
- Rapid fermentation and quick pungency reduction
- Appropriate size for a mouthful intake

#### Part 4

- Skin colour of white onion pickles was acceptable 8 months after date of production.
- Blanc de Galmi was the onion cultivar most appreciated in pickle.

#### Part 5

- Make sure to cover the onions with solution properly leaving a headspace of 6-8 mm. Otherwise browning may occur
- Rod. chilli, garlic and ginger reduces the sourness due to the presence of the vinegar and imparts and very appealing bland of hot taste to the pickle
- B. de Galmi pickle remains white or almost white even 8 months after storage
- Ginger imparts a prominent taste to the pickle, which is stronger than the garlic taste. However both tastes were appreciated. But nevertheless the % composition of garlic should be higher than that of ginger if both are used
- Rod. lime leaves a bitter taste and a lime flavour with some degree of sourness
- Rod. lime predominates the existence of lemongrass such that the latter could not be detected by smell
- Lime in the value addition experiment tends to render the pickling solution a bit viscous
- Two most acceptable taste in the value addition experiment: (Rodriguan chilli + garlic) and (red chilli + ginger + garlic)
- No Flaye requires 10% brine for up to 3 days v/s yellow and white varieties. The red variety No Flaye is very pungent.

#### Part 6

- Five training courses pertaining to onion pickling were undertaken during the course of this project
- Some 79 participants (53 in Rodrigues and 26 in Mauritius) benefited from the training courses on the principles and techniques of onion pickling

- The training courses delivered were practical-oriented, making use of a maximum number of visual aids and incorporating practical sessions to develop hands-on skills on onion pickling techniques

#### **Part 7**

- 1 kg of onion sets 15-25 mm size category will produce 640 – 690 g of onion pickle in brine (drained weight basis or 930 – 990 g of pickle (net weight basis).
- Onion pickle in oil & spices can be successfully produced from undersized/ oversized sets (those not suitable for pickling in brine and vinegar) with a shelf life of above 1 year.
- Onion pickles in brine/vinegar contain higher moisture % and they have higher water activity values, as well as higher total ash % values compared to onion pickles in oil and spices
- By virtue of their lower water activity values, onion pickles in oil and spices are expected to have longer shelf life compared to onion pickles in brine/ vinegar.
- Onion pickles in oil and spices have higher ether extract, which indicates higher fats content.

## PROJECT OUTPUTS/ DELIVERABLES

- Protocols were developed for the making of
  - Onion pickle (brine & vinegar)
  - High value-added onion pickles (brine & vinegar)
  - Onion pickle (oil & spices)

- Size of onion sets

Onion bulbs of diameter 15-25 mm were most appropriate for pickling (brine & vinegar)

- Varieties for onion pickling

Blanc de Galmi (white), Yellow Dessex (yellow) and No Flaye (red) were suitable varieties for pickling in brine & vinegar. Blanc de Galmi was the best variety of all.

- Onion peeling

Onion peeling can be greatly facilitated by initially blanching the onions in hot water (95-98°C) for 1-2 minutes, followed by cold-water dip for 5 minutes. This reduced eye irritation and increased work output

- Onion fermentation

Fermenting peeled onions in a 8-10% NaCl solution (weight by volume basis) for a period of 24-36 hours can significantly reduce onion pungency. This step also improves the taste of onion pickles.

- Pickling solution

Pickling fermented onions in brine resulted in shorter shelf life (3-4 months), while pickling onions in a mixture of brine & vinegar (0.5 L water, 0.5 L vinegar and 30-40 g salt) resulted in longer shelf life (above 8 months) and better product appearance

- Onion browning

Browning of onions during pickling can be minimised by using 500-ppm citric acid and 300-ppm ascorbic acid solutions in combination

- Product stabilisation

Hot filling of jars with pickling solution at 85°C, immediately followed by a quick pasteurisation treatment at 80°C for 3-4 minutes helped in stabilising the product without reduction in product firmness and crunchiness

- Shelf life

A shelf life of above 8 months was obtained for onion pickles (brine & vinegar) prepared from varieties No Flaye, Blanc de Galmi, and Yellow Dessex. With other varieties, the shelf life varied between 4-8 months. The major parameters limiting shelf life were onion browning and clarity of brine.

- Value addition

Taste of onion pickles has been significantly improved by the use of a combination of red chilli, ginger, and garlic or Rodriguan green chilli and local garlic.

## FURTHER WORK

- The course materials used for the delivery of training courses should be compiled in an electronic version (for example CD-ROMs) for the training of women entrepreneurs/ potential food processors
- Training course on onion pickling should be delivered once every year in Rodrigues to promote entrepreneurship and value addition to onions in Rodrigues
- Further research work needs to be conducted on onion pickle in oil and spices to explore means to add value to this product through the use of Rodriguan lime, Rodriguan green chilli and local garlic
- Evaluation of new onion varieties to identify those which are both suitable for fresh-market consumption and for onion sets production for pickling should be initiated
- The Local Red variety needs to be rehabilitated in view of preserving the unique characteristics of this variety and in view of producing onion sets of uniform size

I certify that to best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinions are true and complete) (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated are the original work of the signatories or individuals working under their supervision. I understand that wilfully making a false statement or concealing a material fact in this report or any other communication submitted to MRC is a criminal offence.

<b>Principal Investigator Signature:</b>	<b>Date:</b>
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## ANNEX 1: PROTOCOL FOR MAKING ONION PICKLE IN OIL & SPICES

### ONION PICKLE



#### **Introduction**

Small onion bulbs are not commonly marketed in Mauritius, since they do not meet the minimum market standards of the Agricultural Marketing Board. They are usually kept for planting as sets in the following season. Very often, there are big storage losses. One means to use the onion sets is to process them into pickles, which are consumed as appetisers or party snacks or along with rice-based dishes.

#### **Raw Material Selection**

Choose round and flat onion bulbs with good storage capacity. ‘Silverskin’ white onions give pickles with better appearance, although other onion varieties could be used to make pickles. The size of onion bulbs commonly used is 20-25 mm in diameter

#### **Suitable Varieties**

Among the most suited varieties for making onion pickles are Blanc de Galmi, Yellow Dessex and No Flaye. Other varieties that have been tested gave lower quality of pickle with short shelf life and poor product appearance



## Materials Required

For 1000g of fermented and surface dried onions, use the following amount of spices:

- Mustard  $16.0 \pm 1.6$  g
- Ground tumeric  $13.0 \pm 1.3$  g
- Sugar  $25.0 \pm 2.5$  g
- Garlic paste  $30.0 \pm 3.0$  g
- Chilli powder 15.0 – 18.0g
- Fenugreek 'Methi' 0.7 – 0.9 g

Boiled-and-cooled water ( $\frac{1}{2}$  L), salt (100g), vinegar ( $\frac{1}{2}$  L) and oil (300ml) would also be required.

## Preparation

1. Select good quality onions with diameter of 20 – 25 mm
2. Remove bulb neck with a sharp knife
3. Blanch for 1-2 minutes in boiling water ( $98^{\circ}\text{C}$ )
4. Cool immediately in cold water for 5 minutes
5. Peel onions carefully without bruising onion surface
6. Pickle in vinegar, water and salt ( $\frac{1}{2}$  L water,  $\frac{1}{2}$  L vinegar and 100g salt) for 24-36 hours
7. Drain pickling solution and rinse with clean water
8. Dry at  $65^{\circ}\text{C}$  for 2-3 hours in a ventilated oven
9. Mix the above-mentioned spices with a little amount of oil and add onions to the paste
10. Fill the pre-sterilised jars with oil up to  $\frac{1}{5}$  to  $\frac{1}{6}$  of its volume and then add the mixture from step 9 above to jars containing oil, pressing the onions to the bottom by the help of a spatula
11. Cover onions with oil (if necessary), leaving a headspace of 6-10 mm
12. Pasteurise the product in boiling water for at least 10 minutes.
13. Allow to cool to ambient temperature
14. Store pickles in a clean, dry, and cool place. Avoid direct sunlight during storage.

## Yield

1 kg of small onion bulbs may yield  $960 \pm 30$  g of onion pickles (net weight basis). These may fill around four 290 g jars.

## Shelf life

Above 1 year

## ANNEX 2: VARIETIES USED DURING THE STUDY

Varieties	Skin Colour	Type of variety	Mean % TSS	Yield (t/Ha)	Yield Potential	Shape of bulb
Local Red	Red	Open-pollinated	18.8	10-12	Low	Round & slightly elongated
Veronique	Pink	Open-pollinated	15.0	18-22	Moderate	Round & flat
No Flaye	Pink	Open-pollinated	17.6	18-22	Moderate	Round & flat
Capri F1	Red	Hybrid	13.5	16-20	Moderate	Thick & flat
Early Locker Brown	Yellowish Brown	Hybrid	10.6	≈ 15	Low	Globular
Blanc de Galmi	White	Hybrid	9.4	≈ 27	High	Fflat
Crystal PRR	White	Open-pollinated	8.4	≈ 15	Low	Thick & flat
Nun 7292	Yellow	Hybrid	7.3	30-34	High	Globular
Nun 7294	Yellow	Hybrid	7.3	35-40	High	Globular
Yellow Dessex	Yellow	Hybrid	8.3	35-40	High	Flat
Star 5504	Yellow	Hybrid	9.0	27-31	High	Flat
Galil	Yellow	Hybrid	8.2	30-34	High	Elongated

N.B: The above table states any variety that has been used in the MRC research project throughout the duration of the project. An onion variety might have been evaluated in pre-experimental studies as well. Therefore, not all the above-stated varieties have been used in the main experiments of the project.

### In general, the desirable characteristics of onions for pickling are:

- White skin colour
- Flat to globular/ round shape
- Firm bulb (tightly packed scale leaves), but not too firm though (e.g. Capri F1)
- High dry matter content/ low water content
- Closed bulb neck; adequate storage life
- Producing high yield of uniform sets (minimum variation in size of bulbs)

N.B: These (i.e., desirable characteristics) are not findings from the MRC research project. But can serve as a guidelines for onion variety selection for pickling purposes.

### ANNEX 3: PROTOCOL FOR VALUE ADDITION TO ONION PICKLE

- Select good quality onions with diameter of 20-25 mm
- Discard onions, which are diseased and mechanically damaged
- Cut off the neck of the onion bulbs
- Blanch for 1-2 minutes in hot water (98°C)
- Cool immediately in chilled water for 5 minutes
- Peel onions carefully without bruising onion bulb's surface
- Grade peeled onions to uniform size. Leave aside undersized and oversized onions
- Ferment onions in commercial vinegar (active ingredient: 3 % acetic acid) and water in the ratio of 1:1 (1L water and 1L vinegar) and 160g salt for 36-48 hours
- The raw materials to be added to the onion pickle should be equally fermented according to the table below:

Raw material	Salt concentration (% Weight by Volume)	Vinegar concentration (% Acetic acid)	Duration of fermentation (days)
Chilli	8	1.5	4
Ginger	8	1.5	4
Garlic	6	1.5	4
Lime (1 <sup>st</sup> fermentation)	10	0	7
Lime (2 <sup>nd</sup> fermentation)	8	0	7

*Note: Fermentation of the raw materials should be initiated well before fermentation onions. For example, chilli fermentation should be initiated 2 days before onion fermentation*

- Drain the fermenting solutions and keep the products in a pre-sterilised container
- Fill the pre-sterilised jars (300 g jar) with fermented onions and fermented raw materials as follows:
  - 225 – 230 g of fermented onions
  - 3% weight-by-weight basis Rodriguan chilli (8-12 chillies per 300 g jar)
  - 2% weight-by-weight basis garlic (6-8 cubes of garlic of 0.4 \* 0.4 \* 0.4 mm per jar of 300 g)
- Hot fill the jars at 85°C with the pickling solution, which is comprised of:
  - 1 litre water
  - 1 litre commercial vinegar
  - 80 g fine salt
  - 50 g sugar
  - 0.6 g ascorbic acid
  - 2 g citric acid
- Seal the jars tightly and store them in a clean, cool and dry place
- Pickle is ready for consumption 1 month after production date
- Shelf-life: 8 months

**ANNEX 4 : EVALUATION SHEET FOR ONION PICKLE  
(BRINE/VINEGAR)**

Number:

Date:

**APPEARANCE:**

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
Product Appeal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Low						High

**TEXTURE:**

Hardness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Very Soft		Soft		Semi-hard		Hard

Crunchiness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not crunchy			Crunchy			Very Crunchy

**TASTE :**

Sourness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not sour		Quite sour		Sour		Very sour

Bitterness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not bitter		Quite Bitter		Bitter		Very Bitter

Saltiness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Not Salty		Quite salty		Salty		Very salty

**CHEMICAL HEAT:**

Hot taste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	None		Quite hot		Hot		Very Hot

## ANNEX 5 : COURSE SCHEDULE ON TECHNIQUES & PRINCIPLES OF ONION PICKLING

Time	Tuesday 14 May 2002	Wednesday 15 May 2002	Thursday 16 May 2002	Friday 17 May 2002
9-10	Introduction to Course + Needs Assessment Session	Food Spoilage & Prevention (L)	<b>DEMO:</b> - Onion Pickle (oil & spices)	<i>Class discussion: Marketing opportunities of processed onions</i>  Q & A and Summing-up Session + Course Evaluation
10-11	Techniques & Principles of Onion Processing (L)	Quality Concept - Norms & Standards	- Onion Pickle (spiced vinegar)	
11-12	Hygiene & Sanitation (L)	- Packaging & Labelling - Principles of HACCP		
12-13	<b>BREAK</b>			
13-14 14-15	<b>VIDEO:</b> 'Zone Ultra- Propre' EDUCAGRI Video  <b>DEMO:</b> - Jar Washing/Sterilisation - Onion fermentation in brine/vinegar	<b>DEMO:</b> - Making of spiced vinegar - Bottling technique  Briefing on group work	<i>Brainstorming session on value addition to onion pickle (Groupwork)</i>  <b>DEMO:</b> - Value addition to onion pickle	

Key: L = Lectures (highly illustrated with figures, drawings and photos)

DEMO: Demonstrations

**ANNEX 6 : COURSE SCHEDULE – VALUE ADDITION TO ONION PICKLES**

TIME	MON 23 FEB 2004	TUES 24 FEB 2004	WED 25 FEB 2004	THURS 26 FEB 2004
8.30 - 10	Course introduction Overview of Onion Pickling Project (L)	Hygiene and Sanitation (L) (Design of food processing plant)	Food spoilage and prevention + Factors affecting microbial growth (L)	TQM concept + Labelling norms and standards
10 - 11	Techniques of Onion Processing (L)	Hygiene and Sanitation (L) (Cleaning and disinfection)	<b>DEMO</b> Onion pickle (brine and vinegar) Bottling and hot filling technique	Quality enhancement + Basic principles of HACCP (L)
11 - 12	<b>VIDEO SESSIONS</b> EDUCAGRI + Mauritius College of the Air Video on Fruit & Veg. Processing	Food Act exigencies (Processing plant, equipment, and personal hygiene)		<b>POWERPOINT PRESENTATION</b> (Onion pickling and processing)
12 - 12.45	<b>LUNCH</b>			
12.45 - 15.30	<b>DEMO</b> Jar washing and sterilisation Onion peeling & fermentation Preparation of raw materials for value addition	<b>DEMO</b> Onion pickle (oils and spices) Pickle filling method Pasteurisation technique	Value addition – techniques and principles (L) <b>DEMO</b> Value addition to onion pickles	Marketing aspects (L) Q & A session Summing-up session Course evaluation

**Key:** L: Lectures (highly illustrated with photos)

DEMO: Demonstrations

## ANNEX : CONSUMER-ORIENTED TESTING FOR ONION PICKLES

You are provided with 3 coded samples of onion pickles. Tick the category, which corresponds the most to the parameter under evaluation

<b>EXAMPLE</b>					
<b>Sample code:</b> 3574					
<b>Parameter:</b> taste					
<b>Category:</b>	dislike a lot	dislike a little	<del>neither like nor dislike</del>	like a little	like a lot

### SAMPLE CODE

<b>Appearance</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
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<b>Taste</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
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<b>Willingness to purchase</b>	not willing	quite willing	willing	very willing	extremely willing
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### SAMPLE CODE

<b>Appearance</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
-------------------	------------------	---------------------	-----------------------------	------------------	---------------

<b>Taste</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
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<b>Willingness to purchase</b>	not willing	quite willing	willing	very willing	extremely willing
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### SAMPLE CODE

<b>Appearance</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
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<b>Taste</b>	dislike a lot	dislike a little	neither like nor dislike	like a little	like a lot
--------------	------------------	---------------------	-----------------------------	------------------	---------------

<b>Willingness to purchase</b>	not willing	quite willing	willing	very willing	extremely willing
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